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Evaluation of Nutritional Composition of *Borassus aethiopum* Mart. hypocotyl (*koboula*) Consumed in Burkina Faso

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Abstract The Palmyra palm *Borassus aethiopum* Mart. is one of the most important palm resources in West Africa. In Burkina Faso, it occurs in the Eastern and Central-eastern regions and naturally widespread in several localities. Among its multipurpose uses, the exploitation of its seedlings or hypocotyls (*koboula in local yaana language*) is the main activity which provides financial income to indigenes. Hypocotyls are appreciated and consumed either raw or boiled as food by both young and old people in Burkina Faso. The aim of this study was to evaluate the nutritional composition of raw and boiled *koboula* from *B. aethiopum* produced in Eastern and Central-eastern regions of Burkina Faso. A total of 24 *koboula* samples (12 raw and 12 boiled) were analyzed using standard methods. Proximate analysis expressed in g/100g dry matter (DM) basis of flour from hypocotyls showed a high carbohydrate content of 86.75 ± 1.57 (raw) and 87.19 ± 2.20 (boiled), lipids content, 0.23 ± 0.09 (raw) and 0.17 ± 0.07 (boiled) and protein, 9.16 ± 1.29 and 7.97 ± 1.28 for raw and boiled samples respectively. The ash content was 2.53 ± 0.28 (boiled) and 2.88 ± 0.56 (raw). Mineral content (mg/100g DM) showed the presence of Zn, 2.08 ± 1.70 (boiled) and 0.06 ± 0.08 (raw), Fe, 1.41 ± 1.40 (boiled) and 0.05 ± 0.05 mg (raw). The average values of Ca, Mg, Na and NH4 in boiled hypocotyls were respectively 14.16 ± 6.13; 8.42 ± 2.30; 1.45 ± 0.80 and 108.50 ± 19.99. The overall analysis shows that *koboula* has a high energy value (383.67 ± 2.20 kcal/100g for raw samples and 380.64 ± 5.39 kcal/100g for boiled samples). The hypocotyl of *B. aethiopum* could be transformed into different value-added products due to its nutritional characteristics.

Keywords: *Borassus aethiopum Mart., evaluate, nutritional, composition, "koboula"*

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1. Introduction

Malnutrition is a public health problem in developing countries [1]. In recent years, Burkina Faso, like other developing countries of Africa, faces many difficulties in achieving food self-sufficiency. These difficulties are direct consequence of poverty, drought, ravage of fields by locusts, etc. Many programs and initiatives have therefore been undertaken to increase agricultural production in developing countries. These include support for training in new farming techniques, improved seeds, off-season crops, promotion and enhancement of forest food products. It has been reported that 1.6 billion people depend on forest resources for livelihoods and that 1.2 billion people, living in developing countries, use trees for food or income [2]. The development of non-timber forest products (NTFPs) is therefore an important resource for achieving food security and reducing poverty. Non-timber forest products are defined as all the resources and products (other than timber and industry and their derivatives) that are extracted from forest ecosystems and that are used for domestic or marketing purposes or are 'social, cultural or religious significance' [2]. They are involved in food, pharmacopoeia and as raw material in the manufacture of cosmetics, food, or pharmaceuticals. Among the diversity of NTFPs, plant products are most exploited through leaves, fruits, bark, flowers, seeds, shoots, etc [3].

The Palmyra palm *Borassus aethiopum* Mart. belonging to the *Arecaceae* family, is a multipurpose palm species and has great socio-economic importance to local population [3]. In Burkina Faso, it provides a great diversity of NTFPs and timber products. It is referred to as tree of life with nearly 800 uses including food, beverage, fibre, medicinal, crafts, pharmacopoeia, fodder, energy, soil fertilization, construction, agroforestry, etc [4,5,6]. The Palmyra *B. aethiopum* was described first in India in 1753 and only much later in Africa, botanists believed that it originated from Africa [7,8]. Its dispersal is motivated by elephants, which are so fond of the fruit. The introduction of the current existing grooves of *B. aethiopum* in most of the West African states is due to the migration of elephants as well the slave traders [9]. In terms of ecological requirements, it grows very well in the transitional and savanna areas of the semi-arid and sub-humid tropics in West Africa [8,9,10]. It provides both food and non-food values to the local communities. Its fruits, endosperms and hypocotyls are edible. Studies performed by several authors have shown that the consumption and marketing of hypocotyls are very common in many West African countries such as Benin, Ghana, Nigeria, Ivory Coast, Niger, Cameroun and Burkina Faso [6,8,11-18]. The hypocotyls of *B. aethiopum* are very rich in available carbohydrates (81.00±0.23 g/100g dry weight), crude lipid (0.010±0.00 g/100 g dry weight) and crude protein (6.90±0.14 g/100 g dry weight) [19]. In Benin, it is processed into flour, couscous, biscuits, etc. [20]. Hypocotyl is the root obtained from ripe fruit after 6 or 7 months germination. They possess aphrodisiac properties which have been highlighted in some studies [14,18,21]. Hypocotyls are eaten raw, scratched or boiled and are generally known to improve libido in women and has aphrodisiac properties in men and serves as a source of income for Burkina Faso farmers [6,13,14,17].

