

Nutritional Quality and Functional Properties of Baobab (*Adansonia digitata*) Pulp from Tanzania

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Abstract

Baobab (*Adansonia digitata* L.) is a majestic tree associated with human habitation in some of the semi-arid regions of Africa and establishes an enormous economic and nutritional importance to the rural residential districts. The fruit pulp is considered to be of high nutritional significance; particularly vitamin C and calcium, also possess antioxidant functions as well as high dietary fiber content. Although it is a potential fruit for improving local diets and livelihoods, this fruit is underutilized and its potential not yet fully acknowledged. This work was contracted with the aim of defining the nutritional quality and functional properties of baobab pulp harvested from some selected parts of Tanzania.

Results indicated that the pulp from the three locations had moisture content which ranged between 9.16% to 10.30%, fat 0.46%-1.98%, ash 4.75%-5.21%, fiber 5.91%-9.65%, protein 3.23%-3.53%, carbohydrate 80.49%-85.19, vitamin C 169.74mg/100g-231.57mg/100g, beta-carotene 2.16 mg/100g-3.19mg/100g. Fructose 0.56±0.15-0.81±0.17g/100g, glucose 0.77±0.26-0.87±0.31g/100g and sucrose 0.75±0.25-0.84±0.29g/100g. The substantial differences ($p \leq 0.05$) between locations were observed in fat, crude fiber, carbohydrates, and fructose. Vitamin C, beta-carotene, protein, ash, moisture, sucrose and glucose showed no significance difference ($p \leq 0.05$) among locations. The functional properties included emulsification, foaming and gelling properties which ranged between 37.9-45.15%, 1.85-6.57% and 11-12% respectively and were significantly different ($p \leq 0.05$) among locations. The results show that baobab pulp has a good content of nutrients and functional properties which can be useful in food industries.

Keywords: *Adansonia digitata*, Baobab pulp, functional property, nutritional quality

1. Introduction

The Baobab (*Adansonia digitata*) belongs to the Bombacaceae family which comprises of around 20 genera and 180 species including closely interrelated species such as *Adansonia gregori* and *Adansonia madagascariensis* (Kamatou *et al.*, 2011, Mulani & Kharate, 2015), also known as the “upside down tree”, on pollination by fruit bats, it produces big green or brownish fruits which are capsules and naturally indehiscent. The capsules have a soft whitish powdery pulp and kidney shaped seeds (Sidibe & Williams, 2002).

The baobab is an important indigenous fruit tree throughout the dry lands of Africa, in Malaysia, China, Jamaica and Australia (Jamal *et al.*, 2005). Several studies in Benin, Burkina Faso, Malawi, Mali, Nigeria, Tanzania and South Africa have emphasized this deciduous stem-succulent taxon as precedence species for domestication and increased its consumption (Lamien-Meda *et al.*, 2008). The baobab fruit is also used in the day-to-day diet of rural societies in Africa (Assogbadjo *et al.*, 2008a, Ibrahima *et al.*, 2013). The species contribute to rural revenues (Kamatou *et al.*, 2011) and has several essential food and medicinal uses (Kaboré *et al.*, 2011); the pulp is mostly consumed traditionally in different forms. It is also used in the preparation and formulation of cereals and beverages.

Although, baobabs are extensively recognized, the present scientific information on the biochemistry and significance of its fruit in human nutrition is inadequate. Up to the present time, most of the studies have focused on *A. digitata* in relative to its agronomical, botanical and biochemical characteristics (Gebauer *et al.*, 2002).

It was reported that baobab is a nutrient rich fruit which has ascorbic acid, riboflavin, niacin, pectin and citric, malic and succinic acids, while the oil also comprises the vitamins D, E and A (Besco *et al.*, 2007, Donkor *et al.*, 2014). The pulp of *A. digitata* is also rich in dietary fibers (Ibrahima *et al.*, 2013). The soluble fibers of baobab fruit pulp are prebiotics: non-digestible food components that beneficially affect the host by selectively stimulating the growth and/or activity of beneficial microflora, hence supporting probiotics, (Gruenwald & Galizia, 2005).

The objective of this study was to determine the chemical composition and functional characteristics of the baobab fruit pulp from a specific geographical location in Tanzania.

