Variation in Chemical Composition of Baobab (Adansonia digitata L

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fruits pulp in relation to fruit shape types and locations

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Abstract: The present study was conducted in Blue Nile and North Kordofan States -Sudan to assess data on the nutrient and chemical compositions of the fruits pulp, in relations to fruits shapes type from different locations, five locations from each states sampling was done randomly regardless of their age, size and stand density to select from ten individuals tree with different fruit shape types. Nutrient and chemical composition of baobab pulp was analysis at different locations. Result showed that baobab pulp have high nutritive value in terms of protein, and carbohydrates (energy) contents, it is also contain minerals such as calcium, magnesium, potassium, phosphorus, sodium and vitamin C, specially very high vitamin C content and is an excellent sourceof calcium, contains a high amount of carbohydrate, is low in protein, and extremely low in fat. The study results indicated that dry matter (86.5±0.7), crude protein (10.44±0.15), fat content (1.70±0.14) and carbohydrate (62.58±0.17) were found to be the lowest with spheroid emarginated fruit shape. Globose shape pulp demonstrated highest crude protein (12.55±0.28). as well as in comparison, Ellipsoid, oblong pointed and clavate shape showed lower vitamin C content than those other fruit shapes. However, calcium content was found to be the lowest (500 mg/100 g) in clavate fruit shape. Moreover, this research work revealed a slightly variation of nutrient and mineral contents of baobab pulp based on fruit shape type and studied area. These data would be useful to the local people who deal with baobab product activities in the study area, in helping them devise superior tree species.

Key words: Baobab, fruits pulp, chemical composition**,** fruit shapes

1. Introduction

Baobab or *Adansonia digitata* L. belongs to the Bombacaceae family [1], which consists of around 20 genera and 180 species. The tree species is found widespread throughout the hot, drier regions of tropical Africa. It extends from Northern Transvaal and Namibia to Ethiopia, Sudan and the Southern Fingers of the Sahara. In Sudan, the tree is most frequently found on sandy soils and seasonal streams, "*Khors*," in low grassland Savannas. It forms belts in Central Sudan, in Kordofan, Darfur, Blue Nile, Upper Nile and Bahr el Ghazal [1]. It is a deciduous tree massive, royal tree. It has thick, angular, wide spreading branches and a short, stout trunk, and often becomes deeply fluted.

Literature reviews on baobab published biochemical analyses revealed that the leaves, the seeds and the pulp from baobab are rich in nutrients [2]; [3]; [4]; [5]; [6]. The *Adansonia digitata* has numerous medicinal and non-medicinal uses, the tree provides food, shelter and medicine as well as material for hunting and fishing [7]. The fruit consists of large seeds embedded in a dry, acidic pulp and shell [8], the pulp is used in the preparing cool drinks or sucked in rural areas.The fruit pulp has very high vitamin C content; It contains sugars but no starch and is rich in pectin. However, the vitamin C content of the bulk fruit pulp varies from 1623 mgkg-1 in one to 4991 mgkg-1 in another tree [9].

Nutritional analysis of baobab fruit pulp has shown that it is an excellent source of pectin, calcium, vitamin C and iron. Its vitamin C content has been compared with oranges and found that it is about three times higher. [10] reported that the fruit pulp may also serve as a calcium supplement because of its high calcium content, moreover, Leaves and seeds are identified as good sources of vitamins and minerals [11]. [12] reported that the knowledge of nutrition value of local dishes, soup ingredients and local foodstuffs is necessary in order to encourage the increase cultivation and consumption.According to [6] literature review revealed a great variation in reported values of nutrient contents of baobab part which may be due to the quality of the sample, the provenance of the sample, the age of the sample, the treatment before analysis, the storage conditions, the processing methods, a probable genetic variation, and the soil structure and its chemical composition

Baobab is of high nutritive and economic importance to poor farmers in Africa. Its high nutritive concentration is gaining increased importance in the food industry and as additives to improve nutritional value of foods. the biochemical composition of baobab parts did not vary according to the genetic and ecological provenance of the trees. This suggests that ecological provenance of baobab does not induce variability in the nutritional concentration of its parts [13]. Although Baobab tree have been published by many author about the multipurpose, a few of these authors have presented a (general) literature review, and none of these dealt simply and solely with the nutritional value of baobab products. However these reviews did not detail the nutrient and mineral content according to fruits shape types and their locations of baobab tree. This research aims to focus on detailed data on the nutrient and chemical compositions of the fruits pulp, in relations to fruits shapes type from different locations, in order to enhance the food supply and expand the scope of knowledge on its full utilization for the local population.