In Burkina Faso, the Palmyra *B. aethiopum* occur in the Eastern provinces of Boulgou, Ganzourgou, Gourma, Kompienga, Koulpélogo, Kouritenga and Tapoa [22]. All parts of the Palmyra *B. aethiopum* Mart. are exploited by rural populations but the main forms of farming are the pulling out of seedlings, the collection of ripe fruits to produce seedlings or hypocotyls called *koboula* (in the local *yaana* language) for consumption or sale and the cutting of the wood (stem) and leaves for the construction of houses, sheds, fences, etc. [6]. In the Eastern and Central-eastern regions of Burkina Faso, the main uses of the Palm are mainly for stems, fruits, leaves and seedlings. The exploitation of hypocotyls or young seedlings from ripe fruits remains the most widespread and is practiced especially by women and children [6]. Hypocotyl is highly prized and consumed raw or boiled by all age groups of the population. It can be dried and processed into flour to make porridge, dough or couscous. This mode of adding value to the Hypocotyl is relatively unknown and practiced by rural population in Burkina Faso [6].

In Burkina Faso, studies exist on the socio-economic importance of the hypocotyls from *B. aethiopum* Mart. but there is none on its physico-chemical and nutitional parameters despite the importance of *koboula* consumption among the rural population in Burkina Faso. It was in this context that this study was undertaken to determine the biochemical composition and physical parameters of the hypocotyls produced in Eastern and Central-eastern regions of Burkina Faso for sustainable food and nutrition security in Burkina Faso.

2. Materials and Methods

2.1. Sampling

A total of 24 hypocotyls samples including 12 raw and 12 boiled were collected. The raw hypocotyls were taken directly from the producers in the village of Wango (Central East region, 11° 13' 0' ' North, 0° 22' 59" East) and Kaboanga 2 (East region, 11° 17' 57" North, 0° 37' 18" East) and those boiled at the vendors' shops located at the crossroads of Kaboanga 1 (East region, 11° 16' 57'' North, 0° 37' 18" East) and Koupèla toll station (Central East region, 12° 10' 44' ' North, 0° 21' 15" East). Samples collected in sterile and labeled plastic bags were transferred to the laboratory where they were stored at -20°C before the analysis. The image of the Palmyra *B. aethiopum* Mart., its ripe fruit and the hypocotyl stemming from the germination of the ripe fruit are presented in Figure 1 below.

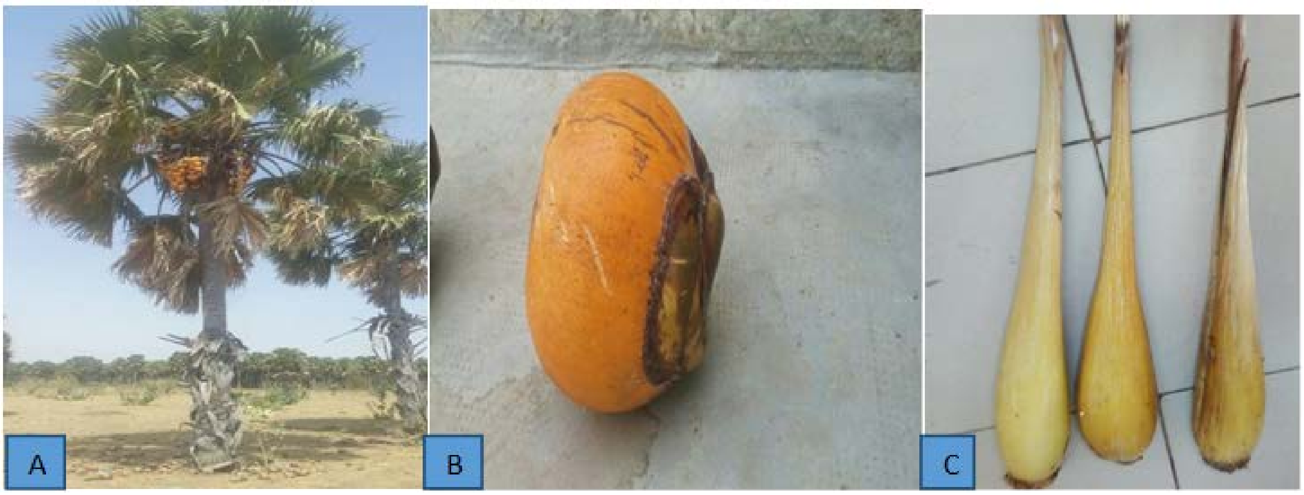

Figure 1. Palmyra palm *B. aethiopum* Mart (A), ripe fruit (B) and boiled hypocotyl (*Koboula*) obtained from germinating ripe fruit (C)

2.2. Preparation of Samples and Process for Obtaining Hypocotyl Flour

The samples were removed from their envelopes, weighed using an electronic scale (GIBERTINI, Europe). They were then dried at 105°C in an oven (MEMMER) where they were held until completely dried for 24 hours. After cooling, samples were weighed again and the moisture content of fresh samples determined. The dried samples were then milled using a mill IKA M20 blender (25000 rpm) into flour (1 µm particle size). Hyocotyls flours thus obtained were stored in Polyethylene bags at room temperature (25-30°C) and were used for the physico-chemical evaluation of the products.

