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Analysis of the Fresh Pulps of *Borassus aethiopum* Fruits of Gulu District, Uganda

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Abstract *Borassus aethiopum Mart*-locally known as *Tugu* by a tribe called Acholi in Uganda is an edible wild fruit tree species greatly valued for its multipurpose uses, fruits inclusive. This tree species is being wantonly destroyed, yet there is no adequate documentation on them. This study determined the nutrient contents in the pulps of its fresh fruits both on fresh matter (FM) and dry matter (FM) basis. The contents were determined using standard procedures prescribed for each nutrient. The potassium, sodium, and calcium contents on FM basis were respectively 42.6mg/100g, 12mg/100g) and 33.6mg/100g. The contents of zinc, iron and magnesium on FM basis were low with all values below 1.00mg/100g. No phytates were detected in these pulps on both FM and DM basis. The study revealed appreciable contents of nutrients in the fresh pulps, making it useful source for supplementing nutrient deficiencies within the community. Further studies are thus recommended to determine the availability of these nutrients in the body when consumed.

Keywords: *Borassus, proximate contents, macro and micro nutrients Compositions*

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1. Background

Borassus aethiopum-Mart belongs to family Aracaceae (Palmae) and also known as African fan palm. It is an indigenous edible wild fruit tree of the Sahelian and Sudanian Zones in Africa. They are among the wild fruit tree species of notable importance. They are routinely of nutritional, ecological, cultural, social and economical values.

B. aethiopum provides both food and non-food values to the local communities. They provide products and services in forms of shelters, food supply, and those which protect the environment. There are also products which are sold to improve the economic status of many members of the local community [16] hence sustain many households [19]. Its fruits, endosperms, and hypocotyls are edible. Its fruits form important part of the daily diets of many children. Many such fruits are recognized as sources of essential minerals and nutrients [9]. An infusion of its roots is used to treat miscellaneous diseases such as stomach ache, throat infections, bronchitis and syphilis [31].

Although many handy edible wild fruits were identified in Gulu [37], they are remarkably of limited domestication. Notably, such fruits are left unattended to in the wild and considered as risky to eat even when many children are malnourish due to nutrient deficiencies. Several factors were identified as influential to the consumptions of the edible wild fruits [38]. For example, the fruits of *B. aethiopum* were notably difficult to eat owing to the process involved in preparing it for consumption [38]. The process involves rigorous pounding of the fruits on a hard surface until it softens, then peeling the hard epicarp before chewing the fibrous mesocarps.

Generally the reduction in the consumption of the edible wild fruits by the community of Gulu district was escalated by the over 20 years of civil war between the Lord Resistance Army (LRA) and the Government of Uganda between 1986 and 2006. During this insurgency, people were displaced in the Internally Displaced Persons (IDPs) camps where they could not access the environment where the edible wild fruit trees grew, these being predominantly in the wild [1]. While in this IDPs camps, there was restriction on the distance to which one could move beyond the designated residence. Consequently, many young people learnt nothing regarding the multipurpose uses of many edible wild fruit trees. Therefore, when the communities returned to their original homeland, they cut down many tree species, *B. aethiopum* inclusive for purposes of economically viable products (Abwola Sam, pers.com.) like timbers and local beehives.

Although some work has been reported on the nutrients compositions of a number of edible wild fruits elsewhere [22], there is scantiness on those for *B. aethiopum* fruits. Even then such information has not been adequately passed to many communities especially those in Gulu district. These could partly account for the reduced support to conservation and the extent to which such fruits are consumed. Remarkably, many of such fruit species

have continued to be mismanaged, unsustainably used, and fruits less consumed.

Heightened by the high prevalence of malnutrition amongst many communities of Uganda [44], and the high rate of destruction of many such edible wild fruit species, there was urgent need to obtain supportive information from edible wild fruits to supplement the already existing conservation efforts. The objective of this study was thus to determine the nutrients compositions of the fresh fruits of *B. aethiopum* in a view to contribute to their conservation and also improve on their consumptions. The fresh fruits were collected directly from the field and analyzed using standard procedures as prescribed for each nutrient in different laboratories in Uganda and Denmark.

2. Materials and Methods

2.1. Materials

The materials used in this study included fresh fruits of *B. aethiopum*, bucket**,** stainless steel knife, polythene bag, a refrigerator, a fine meshed nylon (polyester cloth). Other materials and equipment are embedded in the different procedures used.