2. Materials and Methods

2.1 Study areas

The study was performed on baobab (*Adansonia digitata* L.), Population established within five locations from both North Kordofan and Blue Nile State in Sudan. North Kordofan state located roughly between latitude 10.5˚ and 15˚ north and longitude 27.5˚ and 32˚ east, it occupies a total area of about 185302 km². Blue Nile State located between latitude 10˚ and 13˚ North and longitude 33˚and 36˚ east, and occupies a total area about 38500 km² (Fig.1&Table1). The vegetation of North Kordofan State is mainly composed of savannas the dominant trees are Acacia spp. such as *Acacia senegal*, *Acacia millefera* and other species include *Balanites eagyptiaca*, *Faidherbia albida*, *Ziziphus spp*, *Tamaridus indica* along with the main grasses grown. Blue Nile State has moderate to rich vegetation which includes Acacia trees and short grasses and shrubs

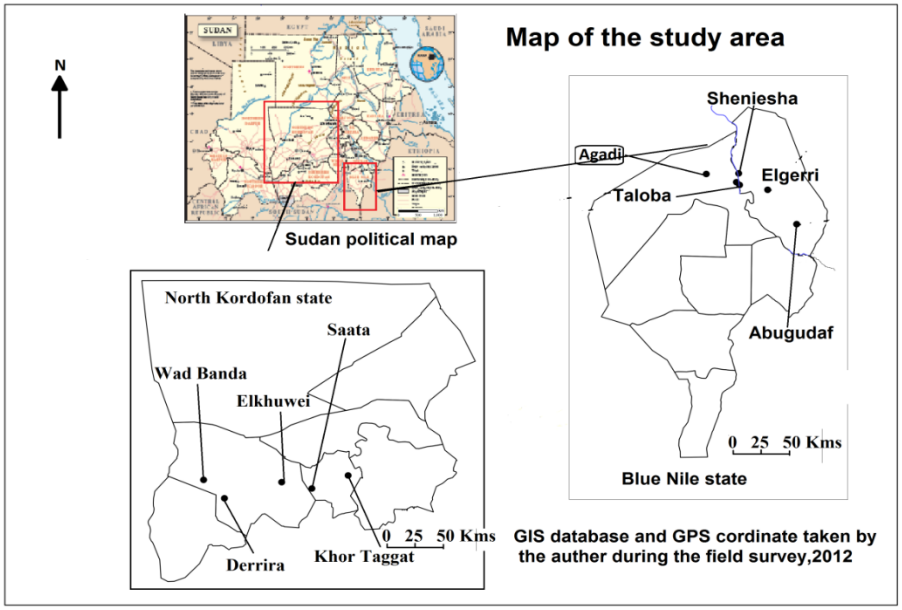

Figure 1 Map of Blue Nile and North Kordofan states.

Table1 The characteristics of the selected locations of study from the two states

State	Location	Altitudes (m)	Soil	Lat. N	Long. E	Average Rainfall (mm)
North Kordofan	KorTaggat	560	Sandy loamy	13° 11′	30° 18′	350
	Saata	512	Sandy	12° 58′	29° 52′	350
	Elkhuwei	530	Sandy loamy	13° 04′	29° 13′	350
	Derrira	565	Sand	12° 47′	28° 16′	350
	WadBanda	623	Sandy loamy	13° 06′	27° 56′	350
Blue Nile	Taloba	474	Stony hill side	11° 49′	34° 23′	700
	Shenisha	465	Silty	11° 57′	34° 22′	700
	Elgerri	538	Stony hill side	11° 49′	34° 36′	700
	AbuGuduf	550	Clay	11° 31′	34° 50′	700
	Agadi	522	Stony hill side	11° 57′	34° 06′	700

Sources: Ministry of Agriculture of North Kordofan and Blue Nile States [14]

2.2 Sampling

Sampling was done randomly regardless of their age, size and stand density to select from ten individuals of baobab with different fruit shape types. Shape types in both Blue Nile and North kordofan States may include: ellipsoid, high spheroid, ovate, obovate, oblong pointed, fusiform, globose, Spheroid emerginate, clavate and ellipsoid pointed as shown in Table 1 and Figure 2.

