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Research Article

A Study to Assess the Biochemical Composition and Nutritional Potential of Desert Date *Balanites aegyptiaca* Fruit Pulp of Northern Region (Korhogo, Côte d'Ivoire)

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Abstract

Balanites aegyptiaca is a perennial tropical plant belonging to the Balanitaceae family. It is mainly used for its leaves and fruit. The fruit contains edible pulp that is an important food source for humans. Although this fruit is used by local populations for its therapeutic properties, few studies have been conducted on the nutritional potential and phytonutrients composition of the fruit pulp. The aim of this study is to contribute to the promotion of this local plant resource in the diet of populations in northern region of Côte d'Ivoire by the biochemical characterizing and determination of nutritional potential of its pulp. 200g of *Balanites aegyptiaca* fruit were purchased from three markets in the city of Korhogo. The fruit was carefully sorted to remove damaged fruit, post-harvest plant debris, and other foreign matter. The fruit was then washed and drained. The different parts were separated manually into the outer layer (pericarp), pulp (mesocarp), and inner layer (endocarp). The pulp was extracted using a stainless steel knife and then ground using a blender. The moisture, fat, ash, crude fibers, protein, and carbohydrate (by difference) contents were determined using the AOAC methods. The mineral content was determined by spectrometry. Total phenolics content and total flavonoids were determined using standard spectrophotometric methods. Results of biochemical analysis show that the moisture content of fruit pulp is 36.4% and amounts of fat is 0.2%. Ash content and crude fibers content are 6% and 1.35% respectively and protein content is moderate (4.54%). Total carbohydrates are the components present in large quantities in the pulp (51.51%). The caloric intake gave a value of 226.0 Kcal/100g. The pulp of the *Balanites aegyptiaca* fruit is rich in minerals such as potassium (505.2 mg/100g), magnesium (3.4 mg/100g), zinc (1.6 mg/100g), sodium (14 mg/100g), and phosphorus (11.5 mg/100g). Calcium and iron are presents in low contents (< 0,14 mg/100g). The Na/K ratio obtained in this work is about 0.03. Results of phytonutrients composition of *Balanites aegyptiaca* fruit pulp indicate that the pulp is particularly rich in total polyphenols (21.01 mg GAE/g ± 0.27), while moderate amounts of flavonoids (3.14 mg QE/g ± 0.10).

Keywords

Desert Date, *Balanites aegyptiaca*, Fruit Pulp, Phytonutrients Compounds, Nutritional Value, Côte d'Ivoire

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1. Introduction

Since ancient time, human beings have depended much on plants for survival either as a source of food or for medicinal purpose [1]. Local and traditional plant resources such as *Balanites aegyptiaca* are attracting growing interest, particularly in semi-arid regions where plants adapted to harsh conditions can offer valuable alternatives [2]. *Balanites aegyptiaca*, known as the desert date palm, is a wild fruit tree found in arid and semi-arid areas in several countries in sub-Saharan Africa, particularly from the coast of Mauritania and Senegal to Somalia, and from southern Egypt to Zambia and Zimbabwe, as well as in the hot regions of the Democratic Republic of Congo and Angola [3]. It is a perennial tropical plant belonging to the Balanitaceae family and can be cultivated for both its fibers and its oil [4]. It is one of the most common but neglected wild plant species in the drylands of Africa and South Asia [5]. *Balanites aegyptiaca* is mainly used by local populations for its therapeutic properties [6]. Extracts from *Balanites aegyptiaca* have shown antidiabetic properties, insecticidal potential, antimicrobial activity against strains of bacterial and fungal pathogens, antiviral and antiparasitic activity, and a hepatoprotective effect [7]. The fruit contains edible pulp that is an important food source for humans and livestock [8]. Although few studies have been conducted on the nutritional composition of the fruit pulp. This part of the fruit, which is often consumed or processed using traditional methods, could be an interesting source of essential nutrients that could be used in human nutrition. The aim of this study is to contribute to the promotion of this local plant resource in the diet of populations in northern Côte d'Ivoire by determination of biochemical composition and nutritional potential of its pulp.