2.2. Methods

The fresh *B. aethiopum* fruits used in this study were collected from Acuto Omer village, Awach Sub County, Gulu district and transported in a coolant to the laboratory in the department of food Science Makerere University and refrigerated at -4°C [22]. These fruits were later pounded repeatedly until they softened, and then peeled and scrapped using a stainless steel knife into a small bucket to obtain about 50g composite sample of the fibrous pulps. Analytical portions were obtained by squeezing the composite through a fine meshed nylon/polyester cloth and packed in a polythene bag, labeled and stored in a refrigerator ready for analysis.

The nutrients under investigation included crude fats, crude fiber, moisture contents, ash, carbohydrates, energy, phytates, crude proteins, vitamin C, carotenoids, iron, zinc, copper, sodium, potassium, magnesium and calcium. The samples were analyzed from the laboratories of Food and Nutrition Department, Makerere University, Uganda and the Department of Human Nutrition, Faculty of Life Science, University of Copenhagen, Denmark following standard procedures for each nutrient.

Moisture contents were determined according to the force draft-air oven method [7]; Samples for minerals and proteins were first digested under a Fume hood (Selecta Block Digest µ40, 1SO 9001-2000 CERTIFIED Co.) and then each one analyzed separately. The samples for the crude proteins were analyzed using the Micro-Kjeldahl method No. 960 [7] and its contents obtained by determining the organic nitrogen content of the sample using a factor of nitrogen by a constant multiple 6.25N [6,11]. On the other hand, all mineral contents were determined using Atomic Absorption Spectrophotometer (AAS). The determination of vitamin C contents followed the procedures of [34], and its contents were determined by titration with 2, 6-dichlorophenol-indophenol solution [2]. Samples for Crude fat was analyzed using Swedish made Soxtec system HT-1043 extraction unit following the procedures by AOAC [7]. Total carbohydrates contents were estimated using the method of [23]. The Ash, Crude fibre, and Energy contents were determined respectively by incineration of the samples in a muffle furnace [42]; the procedures outlined by [24] and using a bomb calorimeter [26]. Finally, samples for phytates were analyzed on high-performance liquid chromatography systems [10].

2.3. Data Analysis

Data were analyzed using STATA 12 (Stata Corp LP, College Station, and Texa, USA). Analysis of Variance (ANOVA) was used to determine means and standard deviations (SD). The results were presented in different tables for both nutrients and minerals on dry (DM) and fresh matter (FM) basis respectively.

3. Results

The macro and micro nutrient contents of the pulps on DM basis were higher than those on FM basis (Table 1). Micro nutrients were all below 1.00mg/100g.

The fresh pulps on DM basis showed low dry matter contents (19.0±0.11g/100g) (Table 2). The moisture contents on FM basis is highest followed by that of carbohydrates (8.54±1.1g/100g). The pulps showed high carotenoid but no phytates.

Table 1. Compositions of macro and micro mineral of the pulps on DM and FM basis

Scientific names	***Edible parts***	***mg/100g of minerals***						
		K	Na	Mg	Ca	Fe	Zn	Cu
B. aethiopum	Fresh pulps (DM basis)	142.4±19.1	17.8± 0.7	64.77±0.2	41.81±1.0	3.15±0.27	0.82±0.0	1.3 ±0.0
	Fresh pulps (FM basis)	42.6±5.1	12.0 ±0.2	19.4 ±1.9	33.6±0.8	0.62±0.3	0.66±0.0	0.26±0.0

Table 2. Proximate nutrient compositions of the pulps on DM and FM basis

Scientific name	Edible Parts	*g/100g*						*Kcal/100g*	*mg/100g*		*µg/100g*	
		Dry matter	Crude fiber	Crude fat	Ash	Proteins	Carb.	Energy	Vit. C	Phytate	Carotenoid	Vit. A
B. aethiopum	Fresh Pulps on DM basis	19.70±0.11	4.50±0.6	2.60±0.1	3.3± 0.5	4.24± 0.2	43.5±5.7	367±9.7	89.9±1.2	0	27230±0.7	2269.2
	Fresh pulps on FM basis	80.3±0.1	0.76±0.3	0.51±0.0	0.64± 0.0	0.83±0.1	8.54±1.1	72.15±1.9	17.68±0.2	0	5350 ±0.13	445.8

4. Discussions

Fresh pulps of *B. aethiopum* fruits have substantial nutrient contents although some are much lower. Even so, these quantities are still useful in supplementing nutrient deficient conditions in circumstances of need for supplementation by the communities.