2.3. Determination of Proximate Composition

The moisture content was estimated by gravity method using 5 g of flours which have been placed in the oven at 105°C for 3 hours [23]. The ash content was estimated by complete incineration 5g of flour in the oven at 600°C during 12 hours [24]. The total protein content was determined according to Kjeldahl's method usind 1g of flour [23]. The crude protein content was calculated by multiplying the percentage of total nitrogen by the conversion factor 6.25. The lipid content was determined according to the Soxhlet method using hexane as a solvent [23]. A test of 5g of flour from each sample was put into a Soxhlet extraction cartridge. The assembly was placed in the extractor (VELP Scientifica SER 148). Hexane was used as a solvent in a 90 min cycle: immersion (30 minutes), washing (30 minutes), recovered at 130 ° C for 30 minutes. At the end of the extraction, the glasses containing the fat were removed and placed in a rack at 105 ° C for 15 minutes. The carbohydrate content has been determined by the differential method [25]. According to the principle of this method, the sample consists essentially of water, minerals, proteins, fats, and carbohydrates. The content of carbohydrates is determined by reduction according to the following formula:

$$\% \, carbohydrates = 100 - \left(\% water + \% \, ash + \% \, proteins + \% lipids\right).$$

The theoretical energetic value of the hypocotyls flours was calculated using the Merrill and Watt coefficients as described by [26]. The calorific value per 100 g of the dried sample was obtained as follows:

$$CV \, \left(kcal \;\; / \;\; 100 \; g \;\; DM\right) = \mathbf{4} \times \% Proteins \;\; + 9 \times \% Lipids + \mathbf{4} \times \% \mathbf{C}arbohydrates.$$

The pH of hypocotyls flours was determined by the AOCS method [24]. The flour (1g) was introduced into 9 ml of distilled water and the pH measured using a digital pH meter (WTW pH 330) after stirring.

2.4. Determination of Mineral Content

The determination of iron and zinc was carried out by flame atomic absorption spectrometry according to the method described in standard NF EN 14082 [27]. A quantity of 0.2g of flour from the sample was introduced into 5 ml of concentrated sulfuric acid and then passed into a mineralizer for 2 h 30 min. After cooling, the contents are supplemented with 15 ml of distilled water and filtered using a filter paper. The concentrations (atomic absorption) of the samples were read at wavelengths of 213.9 nm for Zinc and 248.7 nm for Iron, from the calibration curve made from the standards. Calcium, Magnesium, Potassium, Sodium and Ammonium were determined by High Performance Ionic Chromatography (HPIC). Minerals content was analysed by diluting 1g of flour in 12mL of distilled water and then homogenize. A quantity of 10 µL of filtered samples of hypocotyls flour was injected in HPIC system (Dionex ICS-3000) equipped with column Ion Pac CS16 (3mm x250 mm) preceded by a guard column Ion Pac CG16 (3mm x50mm) provided with a suppressor (CERS - 40mA) upstream of the conductimetric detector. The running was carried out in isocratic mode using Methan Sulfonic Acid 30 mM as mobile phase at a flow rate of 0.36 mL/min at 40°C. The external calibration was done with standards in order to quantify the different ions in hypocotyls samples.

2.5. Statistical Analysis

The data were analyzed with SPSS 21.0 software. The T-test was used to compare the different averages of the physico-chemical parameters of the different samples from raw and boiled hypocotyls flours. The difference between means is statistically significant if $P < 0.05$.

3. Results and Discussion

3.1. Moisture Content of Hypocotyl (*Koboula*) Samples

Table 1 and Table 2 show the fresh weight of the *koboula* samples, the moisture content of the raw and boiled *koboula* of the whole sample and the flour of these same samples. The fresh weight of raw *koboula* ranged between 55.88 and 102.01 g with an average of 75.48 ± 18.52g. The boiled samples weighed between 61.40 and 101.39g with an average of 78.51 ± 9.55g. After total evaporation of the water, moisture content between 51.44% and 70.25% with an average of 60.42 ± 5.67% for the boiled samples and 60.35 ± 4.16% for the raw sample were obtained. There was no significant difference between raw and boiled samples in terms of moisture content ($p=0.936$). For flour, moisture content values between 0.13 and 5.61%, with an average of 2.16 ± 1.36% for boiled samples and 0.98 ± 0.34% for raw samples were obtained. A significant difference exists between these two types of flour with respect to moisture ($p= 0.008$). The fresh weight of hypocotyls samples from *B. aethiopum* were lower than those obtained in Benin by [20] which ranged from 127.8 to 138 g, but are similar to those reported by [11] in Cameroon which averaged 90.44 ± 10.33g. The water content of the fresh samples was very high. It was greater than that obtained by [19] which was 56.33% by weight and lower than that reported by [11] (92.53 ± 0.89%). The high water content of the fresh samples explained their difficult conservation and storage challenges. Higher moisture content is associated with an increase in microbial activity during storage [28].