2. Manuscript Formatting

2.1. Equations

$$\text{Moisture content (\%)} = (\text{weight loss/sample weight}) \times 100 \quad (1)$$

$$\text{Fat content (\%)} = (\text{weight of hexane-soluble dry matter/weight of sample}) \times 100 \quad (2)$$

$$\text{Ash content (\%)} = (\text{AW/IW}) \times 100 \quad (3)$$

AW: weight of ash and IW: initial weight of dry matter.

$$\text{\% nitrogen} = (\text{TS} - \text{TB} \times \text{acid normality} \times 0.014/\text{sample weight}) \times 100 \quad (4)$$

TS: sample volume (mL)
TB: blank volume (ml)
0.014: Meq of nitrogen

$$\text{Protein content (\%)} = \text{\% nitrogen} \times 6.25 \quad (5)$$

$$\text{Total carbohydrate content (\%)} = [100-(\text{protein content (\%)} + \text{fat content (\%)} + \text{ash content (\%)} + \text{moisture content (\%)} + \text{crude fibers content}] \times 100 \quad (6)$$

$$\text{EV (kcal/100g)} = 4 \times \text{P (\%)} + 9 \times \text{L (\%)} + 4 \times \text{TC (\%)} \quad (7)$$

2.2. Figures

Figure 1 presents results of phytonutrients composition of aqueous extracts of *Balanites aegyptiaca* fruit pulp.
Values are expressed as Mean ± standard deviation (n= 3).

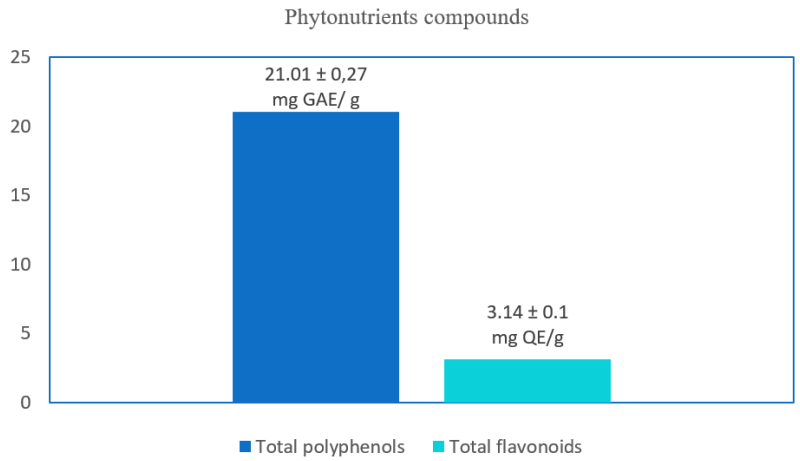

Figure 1. *Phytonutrients composition of Balanites aegyptiaca fruit pulp.*

2.3. Tables

Table 1 presents results of biochemical analysis.

Table 1. *Biochemical composition of Balanites aegyptiaca fruit pulp.*

Parameters	Content (Mean ± SD)
Proteins (%)	4,55 ± 0,09
Lipids (%)	0,2 ± 0,00
Carbohydrates (%)	51,51 ± 1,57
Moisture (%)	36,4 ± 1,41
Ash (%)	6,00 ± 0,28
Crude Fibers (%)	1,35 ± 0,21
Energy value (Kcal/100g)	226,00 ± 5,93

Values are expressed as mean ± standard deviation (n= 3). SD: Standard Deviation

The mineral profil of *Balanites aegyptiaca* fruit pulp is displayed in Table 2.

Table 2. *Mineral composition (mg/100 g) of desert date (Balanites aegyptiaca) fruit pulp.*

Mineral	Content (Mean ± SD) (mg/100g DM)
Calcium (Ca)	< 0,14 ± 0,00
Potassium (K)	505,2 ± 0,00
Magnésium (Mg)	3,4 ± 0,00
Iron (Fe)	< 0,14 ± 0,00
Zinc (Zn)	1,6 ± 0,00
Sodium (Na)	14 ± 0,00
Phosphore (P)	11,5 ±0,00
Sodium/ Potassium (Na/K)	0,03

Values are expressed as mean ± standard deviation of triplicate determinations (n=3). DM: Dry matter. Values indicated as " < "are below the detection limit of the analytical method (ICP-MS).

3. Materials and Methods

3.1. Plant Material

The plant material used in this study consist of the desert date (*Balanites aegyptiaca*) fruit pulp.