2. Material and Methods

2.1 Acquisition of Baobab Fruits

The baobab fruit samples were collected from Arusha, Makuyuni areas from three locations including Naitolia camp, Kwa Muhindi and Oldonyo Orng'ina. Baobab fruit were harvested from three trees per each location. The Criteria used for selecting the trees to be sampled from were trunk which was cylindrical tapering shape and leaf shape. The fruits were collected during September, 2015, and at that time the trees had already shed the leaves and hence so only the trunk shape was used as the harvesting criteria.

2.2 Sample Preparation

2.2.1 Preparation of Baobab Pulp and Yield

Whole baobab fruits were weighed, and their hard woody shells were carefully crushed and the pulp was separated from the seeds, grounded using pestle and mortar to separate the pulp from the seeds. The mixture was sieved using a 0.09 micron sieve to obtain a fine powder. The powder was weighed and instantly packed into polyethylene bags sealed and stored in a dark cool place. This procedure is shown in figure 1.

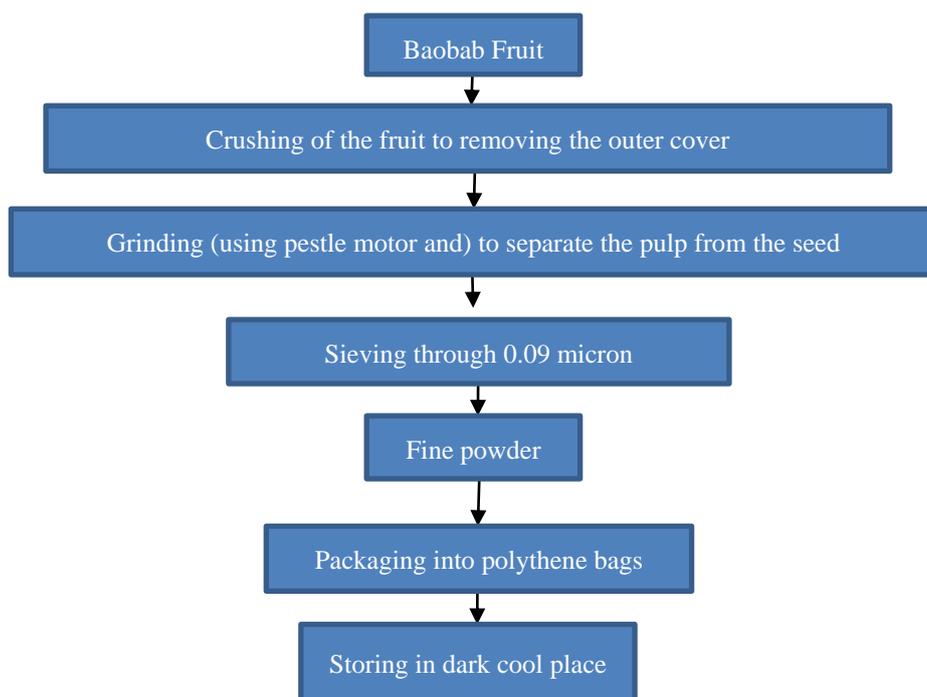


Figure 1. Flow chart of baobab pulp production

2.3 Proximate Composition

The protein, crude-fibre, ash, fat and moisture were determined using the method of Association of Official Analytical Chemists (AOAC, 2003).

2.4 Sugars

Ten grams of ground homogenous sample was mixed with 50ml of 96% ethyl alcohol. The mixture was refluxed at 100 °C for 1 hour and the slurry filtered. The filtrate was evaporated to dryness at 60 °C and dissolved in 10ml distilled water. Two ml of the solution was mixed with 2 ml of acetonitrile and filtered through 0.45 µm, (AOAC, 2003). Then 20µl was injected into Higher Performance Liquid Chromatography (HPLC) -Shimadzu 20 A Series, with amide column -NH₂ -LUNA-100A (250X4.6mm), Diameter -5µl and Refractive Index Detector.