Table 1. Selected Physical evaluation of raw Hypocotyls and flours

Raw hypocotyls	Fresh weight (g)	Moisture content of fresh samples (%)	Moisture content of flour (%)
KC1	59.75	55.21	1.59
KC2	58.95	55.45	1.26
KC3	55.88	63.29	1.42
KC4	109.65	57.14	0.90
KC5	57.17	60.39	1.13
KC6	79.43	63.49	0.70
KC7	60.12	54.19	0.75
KC8	70.31	63.05	0.49
KC9	82.09	61.55	0.92
KC10	93.83	61.82	0.69
KC11	76.57	68.26	0.69
KC12	102.01	60.32	1.19
Means	75.48 ±18.52	60.35 ± 4.16	0.98 ± 0.34

Table 2. Selected Physical evaluation of boiled hypocotyls and flour

Boiled hypocotyls	Fresh weight (g)	Moisture content of fresh samples (%)	Moisture content of flour (%)
KB1	75.87	52.56	1.70
KB2	72.12	64.75	1.35
KB3	76.75	59.31	2.89
KB4	88.71	51.44	5.61
KB5	73.27	63.99	2.07
KB6	61.40	61.61	2.60
KB7	76.74	54.39	2.83
KB8	79.54	64.73	1.29
KB9	78.88	56.75	1.57
KB10	79.43	63.72	2.62
KB11	78.06	61.61	1.24
KB12	101.39	70.25	0.13
Means	78.51 ±9.55	60.42 ± 5.67	2.16 ± 1.36

3.2. Total Ash Content

The results of ash content are presented in Table 3 and Table 4. The ash levels is between 2.20 and 4.41% DM with an average of 2.53 ± 0.28% for the flours of the boiled samples and 2.88 ± 0.56 for the raw samples. There is no significant difference between these two types of flour with respect to ash content ($p>0.05$). The ash contents obtained in this study are higher than those of [19] (1.17%) and [12] which was 1.18% and that of [16] which was 0.8 g/100g. On the other hand, they are similar to those reported by Ahmed et al. (2010) (2.68 ± 0.04 g/100g). This difference could be explained by a difference in soil composition and the different climatic conditions in the hypocotyls production zone.

Table 3. Proximate composition of raw hypocotyls from *B. aethiopum* Mart. (g /100g DM)

Raw Hypocotyls	Ash	Proteins	Lipids	Sugars	Calorific value (kcal/100g)
KC1	2.37	12.86	0.40	82.78	382.62
KC2	2.60	8.59	0.33	87.22	383.28
KC3	3.08	9.54	0.20	85.76	381.23
KC4	2.80	8.26	0.16	87.88	384.59
KC5	2.91	8.77	0.10	87.09	383.46
KC6	2.57	7.61	0.20	88.92	386.15
KC7	2.45	8.36	0.30	88.14	386.04
KC8	2.97	9.21	0.17	87.16	385.51
KC9	2.64	9.32	0.13	86.99	385.26
KC10	4.41	9.12	0.27	85.52	378.57
KC11	3.34	9.41	0.27	86.30	382.85
KC12	2.47	8.90	0.23	87.21	384.47
Means	2.88 ± 0.56	9.16 ± 1.29	0.23 ± 0.09	86.75 ± 1.57	383.67 ± 2.20

Table 4. Proximate composition of boiled hypocotyls from *B. aethiopum* Mart. (g /100g DM)

Boiled Hypocotyls	Ash	Proteins	Lipids	Sugars	Calorific value (kcal/100g)
KB1	2.47	6.45	0.12	89.26	382.86
KB2	3.04	6.81	0.10	88.70	382.06
KB3	3.07	9.07	0.16	84.98	376.19
KB4	2.20	10.07	0.13	81.99	368.24
KB5	2.45	8.23	0.03	87.22	381.81
KB6	2.63	9.10	0.13	85.54	378.58
KB7	2.54	6.36	0.27	88.01	377.50
KB8	2.29	7.04	0.24	89.14	384.75
KB9	2.39	6.94	0.17	88.94	383.52
KB10	2.60	8.63	0.27	85.89	378.10
KB11	2.39	7.47	0.20	88.70	384.70
KB12	2.28	9.44	0.27	87.89	389.33
Means	2.53 ± 0.28	7.97 ± 1.28	0.17 ± 0.07	87.19 ± 2.20	380.64 ± 5.39

3.3. Protein Content

The protein content for the boiled samples was between 6.45% and 10.07% with an average of 7.97 ± 1.28% for the boiled samples and between 8.26% and 12.86% with an average of 9.16 ± 1.29% for the raw samples (Table 3 and Table 4). It was observed that the protein content of the raw hypocotyls flours was higher than that of the boiled hypocotyls. This could be explained by the denaturation of proteins during cooking. The protein content obtained in this study were higher than those reported by [16] concerning fermented and unfermented flour respectively (3.06 ± 0.09 and 2.71 ± 0.09 g / 100 g) and [12] 4.90% and were close to those of [19] (6.90%). The differences can be explained by the nature of the soil and the climatic conditions of the countries where the Palmyra *B. aethiopum* grows. According to [29], plant foods that provide more than 12% protein are considered a good source of proteins. The hypocotyls of *B. aethiopum* studied are then a potential source of protein if they are consumed in adequate quantities.

3.4. Lipid Content

The lipid content of the flours from the raw and boiled samples were very low. These contents are between 0.03% and 0.40% g/100g DM with an average of 0.17 ± 0.07% for the boiled samples. The raw samples have a minimum content of 0.10% and a maximum content of 0.40% with an average of 0.23 ± 0.09% (Table 3 and Table 4). The contents of our lipids samples are higher than those obtained by [19] which was (0.01%), and lower than those reported by [12], [16] and [11] which were respectively 1.49% g/100 g; 1.11 ± 0.02% g/100 g and 10.73 ± 0.00% g/100 g. The low fat content makes *B. aethiopum* shoots an ideal food for weight control, reducing the risk of overweight. It also allows a better storage stability while avoiding rancidity.