3.2. Methods

3.2.1. Sample Preparation

200g of *Balanites aegyptiaca* fruit were purchased from three markets in the city of Korhogo. The fruits were carefully sorted to remove damaged fruits, post-harvest plant debris, and other foreign matter. The fruits were then washed with tap water and drained. The different parts were separated manually into the outer layer (pericarp), pulp (mesocarp), and inner layer (endocarp). The pulp was extracted using a stainless steel knife and then crushed using a blender. The sample was then stored in a hermetically sealed jar for further analysis.

3.2.2. Determination of Biochemical Characteristics

The moisture, fat, ash, crude fibers, protein and carbohydrates (by difference) contents of the *balanites aegyptiaca*

fruit pulp were determined using [9] method.

(i). Moisture Content

The moisture content was determined by the gravimetric method at 105°C until constant weight.

Moisture content (%) = (weight loss/sample weight) × 100 (8)

(ii). Fat Content

Lipids were determined using the Soxhlet method, with hexane as the extraction solvent. The percentage of crude fat is expressed as follows:

Fat content (%) = (weight of hexane-soluble dry matter/weight of sample) × 100 (9)

Where AW: weight of ash and IW: initial weight of dry matter.

(iii). Ash Content

The ash content was determined by incineration in a muffle furnace at 550°C for 3 hours. The ash content was calculated using the following formula:

Ash content (%) = (AW/IW) × 100 (10)

(iv). Protein Content

Total nitrogen was determined by the Micro-Kjeldahl method and converted to crude protein using a conversion factor of 6.25. The percentage of nitrogen and protein was calculated using the following equation.

% nitrogen = (TS – TB × acid normality × 0.014/sample weight) ×100 (11)

Protein content (%) =% nitrogen × 6.25 (12)

Where TS: sample volume (mL)
TB: blank volume (ml)
0.014: Meq of nitrogen

(v). Crude Fibers

Crude fibers were proportioned according to the method described by [9]. Two (2) gram of the sample are weighed in a balloon. 50 mL of sulphuric acid 0.25 N was added to the contents was homogenized and the whole carried with boiling during 30 min under cooling agent with backward flow. Then, 50 mL of sodium 0.31N are added to the contents and the whole carried to boiling during 30 min under cooling agent to backward flow. The extract obtained is filtered on filter paper Whatman and the residue is washed several times at hot water until complete elimination of alkalis. After elimination, the residue is dried with the drying oven with 105°C during 8 H, cooled with the weighed desiccator then. The residue obtained is incinerated with the furnace with 550°C during 3 h. Finally, it is cooled with the desiccator then weighed ashes.

(vi). Total Carbohydrate Content

The total carbohydrate content of the samples was determined by difference, by subtracting protein, fat, ash, crude fibers and moisture.

Total carbohydrate content (%) = [100-(protein content (%) + fat content (%) + ash content (%) + moisture content (%) + crude fibers content] × 100 (13)

(vii). Energy Value

The energy value was calculated according to the equation given by [10].

EV (kcal/100g) = 4 × P (%) + 9 × L (%) + 4 × TC (%) (14)

Where: EV (kcal/100g): Energy value
P (%): percentage of protein
L (%): percentage of lipids
TC (%): percentage of total carbohydrates

3.2.3. Determination of Mineral Content

Minerals were identified and quantified according to the method described by [11]. Five (5) g of *Balanites aegyptiaca* pulp was incinerated in a muffle furnace at 500°C for 12 h, then 0.25 g of ash was removed and 10 mL of HCl/HNO_3 (50%) was added, after which the mixture was homogenized. The resulting mixture is then filtered through Whatman filter paper and the filtrate volume is made up to 100 mL with distilled water. Microanalysis for qualitative and quantitative determination of minerals is performed by spectrometry (ICP-MS) using mineral standard solutions.