2.5 Determination of β-Carotene

About 5g of the sample was weighed accurately, and extraction was done using 40 ml of petroleum ether and 30ml acetone. The mixtures were put in a separating funnel. Distilled water was added slowly along the neck of separating funnel without shaking to avoid emulsion formation. The two phases were then left to separate and the lower aqueous layer discarded. The sample was washed 3 - 4 times with 200ml distilled water each time to remove residual acetone. In the last phase, washing was done ensuring that no amount of the upper phase was discarded. Then, the upper layer was collected into 50 ml flask using anhydrous sodium sulphate filter arrangement to remove residual water, (AOAC, 2003). The absorbance was determined at 450 nm using UV-visible spectrophotometer (Shimadzu -UV 1800). The concentration of beta carotene was calculated undard curve.

2.6 Determination of Vitamin C

Vitamin C was done according to the method described by (Vikram *et al.* ,2005). Basically 1g of the sample was mixed with metaphosphoric acid and centrifuged at 10,000 rpm for 10 minutes at 4 °C in a refrigerated centrifuge (Model H-2000C). The supernatant was sieved through whatman No 4 filter paper. The filtrate was diluted with 1ml of 0.8% metaphosphoric acid and filtered with 0.450 Millipore filter and 20µl of the sample injected into the HPLC(Shimadzu 20 A Series, with column -NH₂ -LUNA-100A (250X4.6mm), Diameter -5µl and Refractive Index Detector.

2.7 Functional Properties of Baobab Pulp Powder

2.7.1 Foaming

Two grams of baobab powder were dissolved in 100 ml of distilled water and blended at high speed for 1 minutes. The volume of the mixture was measured. The foaming capacity was calculated as the volume of the mixture after blending compared to the original volume (Santana *et al.*, 2012). The formula used for calculation was:

$$\text{Foaming capacity} = \frac{v_2 - v_1}{v_1} * 100$$

Where: v₁=Initial volume

V₂ = Final volume

2.7.2 Gelation

Baobab powder sample suspension of 10-15% was prepared in distilled water and vortexed in a vortex (model TM.151) for 5 minutes. Ten milliliter of each prepared dispersion was transferred into a test tube. The tubes were heated in water bath (model SHA-C) at 90 °C for 30 minutes and then placed in a cold room at 4 °C for 30 minutes. The gelation concentration was determined as the lowest concentration at which the sample did not fall down or slip from an inverted test tube (Santana *et al.*, 2012).

2.7.3 Emulsification

A 5g baobab powder sample was dissolved in 20 ml of distilled water, mixed with 20 ml of corn oil, blended for 1 minute and centrifuged at 7500 rpm for 5 minutes (Santana *et al.*, 2012). The formula used for calculation was:

$$\text{Emulsification capacity} = \frac{\text{Volume after homogenization} - \text{Volume after centrifugation}}{\text{Volume after homogenization}} * 100$$

2.8 Data Analysis

All physicochemical results was reported in mean ± standard deviation (SD). Differences were determined by Analysis Of Variance (ANOVA) and the means separated by Least Significance square (LSD) using SPSS version 20 software.

3. Result and Discussion

3.1 Baobab Pulp Yield

The mean weight of baobab fruits were 4465g, 2635g and 4020g for Naitolia camp, Kwa muhindi and Oldonyo Orng'ina respectively. The yields for baobab pulp were 285g (6%) for Naitolia camp, 200g (7.6%) for Kwa muhindi and 320g (7.9%) for Oldonyo Orng'ina, as stipulated on table 1.

Table 1. Baobab pulp yield

Location	Weight of baobab fruits(g)	Baobab pulp yield(g)	% yield of baobab pulp
Kwa muhindi	2635	200	7.6
Naitolia camp	4465	285	6
Oldonyo Orng'ina	4020	320	7.9

3.2 Proximate Composition

Moisture content for baobab pulp was found to be $9.94 \pm 0.54\%$ for Kwa muhindi location, $10.30 \pm 1.28\%$ for Naitolia camp, $9.55 \pm 0.22\%$ and $9.16 \pm 1.15\%$ for Oldonyo Orng'ina respectively as indicated in table 2. The outcomes revealed no significance difference at ($P \leq 0.05$). Moisture content of baobab pulp from Naitolia camp were higher than the value range of 7.87%-8.59% reported by (Abdalla *et al.*, 2010). However, (Osman, 2004) reported 10.4% which is higher compared to all three locations.