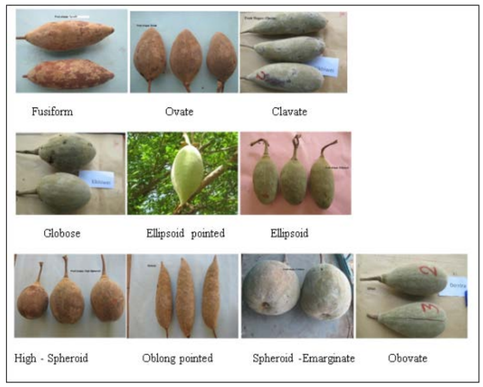

Figure 2: Diversity in fruit shape of *A. digitata* L

Six mature fruits without any damage or defects with careful visual inspection were picked up randomly from different positions in the crown and put in labeled plastic bags. The total number of fruits sampled was 486 from 81 trees from the studied areas. The pulp was separated from the pods and seed manually.

2.3 Proximate Nutrient and Chemical composition analysis:

All nutrients and chemical composition were determined according to the method described by [15]. The moisture content determined by selecting two grams and added into a pre-dried aluminum dish, with a lid then placed in a temperature controlled oven at 103 ºC ± 2 overnight (about 8 hours). The moisture content was calculated as percentage of the original weight of the sample using the formula below.

$$Moisture\ content\ (\%) = \frac{\qquad}{\qquad} \times 100$$

Where: W_1 *= weight of dish + lid,* W_2 *= weight of dish +lid + sample, and* W_3 *=weight of dish + lid + sample after drying.*

Ash content was measured by weighting two grams and placed in muffle furnace at 600ºC for 6 hours. The sample was transferred to cooling room and then weighted and calculated using the formula below:

$$\text{Ash content (\%)} = \frac{W_1 - W_2}{\text{Weight of sample}} \times 100$$

Where: $W_{1=}$ *weight of crucible with ash,* $W_{2=}$ *weight of empty crucible.*

Protein content was determined by using 0.2 g of defatted sample and weighed accurately into a micro-kjeldahl flask, 0.4g of catalyst mixture and 3.5 mlof concentrated sulphuric acid were added, the flask was then placed into the kjeldahl digestion unit for about 2 hours until a colorless digest solution was obtained. The flask was left to cool to room temperature. 20 ml of 40% sodium hydroxide solution were added to the digested solution and the mixture was heated. The ammonia evolved was trapped into 10 ml of 2% boric acid solution, then titrated against 0.02 N hydrochloric acid using universal indicator. The total nitrogen and protein were calculated using the following formula:

$$\text{Crude nitrogen (\%)} = \frac{\text{Volume of HCl} \times N \times 14 \times 100}{\text{Weight of sample} \times 1000}$$

$$\text{Crude protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

Where: Nitrogen (%) = crude nitrogen, Protein (%) = crude protein, and N = normality of HCL. 14 = equivalent weight of nitrogen.

Fat content was assessed using two grams of samples which were extracted with hexane for 8 hours using Soxhlet apparatus. The solvent was evaporated and the remaining crude fat was determined using the following formula.

$$\text{Fat \%} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100$$

Where: W_1 *= weight of empty flask, and* W_2 *= weight of flask with oil*

For crude fiber determination two grams of fat free meals was treated successively with a boiling solution of H2SO4 and KOH. The residue was separated by filtration, washed, dried, weighed and ashed at 500 ºC. The loss of the weight resulting from ashing corresponded the crude fiber in the sample.