3.2.4. Determination of Polyphenol Content

Phenolic compounds are extracted with methanol using the method of [12]. One (1) gram of pulp is homogenized in 10 mL of 70% (v/v) methanol. The resulting mixture is centrifuged at 1000 rpm for 10 min. The pellet is recovered in 10 mL of 70% (v/v) methanol and centrifuged again. The supernatants are collected in a 50 mL flask and made up to the mark

with distilled water. The resulting solution is called methanolic extract. One (1) mL of methanolic extract is introduced into a test tube and 1mL of Folin-ciocalteu reagent is added. The tube is left to stand for 3 min, then 1 mL of 20% (w/v) sodium carbonate solution is added. The contents of the tube are made up to 10 mL with distilled water and placed in the dark for 30 min. Optical density is read at 725 nm against a blank. A standard range established from a stock solution of gallic acid (1 mg/mL) under the same conditions as the assay is used to determine the amount of phenols in the sample.

3.2.5. Determination of Flavonoid Content

The method for determining flavonoid content is that of [13]. A volume of 0.5 mL of methanolic extract is introduced into a test tube. To the contents of the tube are successively added 0.5 mL distilled water, 0.5 mL aluminum chloride and 0.5 mL sodium nitrite. The tube is left to stand for 30 min in the dark, and the optical density (OD) is read at 415 nm against a blank. The flavonoid content of the samples was determined by means of a calibration line performed under the same conditions as the assay, using a quercetin stock solution at 0.1 mg/mL.

3.3. Statistical Analysis

All analyses were performed in triplicate. Results are expressed as mean ±standard deviation using Statistica 7.1 software.

4. Results

4.1. Biochemical Analysis

Table 1 presents the results of biochemical analysis. Characterization of *Balanites aegyptiaca* fruit pulp shows that fruit pulp has moisture content of 36,4% and lower amounts of fat (0.2%). Ash and crude fibers contents are 6% and 1.35% respectively. Protein content is moderate (4.54%). Carbohydrates are the components present in large quantities in the pulp (51.51%). The caloric intake gave a value of 226.00 Kcal/100g.

4.2. Mineral Profil of *Balanites aegyptiaca* Fruit Pulp

The mineral profil of *Balanites aegyptiaca* fruit pulp are displayed in Table 2. *Balanites aegyptiaca* fruit pulp is rich in minerals including calcium, potassium, magnesium, iron, zinc, sodium and phosphorus. *Balanites aegyptiaca* fruit pulp has a high potassium content.

4.3. Phytonutrients Composition of *Balanites aegyptiaca* Fruit Pulp

Figure 1 presents the results of phytochemical composition of aqueous extracts of *Balanites aegyptiaca* fruit pulp. Results indicate that pulp is particularly rich in total polyphenols (21.01 mg GAE/g ± 0.27), while moderate amounts of flavonoids (3.14 mg QE/g ± 0.10).

5. Discussion

The moisture content of *Balanites aegyptiaca* fruit pulp (36.4%) is high. According to [14], the high moisture content in fruits and vegetables can help enhance food digestion and peristaltic movement on consumption.

The fat is present in an extremely low amount at the rate of 0.2% of dry pulp. [15] measured an almost similar content (0.41 g/100 g DM). However, it is known that low levels of lipids are common in fruit pulp and are usually less than 1 g /100 g DM, and would not have a great nutritional importance.

The value obtained for ash content (6%) is simillar to value of 5.21% obtained by [1]. Ash content of the sample gives an idea about the minerals content of the food material. This implied that the pulp would be rich in minerals.

Crude fibers content for the pulp is 1.35%. The value is low than the value 3.91% obtained by [1]. Crude fibers are known to expand the inside walls of the colon, easing the passage of waste, and this makes it quite effective against constipation [16] but in excess may bind trace elements, leading to deficiencies of iron and zinc [1].

The crude protein content of 4.55% was found in the pulp of *Balanites aegyptiaca*. The protein content was high when compared to 3.97% as reported by [17]. The high crude protein content indicates that the pulp could be an important source for protein supplement.

Carbohydrates are the dominant compounds (51.51%). This content is relatively high compared to the of dry pulp reported by [15] for *Balanites aegyptiaca* fruit pulp from northen ferlo in senegal. The high carbohydrate content of *Balanites aegyptiaca* pulp means that the pulp is an excellent source of carbohydrates. This result shows that *Balanites aegyptiaca* fruit pulp can provide the body with energy.

The caloric intake derived from the pulp content in the term of protein, sugar and fat gave a value of 226.00 kcal /100 g pulp (Table 1). It can therefore be an important energy source especially in poor rural areas, where food is mainly based on cereals.