Baobab pulp in this study contained crude fat value of $1.98 \pm 0.69\%$, $1.11 \pm 0.35\%$ and $0.46 \pm 0.13\%$ for Kwa muhindi, Naitolia camp and Oldonyo Orng'ina respectively. Significant differences were observed among the three locations ($P \leq 0.05$). Present findings were noticeably higher compared to the value of 0.3% reported by (Osman, 2004), 0.2% (Abdulkarim *et al.*, 2014) and for 1.43% (Abdalla *et al.*, 2010).

Ash content was $5.21 \pm 0.39\%$, $4.87 \pm 0.51\%$ and $4.75 \pm 0.51\%$ for Naitolia camp, Kwa muhindi and Oldonyo Orng'ina samples, respectively. Results indicated that there is no significant difference ($P \leq 0.05$) as shown in table 2. Present findings for the locations were within the range as reported value of 4.5% stated by (Osman, 2004) and 5.5% (Magaia *et al.*; 2013b), but lower for both location as reported value of 5.8% (Sidibe & Williams, 2002).

As shown in Table (2), pulp collected from Kwa muhindi, Naitolia camp and Oldonyo Orng'ina was found to contain sequentially $6.29 \pm 2.57\%$, $9.65 \pm 0.36\%$ and $5.91 \pm 1.42\%$ crude fiber. Data showed that the three locations were significantly different ($P \leq 0.05$). These results were comparable to those reported by (Sidibe & Williams, 2002) and Caluwé & Damme, 2010;) which ranged between 5.4 and 11.5%.

Protein content of baobab fruit pulp was found to be $3.53 \pm 0.29\%$, $3.23 \pm 0.23\%$ and $3.52 \pm 0.27\%$ for Naitolia camp, Kwa Muhindi and Oldonyo Orng'ina, respectively with no significant difference ($P \leq 0.05$) between the three locations. Results reported were within the range of 2.5-17% obtained by (Ibrahima *et al.*, 2013) and (Sidibe & Williams, 2002), but higher than the 2.1-2.4% concentration reported by (Gebauer *et al.*, 2002) and (Magaia *et al.*, 2012a), respectively.

The carbohydrate content of the baobab pulp was $80.49 \pm 0.48\%$, $83.58 \pm 2.77\%$ and $85.19 \pm 1.53\%$ for Naitolia camp, Kwa Muhindi and Oldonyo Orng'ina, respectively. Samples from Oldonyo Orng'ina showed significantly higher content for carbohydrate ($P \leq 0.05$) than the remaining two sites. Data obtained were within the range compared with 73.7 to 81% previously reported by (Osman, 2004), (Abdalla *et al.*, 2010,) and (Rahul *et al.*, 2015).

The variation for the proximate results may be due to, the provenance of the sample, the treatment before analysis, the storage environments, the processing techniques, a probable genetic variation, ripening age difference (Fagbohun *et al.*, 2012) and physical chemical characteristics of the soil (Assogbadjo *et al.*, 2012b, Fagbohun *et al.*, 2012). Apart from the variability in the material, the analytical methods and inherent variability may also be a cause of variability.

In general, these results reveal that baobab pulp is rich in carbohydrate, ash but low in moisture and fat content. This is an important finding which indicates that it can be kept for a period of time before going bad.

Table 2. Proximate for baobab pulp

Location	Moisture (%)	Fat (%)	% Ash(%)	Crude fiber(%)	Protein(%)	Carbohydrate (%)
Kwa Muhindi	9.94±0.54 ^a	1.98±0.69 ^a	4.87±0.51 ^a	6.29±2.57 ^a	3.23±0.23 ^a	83.58±2.77 ^a
Naitolia camp	10.30±1.28 ^a	1.11±0.35 ^b	5.21±0.39 ^a	9.65±0.36 ^b	3.53±0.29 ^b	80.49±0.48 ^b
Oldonyo Orng'ina	9.16±1.15 ^b	0.46±0.13 ^c	4.75±0.51 ^b	5.91±1.42 ^{a,c}	3.52±0.27 ^{b,c}	85.19±1.53 ^{a,c}
P value	0.08	0.00	0.11	0.00	0.38	0.00
LSD	0.36	0.64	0.11	0.38	0.29	1.61

Each value in average of three replicates

Values are Mean ±Standard deviation

Means in the same column followed by the same superscript are not significantly different at $p < 0.05$.