Total Carbohydrate was calculated by difference according to [16] using the following formula:

Total carbohydrate% = 100 – (moisture % + crude fat % + crude protein % + ash %+ crude fiber)

Mineral content of raw and processed samples were extracted according to Pearson's methods 1981. Vitamin C the level of vitamin C was estimated by the method of [17] by reading at 520 nm in spectrophotometer UV/vis unicam 8625.

2.4 Statistical analysis

To investigate the relationships between the locations, the biochemical and nutrient composition of the baobab pulp and fruit shape types, analysis of variance (ANOVA) was conducted, using SPSS version 16.

3. Result and discussion

From the results baobab pulp contains nutrient composition that include moisture content, dry matter, ash, crude protein, fat content, crude fiber and carbohydrates in variable proportions (Table 2). Moreover, this study revealed that baobab fruit pulp contained mineral content as; calcium (Ca), potassium (K), phosphorus (P), Sodium (Na), Magnesium (Mg) and vitamin C.
The results also illustrated that there were significant differences ($P \leq 0.05$) between baobab fruit pulps in relation to individual trees fruit shapes. The study results indicated that there was a high significant difference in moisture and crude fiber content (13.5 ±0.70 and 6.3±0.14 Mg/100g respectively) with spheroid fruit shape. In contrast dry matter, crude protein. Fat content and carbohydrate were found to be the lowest with spheroid emarginated fruit shape. Globose shape pulp demonstrated highest crude protein. Whereas, fusiform and clavate fruit shape found to be the lowest overall fruit shapes. Oblong pointed and ellipsoid pointed showed highest crude fiber; whereas, clavate shape having lowest crude fiber (Table 2).

Table 2: Chemical composition of the fruit shape types pulp of baobab

Parameter / Fruits shape	**Moisture** Content	**Dry matter**	**Ash**	**Crude Protein**	**Fat content**	**Crude fiber**	**Carboh. N.F.E**
Ellipsoid	7.66± 1.96 b	92.33± 1.96 a	4.83± 0.75 a	11.72± 0.31 b	1.93± 0.23 a	4.73± 0.43 b	69.27± 2.71 a
High spheroid	6.75± 0.88 b	93.26± 0.88 a	4.50± 1.19 a	11.69± 0.46 b	1.96± 0.21 a	4.53± 0.38 b	71.3± 2.56 a
Ovate	7.5± 1 b	92.33± 1 a	5.50± 2.38 a	11.33± 0.29 b	2.10± 0.08 a	4.87± 1.42 b	67.94± 3.45 a
Obovate	5.66± 1.50 b	94.33± 1.3 a	4.50± 1.04 a	11.27± 0.46 b	2.10± 0.08 a	4.41± 0.57 b	72.04± 1.92 a
Oblong	7.5± 0.7 b	92.50± 0.71 a	4.50± 0.7 a	11.11± 0.12 b	1.75± 0.21 b	5.40± 0.14 a	69.98± 0.30 a
Globose	6.83± 1.47 b	93.16±1. 47 a	6± 0.63 a	12.55± 0.28 a	2.2± 0.1 a	4.71± 0.62 b	67.72± 2.28 a
Spheroid. Emerginat	13.5± 0.7 a	86.5± 0.7 b	5.5± 0.7 a	10.44± 0.15 d	1.70± 0.14 c	6.30± 0.14 a	62.58± 0.12 b
Fusiform	6.66± 1.36 b	93.33± 1.36 a	5.66± 0.51 a	10.6± 0.31 c	2± 0.14 a	4.76± 0.52 b	70.14± 1.94 a
Clavate	8.50± 0.7 b	91.5± 0.7 a	3.5± 0.7 a	10.81± 0.18 c	2.1± 0.14 a	3.85± 0.07 c	71.24± 1.66 a
Ellipso.P	7.25± 2.62 b	92.75± 2.62 a	6± 0.81 a	11.42± 0.36 b	2.15± 0.1 a	5.07± 0.09 a	68.1± 2.77 a

Each value represents means ± standard deviation of three replicate determinations. Compositions (mg/100 g)