Calcium content of the pulp is low (<0,14 mg/100g). Calcium is essential to maintaining total body health. Our bodies need calcium every day not just to keep our bones and teeth strong over but to ensure proper functioning of muscles and nerves, and also help our blood to clot [18].

Potassium content of *Balanites aegyptiaca* fruits pulp is 505,2 mg/100 g. It was reported that, plants foods are usually high in potassium [19]. High amount of potassium in the body was reported to increase iron utilization [20].

Magnesium and iron contents of *Balanites aegyptiaca* fruit pulp (3,4 mg/100g and <0,14 mg/100 g) respectively are low when compared to 73 mg/100g for magnesium and 4.94 mg/100g for iron reported by [15] in a study on *Balanites aegyptiaca* fruit pulps from northen ferlo in senegal. According

to [21, 22], magnesium is an activator of many enzyme systems and maintains the electrical potential in nerve and iron is an important element in the diet of pregnant women, nursing mothers and infants to prevent aneaemia.

The Zinc content of the pulp (1.6 mg/100g) is low when compared to 28.73 mg/100 reported by [17]. According to [23], the zinc content in the pulp indicates that *Balanites aegyptiaca* fruit could play a major role in normal body development, since zinc is an essential element in protein and nucleic acid synthesis.

The sodium content of *Balanites aegyptiaca* fruits pulp is 14 mg/100 g. Sodium plays an important role in osmotic regulation of the body fluids and transmission of nerve impulses. Na/K ratio in the body is important because it help in controlling high blood pressure. Na/K ratio of less than one is recommended [24]. The Na/K ratio obtained in this work is about 0.03 for pulp, which indicate that the *Balanites aegyptiaca* fruit pulp could be useful in the lowering blood pressure.

Phosphorus contents of the pulp is 11.5 mg/100 g. Phosphorus is responsible for cell division, reproduction and the transmission of hereditary traits [20]. Phosphorus is related to Calcium for bones, teeth and muscles growth and maintenance [25].

Results of phytonutrients composition of aqueous extracts of *Balanites aegyptiaca* fruit pulp indicate that the pulp is particularly rich in total polyphenols (21.01 ± 0.27 mg GAE/100g DM), while moderate amounts of flavonoids (3.14 ± 0.10 mg/100 g DM). Total polyphenols and total flavonoids contents found in the present study are lower than those reported by [26] which are 264 mg GAE/100g DM for polyphénols and 34.2 mg/100 g DM for flavonoids in fruit pulp of *Balanites aegyptiaca* from the arid zone of Mauritania, Northwest Africa. Several factors may explain these variations: the impact of soil and climatic conditions, the maturity of analyzed fruits, or changes in analysis methods used. Due to the reasonable concentrations of some of these minerals, and phytochemicals compounds in the desert date pulp, it can easily be said the pulp can serve as an excellent supplement for these minerals and a natural food source of compounds beneficial to the human body.

6. Conclusions

This study highlights the biochemical composition and nutritional potential of *Balanites aegyptiaca* fruit pulp consumed in northern region (Korhogo, Côte d'Ivoire). Fruit pulp is high carbohydrate content and appreciable energy value make it an important source of energy, particulary for rural populations. The pulp also provides moderate protein levels and a favorable mineral profile, notably rich in potassium with a low Na/k ratio, which may support cardiovascular health. In addition, the presence of phytonutrients compounds such as polyphenols and flavonoids suggests potential antioxidant benefits. Overall, the findings confirm that *Balanites aegyptiaca* fruit pulp represents a valuable, underutilized local food resource. Its promotion and valorization in northern Côte d'Ivoire could contribute to improved food security and better nutritional health among local populations.

Abbreviations

Kcal	Kilocalories
GAE	Gallic Acid Equivalent
QE	Quercetin Equivalent
Meq	Milliequivalents
P	Protein
L	Lipid
TC	Total Carbohydrates
EV	Energy Value
W/V	Weight/ Volume

Author Contributions

Mandou é St éphanie Bamba: Conceptualization, Funding acquisition, Methodology, Writing – original draft

Dehegnan Penan Patricia Oulai: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft

Noelle Fran çoise Kodjo: Methodology, Formal analysis, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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