3.5. Carbohydrate Content and Calorific Value

The results of the carbohydrate content and the energy value of the *koboula* samples analyzed are presented in Table 3 and Table 4. Our samples are very rich in carbohydrates. The Boiled *kobula* flour has a minimum content of 81.99% and a maximum of 89.26% with an average of 87.19 ± 2.20% and raw *koboula* flours have a minimum value of 82.78%, a maximum of 88.92% with an average of 86.75 ± 1.57%. The calorific value of *B. aethiopum* hypocotyls flours ranged from 368.24 to 389.23 kcal/100g with an average of 380.64 ± 5.39 kcal/100g for boiled samples and 383.67 ± 2.20 kcal/100g for raw samples. These results show that carbohydrates are the major macronutrients in the young shoots (Hypocotyls) of *B. aethiopum* Mart. The carbohydrate levels obtained in this study are higher than those obtained in Benin by [20] with a value of 43.5% g/100g and in Nigeria by [19] (81% g/100g), [12] which was 83% and in Cameroon by [11] (39.98 ± 0.20% g/100g). Our results are close to those obtained in Côte d'Ivoire by Mahan et al. (2016) which averaged 83.79 ± .10 g/100g. The main function of carbohydrates is the supply of energy. For populations, *koboula* is comparable to most starchy foods, namely yam, cassava and potato, with little protein and fat [30], whose carbohydrate more than 80% of the calorific value. The energy value of *koboula* is higher than that obtained by [19] (351.69 ± 0.34 kcal/100g) and [12] (365.71 kcal/100g) in Nigeria. In Côte d'Ivoire [16] also reported lower values than ours that ranged between 315.03 ± .10 and 315.41 ± .10 kcal/100 g. The differences can be explained by the fact that our samples have higher carbohydrate contents than those obtained by these authors, the high calorific value being linked to the high carbohydrate content. The energy value of our samples is in the recommended daily intake range of 300 kcal/100g energy per 65 kg body weight of an adult [31]. Hypocotyls, consumed in adequate quantities, could be a good source of energy.

3.6. pH of Hypocotyls Flours

Figure 2 and Figure 3 show the pH of *koboula* flour samples analyzed. These values are between 4.06 and 5.02 with an average of 4.66 ± 0.31 for the boiled samples. The raw samples have values between 3.83 and 4.60 with an average of 4.12 ± 0.27. A significant difference exists between the two types of samples with respect to pH ($p<0.001$). Raw samples are more acidic than boiled samples. The increase in pH could be explained by a probable addition of potash by the vendors during cooking. The vast majority of these values are in compliance with the Ivorian standard [32] which recommends that products derived from tubers should have pH values between 4 and 5.

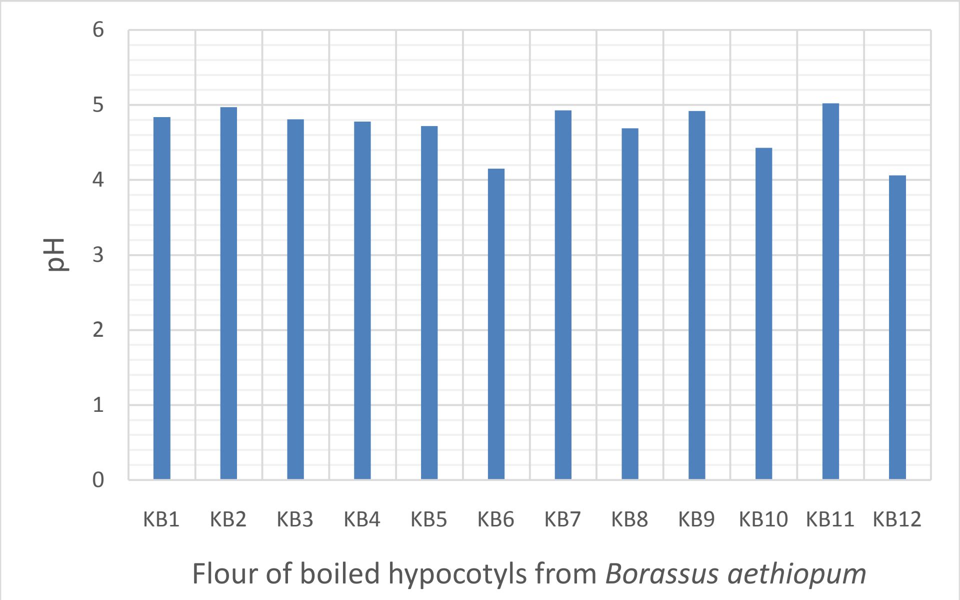

Figure 2. pH of boiled hypocotyls flours of the palmyra *Borassus aethiopum* Mart