The study revealed that there were slight significant differences ($P \leq 0.05$) in baobab pulp minerals related to fruits shape (as potassium calcium, sodium, phosphorus and magnesium) and vitamin C in variable proportions. In comparison, Ellipsoid, oblong pointed and clavate shape showed lower vitamin C content than those other fruit shapes (Table 3). However, calcium content was found to be the lowest (500 mg/100 g) in clavate fruit shape. The obtained results also indicated that there were insignificant differences in phosphorus, potassium and magnesium in the ten fruit shapes (Table3). As tabulated in Table 3, the oblong pointed and spheroid emarginated show the highest sodium content. In contrast, high spheroid, obovate, clavate and ellipsoid pointed show the lowers sodium content. the reason of this may be differences in fruit morphology and their relation to the environment and the effect of soil type on fruit characteristics, which has been observed for other fruit tree species, such as the shea tree [18].

Table 3: Vitamin C and Minerals content of baobab fruit shapes type pulp

Parameter / Fruits shape	Vitamin C	Phosphorus (P)	Calcium (Ca	Sodium (Na)	Potassium (K)	Magnesium (Mg)
Ellipsoid	227± 0.38 b	57.5± 0.47 a	555± 5.57 a	23.5± 0.26 b	608.3± 4.02 a	543.3± 2.25 a
High spheroid	246± 0.31 a	58.3± 0.11 a	572.5± 2.76 a	22.0± 0.13 c	575± 2.39 a	588.7± 2.94 a
Ovate	233± 0.25 a	56.2± 0.09 a	575± 1.29 a	23.5± 0.12 b	602.5± 1.50 a	575± 4.79 a
Obovate	240± 0.09 a	52.73± 0.37 a	548.3± 7.49 a	22.8± 0.19 c	583.3± 5.04 a	566.6± 1.96 a
Oblong	203± 0.07 b	61.5± 0.21 a	515± 2.12 a	27.5± 0.21 a	565± 2.12 a	580± 1.41 a
Globose	233± 0.36 a	558± 0.29 a	535± 2.42 a	24.3± 0.27 b	606.6± 1.36 a	560± 1.78 a
Spheroid emarginated	259± 0.08 a	58.5± 0.07 a	620± 1.41 a	28.5± 0.07 a	570± 1.41 a	590± 1.41 a
Fusiform	254± 0.23 a	56.8± 0.24 a	583.3± 5.92 a	23.3± 0.12 b	598.3± 2.04 a	600± 1.54 a
Clavate	221± 0.12 b	60.5± 0.07 a	500± 1.41 b	20.5± 0.07 c	620± 2.82 a	545± 0.7 a
Ellipsoid pointed	298± 0.08 a	60.7± 0.09 a	595± 1.29 a	23± 0.08 c	617.5± 0.95 a	585± 1.29 a

Each value represents means ± standard deviation of three replicate determinations. Mineral and vitamin C (mg/100 g).

The study findings also revealed that there were insignificant variations in chemical composition of fruits pulp from the study areas, with the exception of calcium content in North Kordofan State (Table 4). These differences in Mineral content and Vitamin C may be attributed to climatic factors and soil factors variation between the study areas.

Table 4: Chemical composition of baobab pulp, according to the studied states.

States Parameters	Blue Nile	North Kordofan	Total means of states
Moisture	7.38 ± 2.38 a	7.05 ± 1.46 a	007.21 ± 1.92
Dry matter	92.61 ± 2.38 a	92.95 ± 1.46 a	092.78 ± 1.92
Ash	5.23 ± 1.21 a	4.95 ± 1.19 a	005.09 ± 1.20
Crude protein	11.26 ± 0.58 a	11.67 ± 0.72 a	011.46 ± 0.65
Fat	1.99 ± 0.2 a	2.06 ± 0.17 a	002.02 ± 0.18
Crude fiber	5.05 ± 0.72 a	4.37 ± 0.42 a	004.71 ± 0.57
Carbohydrate	69.16 ± 3.64 a	69.94 ± 1.98 a	069.55 ± 2.81
Vitamin C	246 ± 0.27 a	239 ± 0.38 a	242.50 ± 0.32
Phosphorus (P)	58.2 ± 0.26 a	57.3 ± 0.33 a	057.75 ± 0.29
Calcium (Ca)	586.5 ± 3.47 a	530.5 ± 4.52 b	558.50 ± 3.99
Sodium (Na)	23.8 ± 0.27 a	22.9 ± 0.15 a	023.35 ± 0.21
Potassium (K)	596.1 ± 2.88 a	593.5 ± 3.39 a	594.80 ± 3.13
Magnesium (Mg)	571.9 ± 2.91 a	576.5 ± 2.85 a	574.20 ± 2.88

Means (m) ± standard deviation (s)for the same parameter, data with the same letter are not significantly different for the variables considered Mg/100g.