Nutrients are useful substance that provides nourishment for growth and maintenance of life. For example, the need to always replenish potassium in the body especially after hard exercises and profuse sweating have been so much emphasized in literatures. Thus, from our study *B. aethiopum* fruits are a good source of potassium which can be exploited for such replenishments. The quantity of potassium from this study if compared to with that of sodium gives a very low ration and this makes it more relevant in reducing hypertension. Therefore adequate consuming the pulps of this fruit can supplement deficient conditions in the community.

The potassium content of *B. aethiopum* fruit pulps on FM basis when compared with the contents of *Psidium guajava* (Guava), *Artocarpus heterophyllus (Jackt fruits), Carica papaya (Pawpaw), Mangnifera indica* (Mango) and *Ananas comosus (*Pineapple*)* ([28]) is lower. Since most introduced fruits are expensive and hardly affordable by the local communities, the fruits of *B. aethiopum* become one cheaper way of obtaining adequate potassium, These fruits also exist freely in their vicinity. Increasing the consumptions of such edible wild fruits supplements many minerals in the body thereby reducing many risks such as getting fatigued, irritability, and hypertension due to lack of potassium in the body

The Na content in the fresh pulps of *B. aethiopum* as from this study is low therefore an indication of its worthiness in controlling hypertension. This content is favorable for enhancing electrolytes balance in the body and making the ratio of K:Na approparite. Literatures indicate that consuming double the amount of potassium than sodium reduces to halve the risk of dying from cardiovascular diseases. The sodium content from this study on FM is however higher compared to the contents of some introduced fruits, such as *Psidium guajava Artocarpus heterophyllus* and *Carica papaya* [28].

The magnesium contents in the fresh pulps of *B. aethiopum fruits* on FM basis is similar to the values for Kousser (20.6mg/100g) and Ngaoundere (21.01mg/100g) [4]. The same content is lower than the contents in some introduce fruits such as Dodo mango (37.51mg/100g) and Viringe mangoes (43.22mg/100g) [34]. Since magnesium is essential for energy production, protein formation and cellular replication, these fruits become very important to human life.

Our study indicate lower calcium contents in the fresh pulps of *B. aethiopum pulps* on FM basis compared to those reported for the species from Kousseri and Ngaoundere [4]. However, this content is higher than the contents for *Ananas comosus* and *P. guajava* [20]. Calcium being very important for building strong bones, improving nerve impulses and blood clotting and muscle contractions [3], these pulps are therefore a potential source.

The iron content on the other hand from these the fresh pulps of *B. aethiopum* on FM basis is quite low compared to the values reported for the species from Kousseri and Ngaoundere [4,5]. This content is however similar to the content of Apple and Jack fruits [11]. Such similarities indicate that edible wild fruits are as vital as the introduced ones. Though low, the content in these pulps is still adequate in keeping one out of conditions which result from deficiencies of iron in the blood. Adequate fruit consumption will relief from incidences of anemic conditions especially among children and teenagers, one feeling tired, the inability to tolerate a usual amount of activity or exercise, headaches, dizziness, and feeling short of breath.

The quantity of zinc in the fresh pulps of *B. aethiopu*m on FM basis is higher compared to its contents in *Mangnifera indica, P. guajava* and *Carica papaya [25]*. It is however similar to that of banana, mango, guava, lemon, papaya and oranges with all the contents below 1.00mg/100g [28]. This content constitutes 4.3% daily Value (DV) for adults or children aged 4 or older, based on a 2,000 calorie reference diet [38]. Zinc is noted as central in the body for cell division, protein synthesis, and growth [44]. Therefore being an essential element in human nutrition, its presence in such quantity makes the pulps a very useful food supplement.

The quantity of Cu in the fresh pulps of *B. aethiopum* fruits on FM basis is low although it constitutes up to 11.1% DV based on total dietary energy intake of 2000cal per day; for adults and children four or more years of age per day [43]. This content is similar to its amounts in banana, mango, lemon, orange, papaya and pineapples with all their concentrations below 1.00mg/100g [25]. Cu is notably very vital in the body for bone, & connective tissue production, and coding specific enzymes that range in function from eliminating free radicals to produce melanin. Furthermore, Cu reduces problems such as osteoporosis, joint pain, and remarkably important during old age when the ability to absorb copper reduces. Consequently, it is advisable that the aging individuals take a little more of these fruits so as to boost their Cu level.

The moisture content (MC) of the fresh pulps of *B. aethiopum* fruits from our study is high but very similar to those from other studies [4,5]. Such a high value shows how susceptible the fruits can be to infection, and their decreased ability for long storage.] It is noted that that the high water content pre-disposes fruits to a rapid change after harvesting, hence affecting their life span for preservation [4]. This therefore calls for appropriate post handling techniques for the fruits.