3.8 Ascorbic Acid (Vitamin C) and Beta Carotene Content

As presented in table 3, pulp obtained from baobab fruit from Kwa muhindi location had the maximum ascorbic acid content 231.57±140.41 mg/100g followed by Oldonyo Oring'ina 211.99±84.82 mg/100g), whereas that from Naitolia camp revealed the lowermost vitamin C level (169.74±85.43 mg/100g), and the outcomes showed no significant difference ($P \leq 0.05$). The content are higher compared with 34-200mg/100g reported by (Sidibe & Williams ,2002), and lower with content of 300mg/100g and 355.7mg/100g ,reported by (Gebauer *et al.*,2002) and (Almustafa ,2003) respectively.

The high values of ascorbic acid in baobab pulp imply the potential use of the fruit as a good antioxidant. The recommended daily intake (RDI) of ascorbic acid is about 30 mg/day for adults and 17 mg/day for children(Othman *et al.*, 2014). Consequently, these fruits could be well-thought-out as good sources of ascorbic acid for purposes of human nutrition.

Beta carotene was found to be 2.16±1.77mg/100g,3.03±1.79mg/100g and 3.19±1.68mg/100g for Kwa Muhindi, Naitolia camp and Oldonyo Orng'ina raw pulp respectively. Oldonyo Orng'ina sample showed higher beta carotene content compared with those from Naitolia camp and Kwa muhindi. In this research, the results indicated no significance difference ($P \leq 0.05$) in beta-carotene content between the three locations.

Moreover, micronutrients, such as minerals and vitamins , are biologically active. They can interact with other nutrients and change in their bioavailability, hence it may be also a contributing factor for variation(Caluw é & Damme, 2010),in addition to the previously mentioned factors under proximate variation.

Table 3. Vitamin C, Beta- carotene and for baobab pulp

Location	VitaminC (mg/100g)	Beta carotene (mg/100g)
Kwa Muhindi	231.57±140.41 ^a	2.16±1.77 ^a
Naitolia camp	169.74±85.43 ^a	3.03±1.79 ^a
Oldonyo Orng'ina	211.99±84.82 ^a	3.19±1.68 ^a
P value	0.47	0.42
LSD	19.57	0.16

Each value in average of three replicates

Values are Mean ±Standard deviation

Means in the same column followed by the same superscript are not significantly different at $p < 0.05$.

3.10 Sugars

Sugars tested were glucose, fructose and sucrose and the results are stipulated in table 4. Fructose was high in Naitolia camp while glucose and sucrose was high in Kwa muhindi locations. The simple sugar values ranged as follows: fructose 0.56±0.15-0.81±0.17g/100g, glucose 0.77±0.26-0.87±0.31g/100g and sucrose 0.75±0.25-0.84±0.29g/100g for Naitolia camp, Kwa muhindi and Oldonyo Orng'ina locations. One study reported glucose, fructose and sucrose to be 7.9g/100g and 7.0g/100g 1.7g/100 respectively (Ibrahima *et al.*, 2013). The results for sucrose were lower whereas glucose and fructose were higher than the values reported by Ibrahim *et al.*, (2013) The results show there is significance difference at ($P \leq 0.05$) for fructose while no significance for sucrose and lactose among the location. Fructose, sucrose and glucose contribute to the pulp sweetness (Caluw é & Damme, 2010, Namratha & Sahithi, 2015).

Table 4. Sugar content for baobab pulp

Location	Fructose (g/100g)	Glucose(g/100g)	Sucrose(g/100g)
Kwa Muhindi	0.62±0.17 ^a	0.87±0.31 ^a	0.84±0.29 ^a
Naitolia camp	0.81±0.17 ^b	0.81±0.24 ^a	0.79±0.23 ^a
Oldonyo Orng'ina	0.56±0.15 ^c	0.77±0.26 ^a	0.75±0.25 ^a
P value	0.01	0.76	0.76
LSD	0.05	0.04	0.04

Each value in average of three replicates

Values are Mean ±Standard deviation

Means in the same column followed by the same superscript are not significantly different at $p < 0.05$.