Comparing the results obtained in this study with those reported in literature, the means of the carbohydrate, fat, ash, crude fiber and crude protein from BN and NK were higher than those reported by [19], [20] and [21] (Table 5). Whereas, the other authors in the same table reported that the chemical composition were higher than those from BN and NK state.

Table 5: Comparative data on the chemical composition of baobab fruit pulp(Mg/100 g)

Moisture	Crude Protein	Crude Fiber	Ash	Fat	Carbu-hydrate	References
17.9- 33.8	1.4-2.1	-	3.3-3.4	0.1-0.7	-	[22]
5.2	14.3	10.7	7.3	13.9	51.4	[23]
6.7	2.6	5.7	5.3	0.2	86.2	[24]
19.9	19.1	-	2.4	5.1	73.4	[25]
13.2	3.1	8.3	5.0	4.3	79.5	[26]
6.2	10.9	6.2	2.0	4.3	45.2	[19]
10.55	2.2	11.2	5.7	0.4	70.0	[27]
4.7	4.7	4.51	5.1	0.7	46.6	[20]
-	5.3	44.0	-	0.2	30	[21]
10.4	3.2	5.4	4.5	0.3	76.2	[10]
7.21	11.46	4.71	5.09	2.02	69.55	Present study

The results tabulated in Table 6 indicate that the mineral content of baobab fruit pulp are excellent sources of potassium, calcium, and magnesium, but poor sources of sodium. The fruit pulp mineral contents are comparable to those reported for baobab fruit from Sudan and West Africa.

As can be seen from Table 5 the comparison shows that the mineral contents (Mg, K, Na, Ca and P) of the pulp from BN and NK state obtained in this work were found to be higher than those reported by the authors. However, [24] reported the highest content of calcium, while highest Phosphorus (P) content was reported by [3] which were found to be higher than those from BN and NK. The high calcium contents of the fruit pulp make the baobab fruit attractive as a natural source of calcium supplementation for pregnant and lactating women, as well as for children and the elderly [10]. [28] reported that the vitamin C content of the pulp of *A. digitata* is among the highest known among the African wild fruits, and 6 to 10 times that of oranges.

Table 6: Comparative data on the mineral content (Mg/100 g) of *A. digitata* fruit pulp

Phosphorus (P)	Calcium (Ca)	Sodium (Na)	Potassium (K)	Magnesium (Mg)	References
50.8	655	-	-	-	[24]
50	60.0	-	-	208.8	[29]
35	390				[30]
45	115.6	18.8	383.64	209	[26]
-	043	-	-	78.1	[11]
73.3	341	05.46	-	209	[3]
49.79	211			123	[27]
57.75	558.5	23.35	594.8	574.2	Present study

The differences in fruit pulp chemical compositions between the study areas may be attributed to climatic factors. Concerning the study results, it was found that calcium (Ca) content was higher (558.5mg/100g) than those reported in other country. In this regard, many authors from Africa such as [26], [3], [20] and [10] who reported that Ca contents was 115.6mg/100 g, 341mg/100g, 211mg/100g and 295mg/100g in the same order.

4. Conclusions

In conclusion, the variations in nutrient and mineral contents of baobab pulp based on fruit shapes, may suggest the fact that there are ecotypic and phenotypic variations between trees which ultimately affect the biochemical properties of the baobab pulp. The fruit pulp has a very high vitamin C content as well as carbohydrate with exception of protein and fat which were extremely low. This rich vitamin C in baobab fruits may fill important gaps in food deficiency in the rural areas where more vitamins producing trees are lacking.the fruit pulp may also acts as calcium enhancement because of its high calcium content.

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