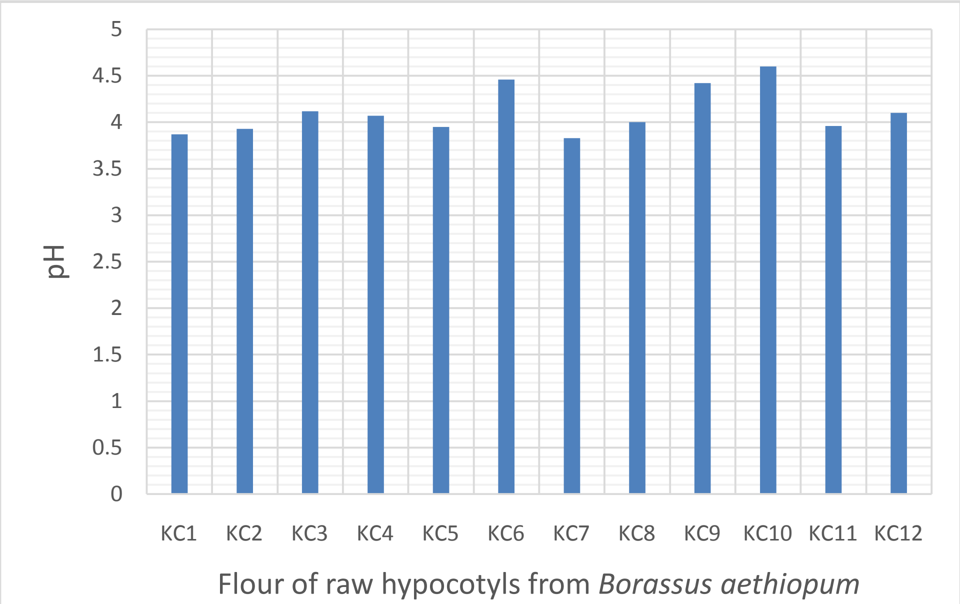

Figure 3. pH of raw hypocotyls flours of the palmyra *Borassus aethiopum* Mart

3.7. Mineral Content

The results of the minerals analysis of raw and boiled *Koboula* flour are presented in Table 5 and Table 6 respectively. The iron content of the boiled hypocotyls samples was between 0.30 mg/100g and 4.40 mg/100g DM with an average of 1.42 ± 1.40 mg/100g. The Zinc content of the boiled samples was between 0.25 mg/100g and 5.22 mg/100g with an average of 2.08 ± 1.70 mg/100g. The average values of Ca, Mg, Na and NH4 in boiled hypocotyls were respectively 14.16 ± 6.13; 8.42 ± 2.30; 1.45 ± 0.80 and 108.50 ± 19.99. For raw samples the iron and zinc content were between 0.001 mg / 100g and 0.12 mg / 100g in the iron contents. Most of the raw sample flours had values below 0.01 mg / 100g (detection limit value of the device used for the analysis). Raw hypocotyls flour contained, Ca (19.32 ± 7.61 mg/100g DM), Mg (9.11 ± 2.34), Na (0.80 ± 0.42) and NH4 (49.31 ± 31.18). Potassium was not detected in the boiled and raw hypocotyls from *B. aethiopum* Mart. The difference was significant between the boiled and raw samples for Fe and Zinc content ($p < 0.05$). There is a large divergence between raw and boiled samples in the composition of Ca, Mg, Na and NH4 ($p<0.05$). These differences could be explained by the difference of soil composition where hypocotyls are produced. Daily iron intake is recommended at 18 mg/day for adults [33]. The recommended nutritional intake of Zinc has been set at 12 mg/day adults [34]. Iron is used in the body for the transport of oxygen to the tissues and the formation of melanin [35]. It is also an important part of the diet of pregnant women, nursing mothers, infants, convulsive patients and the elderly to prevent anemia and other related diseases. However, excessive consumption may lead to liver failure [35]. Zinc is known to play an important role in gene expression, regulation of cell growth, and participates as an enzyme cofactor [36].

Table 5. Mineral composition of raw hypocotyls from *B. aethiopum* Mart. (mg /100g DM)

Raw Hypocotyls	Zn	Fe	Ca	Mg	K	Na	NH4
KC1	nd	0.01	20.18	10.39	nd	0.35	88.60
KC2	nd	0.05	24.93	8.44	nd	0.39	13.49
KC3	0.12	0.11	30.90	7.12	nd	0.20	34.75
KC4	nd	nd	26.32	11.13	nd	2.54	13.52
KC5	nd	nd	8.89	8.78	nd	0.43	26.32
KC6	nd	nd	19.02	15.23	nd	2.51	44.34
KC7	nd	nd	21.42	6.62	nd	0.78	59.91
KC8	nd	nd	25.33	7.52	nd	0.07	13.16
KC9	nd	nd	10.34	8.35	nd	1.13	75.70
KC10	nd	nd	9.82	9.60	nd	0.55	76.86
KC11	nd	nd	10.52	8.70	nd	0.39	107.74
KC12	nd	nd	24.18	7.45	nd	0.28	44.53
Means	nd	nd	19.32± 7.61	9.11± 2.34	nd	0.80± 0.42	49.91± 31.18

nd=not detected

Table 6. Mineral composition of boiled hypocotyls from *B. aethiopum* Mart. (mg /100g DM)

Boiled Hypocotyls	Zn	Fe	Ca	Mg	K	Na	NH4
KB1	4.4	4.4	11.00	9.71	nd	0.62	148.04
KB2	1.26	1.14	21.48	6.09	nd	2.12	96.44
KB3	0.83	0.3	23.32	9.35	nd	1.23	90.13
KB4	0.64	0.61	12.45	10.75	nd	1.14	134.56
KB5	0.25	0.81	15.31	14.03	nd	1.02	97.65
KB6	0.68	0.36	25.96	7.9	nd	1.23	90.51
KB7	0.88	0.36	9.86	7.41	nd	0.46	89.41
KB8	5.22	2.17	11.03	8.76	nd	1.22	116.82
KB9	3.71	3.87	13.36	6.45	nd	2.23	115.26
KB10	3.2	1.86	7.74	6.96	nd	1.29	97.86
KB11	2.92	0.81	8.05	6.26	nd	3.45	95.32
KB12	0.99	0.33	10.37	7.36	nd	1.38	130.03
Means	2.08± 1.68	1.42± 1,3	14.16± 6.13	8.42± 2.30	nd	1.45± 0.80	108.50± 19.99

nd=not detected.