The rude fiber contents in *B. aethiopum* pulps from our study is lower [4] on both FM and DM basis, and those for its sister species *B. flabellifer* [8] on DM basis. The low content from our study could be because we used only the finest edible portion of the fruits in the analysis. Nonetheless the same amount is similar to the quantities for some introduce fruits such as *Carica papaya, Mangnifera indica*, and *Artocarpus heterophyllus* [28]. Though low, this amount is important because fibers are of physiological benefit to human body in stimulating and accelerating intestinal contraction and transit, and also increasing fecal volume. Furthermore, they prevent obesity, diabetes and cancer of the colon and other ailments of the gastro-intestinal tract of man [29].

The amount of fat in the fresh pulps of *B. aethiopum* pulps on FM basis is similar to the amount of lipid [4] and those of *Carica papaya* [39,40]. However, these contents constitute only 0.78% DV of the 65% total fat based on total dietary energy intake of 2000kcal per day; for adults and children four or more years of age per day [14]. Consequently, increased consumption of these fruits can increase its availability and subsequently the energy which the local communities may need as they to perform many of their activities such as farming.

The amount of ash on DM basis is lower but similar to the values for its sister species *B. flabelifer* [4,8,27] and of the round yellow papaya [28]. Being, an indicator of the amount of minerals that is availability in any food, this quantity shows that these pulps are a potential source of many minerals.

The protein content of these fresh fruits is similar to the values reported by other researchers [4] on FM basis. It is also similar to the amounts present in apples and mangoes [28] and for those in the papaya types [30] on FM basis. This same amount constitutes only 1.66% DV of the 50% crude proteins based on the 2000Kcal/100g [14]. It is below DV for children, adult, pregnant and lactating women as well the upper tolerable values per day [14]. Nonetheless, this amount is still valuable, proteins being the building block of the body, and necessary for provision of energy. For full realization from these pulps there is need for increased consumption of these wild fruits.

The amounts of carbohydrates on both FM and DM basis from our study are higher [4,5]. Conversely this amount on FM basis is similar to those of *Carica papaya*, *Ananas comosus* and *Psidium guajava* [25,28]. This amonut accounts for only 2.85% DV of the 300g/d carbohydrates based on the 2000Kcal/d [14]. This DV is lower for all categories of person so increased consumptions are encouraged if adequate contribution to energy is to be realized.

In our study, we defined energy as the density of energy in each given weight of the fruit pulps used in the analysis. Besides the relatively high content of energy as determined from this study, most fruits and vegetable are noted to generate low energy contents [41]. When compared with the contents from pawpaw; guava and apple, the amount from this study is higher though similar to that of *Mangnifera indica* [28]. The content of these pulps might have also been influenced by its high moisture contents. Nevertheless, this energy is very useful to the local communities, especially in seasons when they are undertaking hard manual work. Therefore we so much encouraged increased consumption of these pulps for full achievement of the necessary energy.

The amount of vitamin C from the fresh pulps on FM basis is lower compared with other reports [4]. It is however similar to the values for *Mangnifera indica* but higher than for Apple (1mg/100g) and *Artocarpus heterophyllus* [28]. Being an important biological antioxidant [36], this amount indicates that it is a potential source of vitamin C. Consistent consumptions of these fruits are thus encouraged for full attainment of adequate vitamin C. This will help reduce the risks of iron deficiencies, incidences of cancer and heart disease, low blood pressure, prevalence of cataract and a heightened immunity against tropical disease [27].

Phytates are anti-nutrients which interfere with availability of minerals in any food or body. Because phytates have been implicated in decreasing protein digestibility by forming complexes and also that it interacts with enzymes such as trypsin and pepsin [32] in [13], its absence in these pulps is thus of advantage to promoting the consumptions of the fruits of *B . aethiopum*.

The deep orange color in *B. aethiopum* fruits naturally indicates high contents of carotenoid. However, when these values were compared with the value 27.42±0.9mg/100g from another study [4], the value from this study is low. Nevertheless this content is good and should persuade many people to consume more of these fruits if adequate vitamin A is to be obtained. Many scholars have reported on the significance of this vitamins in the plants for humans [16,17]. Vitamin A plays great roles in preventing diseases such as cancer, cardiovascular diseases, Osteoporosis, diabetes and eye diseases [31]. Since *B.aethiopum* fruits are freely accessible by the community, there is need to sensitize the community on such vital nutrients. The main intention of this will be to increase community's fruit consumption rates and also improve on the conservation of these fruit trees. These are also need to further investigate the availability of these nutrients in the body whenever consumed.

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