3.11 Gelation

The lowest concentration at which the sample does not fall down/slip from an overturned test tube was used as index of gelation capacity. The lower the Lowest Gelation Concentration(LGC), the superior the gelatin capacity of the protein ingredient (Atta & El-Shenawi, 2013). As shown in figure 1 a good gel was formed at 11% (w/v) which is within the range as similar to (Eltayeb, *et al.*, 2011), 8%-18%. The lower the Lowest Gelation Concentration(LGC), the better the gelatin ability of the protein ingredient (Atta & El-Shenawi, 2013). The low LGC observed in the baobab pulp may be advantage in respect to the production of some products such as curd since production of such, requires ingredients with high gelation capacity like milk protein(casein) (Kisambira, *et al.*, 2015), and in jam making due to higher content of pectin which contribute to the excellent gelling capacity (Ndabikunze, *et al.*, 2011).

3.11.1 Foaming Capacity

In this study, low foaming capacity was found from the baobab pulp powder of Kwa Muhindi location with a value of 1.85%. While the highest foaming capacity was from Naitolia camp location which had a value of 6.57%, with significance difference at ($P \leq 0.05$), as presented in figure 1. In comparison with baobab pulp mixed with ogi flour (Adejuyitan, *et al.*, 2012) ranged 3.2-11.7 %, which is within for Naitolia camp. Baobab pulp powder tends to have a lower foaming capacity in comparison with egg yolk powder which is commonly used for its exceptional foaming capacity having a value of 38.50% (Ndife, *et al.*, 2010). In comparison with other fruits like watermelon seed flour, the value are lower as reported by (Oyeleke *et al.*, 2012) with 23.5% and higher compared to the dehulled and cooked jackbean flour which is 0.02%, (Obiageli, 2005). In regard with these results, use of baobab pulp powder for foaming application may therefore, not be ideal as my require further modification.

3.11.2 Emulsification

As shown in Figure 2, the highest emulsion of baobab pulp powder was reported on Oldonyo Orng'ina location with value of 45.15% and the lowest was on Naitolia camp 37.90%, with significance difference at ($P \leq 0.05$). This results revealed that baobab pulp powder had almost half emulsification capacity, 74% (Ndife *et al.*, 2010), the emulsification properties of egg yolk powder one of the first-rate emulsifiers. In comparison with other fruits, it has slightly similar value with yam bean flour 35.70% (Kisambira *et al.*, 2015) for Naitolia camp but higher for Kwa muhindi and Oldonyo Orng'ina, and higher compare to jack fruit flour 2.53-3.16% reported by (Obiageli, 2005) for both locations. According to this result, the use of baobab pulp powder for emulsification application may not be ideal and require further modification.

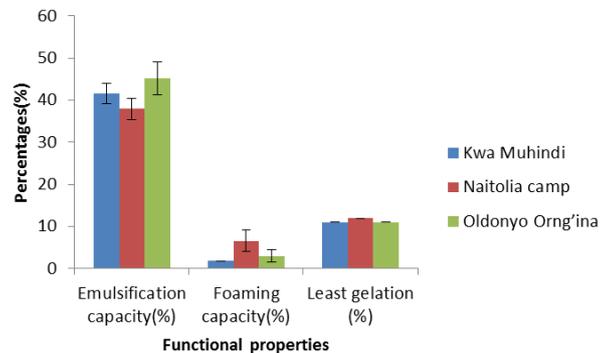


Figure 2. Functional properties of baobab pulp

4. Conclusion

The major findings in this research indicated that baobab (*Adansonia digitata*) pulp had low fat and protein content. The pulp also had low fat and moisture contents, indicating that it had good keeping qualities. It is also a good source of macronutrients, specially carbohydrate, crude fiber and micronutrients especially Vitamin C and beta-carotene. This could be useful in value addition and product development hence promoting the use of non-timber forest products. Functional properties for baobab pulp indicates can be used for various food products companies in recipe development, as it has good gelation properties which is a significant attribute for food processing.

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