The results obtained in this study indicated that *koboula* contains more Zinc than Iron. The Iron and Zinc content were lower than those reported by [19] which was 12.74 mg for Zinc and 11.51 mg/100g for Iron. A low iron and zinc content of *B. aethiopum* hypocotyl flour of 0.51 ± 00 mg/100g and 0.50 ± 0.02 mg/100g have also been documented by [11]. The content of Ca, Na, K, Mg, NH4 obtained in this study was lower than those reported by [11] in Cameroon (calcium (119.48 ± 0.45 mg/100 g of DM), sodium (784.4 ± 18.16 mg/100 g of DM) and [19] in Nigeria (Mg 640mg, Ca 433.3mg, K 236.7mg/100g DM). The mineral composition of the soil and the climatic conditions could explain this difference. It could also be explained by the presence of antinutritional factors such as phytate that can bind to 44 essential dietary minerals such as zinc, calcium and iron to reduce the bioavailability of these minerals [11,37].

4. Conclusion

This study evaluated the physicochemical composition of the hypocotyls (*koboula*) of the Palmyra *B. aethiopum* Mart. products in Eastern and Central-eastern of Burkina Faso. *Koboula* is richer in carbohydrate than protein and has a very low lipid content. The mineral content especially in terms of zinc and iron were also low. However, consuming an adequate amount of hypocotyls could provide the daily requirement for carbohydrates, protein and zinc. The results obtained show a high water content in the fresh hypocotyls which does not promote storage in the fresh form. Hypocotyls could be used for the manufacture of different products such as flour, couscous, biscuits, gari, chips, meal, etc. to promote value addition in different forms similar to its existing forms of utilization in different value added forms in Benin.

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Statement of Competing Interests

The authors have no competing interests.

References

[1] Bobby, J., Aaron, R. and Poonam-Vimal, D.R. (2002). Prevalence of malnutrition in Rural Kamata, South India. A comparison of Anthropometric Indicator. *Journal of health and nutrition Community foresty*; 3: 239-244.

[2] FAO (2001). Evaluation of the importance of wood forest products in Senegal, FAO, Regional Office for Africa, Accra, Ghana, 2nd edition Safety.

[3] Anonyme and Peltier, R. (1993). The palmyra *Borassus aethiopum* Mart. (Palmae). *The Flamboyan*; 27: 29-30.

[4] Arulraj, S. and Augustine, B.J. (2008). Underutilized palms. In: Peter KV (ed) Underutilized and underexploited horticultural crops, Vol. 3. New India Publishing Agency, New Delhi, pp 415-429.

[5] Yaméogo, J., Bélem-Ouédraogo, M., Bayala, J., Ouédraogo, MB. And Guinko, S. (2008). Uses and commercialization of *Borassus akeassii* Bayton, Ouédraogo, Guinko non-wood timber products in South-Western Burkina Faso. *West Africa. Biotechnologie, agronomie, sociétéet environnement*; 12(1): 47-55.

[6] Zongo, O., Tapsoba, F., Cisse, H., Traore, Y. and Savadogo, A. (2018). Modes of use of the palm *Borassus aethiopum* Mart. by the rural populations of Eastern and Central-Eastern regions from Burkina Faso. *Int.J.Curr.Microbiol.App.Sci*.; 7(12): 62-74.

[7] ICRAF (1988). A tree species reference and selection guide. ICRAF, Agroforestry Data base, Nairobi, Kenya.

[8] Jatau, D.F. (2008). Profitability assessment of *Borassus aethiopum* (Mart) marketing in Adamawa State, Nigeria. *J. Agri. Soc. Sci*.; 4: 159-64.

[9] FAO (1988). Traditional food plants-policy and nutrition paper 4, vol. 42. ICRAF Agroforestry Data base.

[10] ICRAF (1992). A selection of useful trees and shrub for Kenya: Notes on their identification, propagation and management for use by farming pastoral communities. ICRAF, Kenya.

[11] Ahmed, A., Fadimatou, B., Tchiegang, C., Saidou, C. and Adji, M.B. (2010). Physico-chemical and functional properties of bâtchi or hypocotyle axes of *Borassus aethiopum* Mart. *African Journal of Food Science*, 4(10): 635-641.

[12] Akinniyi, J.A. and Waziri, M. (2011). Proximate value and Mineral content of the shoots of *Borassus aethiopum* Mart (Giginya). *Journal of Chemical Society of Nigeria*; 36: 100-103.

[13] Balami, A.A., Dauda, S.M., Lawal, A. and Ahmad, D. (2016). Some engineering properties of Palmyra palm tree (*Borassus aethiopum*) germinating shoot. *Agric Eng Int: CIGR Journal*; 18: 58-69.

[14] Gbesso, F., Adjatin, A., Dansi, A.A. and Akoegninou, A. (2016). Aphrodisiac properties of hypocotyls extracts of *Borassus aethiopum* Mart. (*Arecaceae*) collected in Central of Benin Republic. *International Journal of Current Microbiology and Applied Sciences*; 5(3): 802-814.

[15] Guimbo, ID., Barrage, M. and Douma, S. (2012). Preliminary studies on the food use of wild plants in the peripheral areas of Niger's W Park. *Int. J. Biol. Chem. Sci*.; 6(6): 4007-4017.

[16] Mahan, M.R., Konan, N'G.Y., Sidibe, D., Coulibaly, A., Ezoua, P., Chatigre, K.O. and Biego, G.H.M. (2016). Nutritive compounds from leaves of *Moringa oleifera* L. and beans of *Vigna unguiculata* W. for improvement of the meal deriving with new shoots of *Borassus aethiopum* M. in Côte d'Ivoire. *International Journal of Environmental and Agriculture Research*; 2:1-11.

[17] Ohin, B.M., Adeoti, K., Noumavo, P.A., Kouhounde, S.H.S., Garba, K., Tovide, N.S., Ogoua, S., Baba-Moussa, L., Toukourou, F. and Baba-Moussa, F. (2018). Technological processes itinerary and socio-economic impact assessment of*Borassus aethiopum* hypocotyles "agonté" produced in centre of Benin Republic. *Food and Public Health*; 8(2): 35-41.

[18] Siaw, D.E.K.A., Asamoah, E.F. and Baidoe, G.A. (2014). The stock and socio-economic uses of Borassus aethiopum in Abrimasu Forest Reserve of Mampong Forest District. *JENRM*; 1(3): 148-155.

[19] Kabiru, J.U., Bello, M.A., Badaru, M., Sirajo, M., Lawal, G.H. and Nasiru, A.S. (2015). Nutritional and antinutritional profile of *Borassus aethiopum* Mart. (African Palmyra Palm) shoots. *International Journal of Sciences Basic and Applied Research*; 24(3): 39-49.

[20] Akouekou, C.S. and Azokpota, P. (2015). Valorization of the palmyra palm hypocotyl (*Borassus aethiopum* Mart.) in the communes of Savé and Glazoué in Benin, Bibliothèque Nationale du Bénin 4th quarter, 9-14.

[21] Akinniyi, J.A., Waziri, M. and Usman, H.S. (2010). "Assessment of the anabolic effect of androgens of the edible portion of the shoot of giginya plant (*Borassus aethiopum* Mart.)." *Journal of Scientific Research*; 2(2): 362-368.

[22] Bayton, R.P. and Ouédraogo, A. 2009. Discovering Africa's newest palm (*Borassus akeassii*). *PALMS*; 53(1): 37-45.

[23] AOAC (1999). Official method 925, 10. Official Methods of Analysis. Association of official Analytical Chemist International, Gaithersburg, MD, Washington, DC, USA.

[24] AOAC (1990). Official methods of analysis. Association of Official Analytical Chemists Ed., Washington DC, USA, 684 p.

[25] Al hooti, J.S., Sidhu, S.S. and Qabazard, H. (1998). Chemical composition of seeds date fruit cultivars of united Arab Emirates. *Food sciences and technology*; 35: 44-46.

[26] FAO (1970). Food composition table for use in Africa. Italy, Rome, FAO, Doc. Nutr. 3: p218.

[27] AFNOR (2003b). Food products - Determination of trace elements - Determination of lead, cadmium, zinc, copper, iron and chromium by atomic absorption spectrometry (ASA) after dry calcination. Afnor Saint Denis (FRA).

[28] Hassan, L.G. and Umar, K.J. (2004). Proximate and mineral composition of seeds and pulp of African locust bean (Parkia biglobosa L.). *Nigerian Journal of Basic and Applied Sciences*; 13: 15-27.

[29] Watt, B.K. and Merrill, A.L. (1963). Composition of foods. Agricultural Handbook No. 8. Washington, DC: U. S. Department of Agriculture, of palmyrah (*Borassus aethiopum* Mart.). *Journal asiatique des sciences et de la technologie*; 4: 36-47.

[30] Akingbala, J.O., Oguntimein, G.B. and Sobande, A.O. (1995). Physicochemical properties and acceptability of yam flour substituted with soy flour. *Plant Food for Human nutrition*; 48: 73-80.

[31] Muller, H.G. (1988). An Introduction to Tropical Food Science. Cambridge University Press, p59-118.

[32] CODINORM (2006). Root and Tuber-specs. NI4511, Ivory Coast.

[33] FDA (2001). Food and drug administration. US Government Laws, Regulations, and Guidelines Catalog. Code of Federal Regulations.

[34] Muhammad, S., Umar, K.J., Sani, N.A. and Muhammad, S. (2015). Evaluation of nutritional and anti-nutrional profiles of gingerbread plum (*Neocarya Macrophylla*) seed kernel from Sokoto State, Nigeria. *International Journal of Science and Technology*; 4: 361-367.

[35] House, W.A. (1999). Trace Element Bioavailability as exemplified by Iron and Zinc. *Field Crops Research*; 60: 115-141.

[36] Camara, F. and Amaro, C.A. (2003). Nutritional aspects of Zinc availability. *International Journal of Food Sciences and Nutrition*; 54: 143-152.

[37] Fergusin, E.L., Gibson, R.A., Opara, O., Stephen, A.M. and Thomson, L.U. (1993).The zinc, calcium, copper, magnesium, non-starchpolysaccharide and phytate content of seventy eight locally grown and prepared African foods. *Journal of Food Analysis;* 6: 337-342.