

Full Length Research Paper

Comparative analysis of nutritional contents in the leaf, pulp and seed of *Adansonia digitata* L. consumed in Adamawa State, Nigeria

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***Adansonia digitata* L. is a tree commonly called Baoba tree which is a native of African savannah widely distributed in arid zones of Sahara. This study was carried out to investigate the native uses and nutritional content (proximate composition and minerals profile) of the leaf, pulp and seed of *A. digitata* L. (Baoba). The methods adopted for data collection included well-structured questionnaire, field and laboratory methods. Results from the survey revealed that different ethnic groups in Adamawa used parts of *A. digitata* L. for medicine, food, spices and special drinks. The results of proximate composition showed protein 38.18, 17.57 and 48.49% in the leaf, pulp and seed of Baoba tree, respectively. The carbohydrate content showed 37.30, 63.71 and 22.95%, respectively. The moisture and ash contents in the three samples ranged between 6.30 and 11%, while the crude fiber ranged from 1 to 3%. The minerals content in the pulp samples revealed that Mg and Fe significantly recorded the highest. There was significant difference in both minerals and nutritional profiles in the three parts of *A. digitata* L. In conclusion, the three parts of the plants studied contained important nutrients and minerals that are good for human consumption and therefore conservation strategies should be employed to ensure sustainability in utilization of the plant products.**

Key words: Savannah, *Adansonia digitata* L, Baoba, minerals, leaf, pulp.

INTRODUCTION

Adansonia digitata L., is a tree commonly called Baoba tree which is a native of African savannah, Madagascar, Australia and Arabia which belonged to genus *Adansonia* and to the family Malvaceae (Wickens and Lowe, 2008). The tree is widely distributed in arid zones of most countries of Sahara. The trees are commonly found in the thorn woodlands of African savannahs which tended to

be at low altitudes with 4 to 10 dry months in a year (Wickens and Lowe, 2008). The tree usually grows in solitary manner, though it can be found in small groups depending on the soil types. The plant is not found in places that are deeply sandy and very sensitive to frost and water logged areas.

All locations where *A. digitata* is found are in the arid or

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semi-arid regions of the world (Shuaibu and Rabi, 2014). Baoba tree is visible in both residential area and wild. In Nigeria, the Baoba trees are widely distributed in Sodano-Sahelian part of the country engulfing Kano, Katsina, Sokoto, Zamfara, Kebi and Jigawa states in the Northwestern part and in the Northeastern part covering Yobe, Borno, Gombe, Bauchi and Adamawa states (Shuaibu and Rabi, 2014).

A. digitata L., being a massive deciduous tree, it can grow up to 20 to 30 m in height with a diameter of 2 to 10 m at adult age. It has trunk with vast girth, smooth bark, and reddish brown to grey, soft and possesses longitudinal fibers. *A. digitata* is highly branched which produces extensive lateral roots system up to 50 m from the trunk. The roots' tips are often tubular while the tap root of the tree is shallow rarely extend beyond 2 m depth which makes them easily fell down by storms (Sidibi and Williams, 2002). The adult tree begins each season by producing simple leaves with 2 to 3 leaflets. The flowers are white large, pendulous, solitary or paired in the leaf axils. Flowering begins about the end of dry or just before the first rains often when the first leaves appear after annual shedding (Jitin et al., 2015). Baoba trees have life span ranging from 200 to 300 years and others can live up to 1000 years (Jitin et al., 2015). *A. digitata* L. is a multi-purpose tree and is called tree of life and small pharmacy because it offers goods and services that include protection, food, clothing materials, medicinal, fiber materials derived from barks, seeds, leaves, and roots (Jitin et al., 2015). According to traditional sources, leaves of Baoba have been reported to cure malaria fever, diaphoretic fever remedy, toothache (gingivitis), diarrhea, fever, inflammation of kidney and bladder diseases, blood clearing and asthma (Wickens and Lowe, 2008). The bark cures anemia and wound healing while seeds are used as therapy for fever, diarrhea and cough (Van Wyk and Gericke, 2000; Brendler et al., 2003; Tapsoba and Deschamps, 2006; De Caluwe et al., 2009; Nguta et al., 2011).

From economic point of view, *A. digitata* L. make great socio-economic impact on the livelihoods of people living in the arid zones. The leaves of Baoba trees are staple for populations in Africa especially in the Sudano-Sahelian and central regions of the continent (Gebauer et al., 2002). During rainy season when the Baoba leaves are tender, people harvest the fresh batch of leaves for domestic consumption (Abelrumand, 2011). The fresh young leaves are used widely cooked as spinach, ground into powder and used over porridge, thick gruels of grains or boiled rice. Toward the end of rainy seasons, leaves of Baoba tree are harvested in abundance and are dried for domestic consumption and sold in the markets for income generation that sustains local livelihoods (Sidibi and Williams, 2002). This is evident from a report carried out in six local government areas in Katsina State in Nigeria where the results revealed that out of 240 people considered as sample population for the research,

23.33% use *A. digitata* as staple food, 32.58% as means of superstitious beliefs, 21.25% for protection, 13.33% for income generation and 9.25% for medicinal purposes (Shuaibu and Rabi, 2014).

The pulp of Baoba fruit is another new discovery which revealed that the fruit contained high percentage of vitamin C which is almost ten times that of *Citrus* (sweet orange) (Nguta et al., 2011). Another source revealed that vitamin content in the pulp of Baoba is very high ranging from 280 to 300 mg/100 g while orange is 51 mg/100 g (Manfredini et al., 2002). The consumption of 40 g of Baoba pulp provided 100% of the recommended daily intake of vitamin C in pregnant women (Chadare et al., 2009). It contained sugar but not starch and rich in pectin. It can be dissolved in water or milk and used as a drink, a sauce for food, a fermenting agent in production of local brewing or as a substitute for cream of tartar in baking (Juliani et al., 2009). The seeds of Baoba are used as thickening agent in soups, and can also be fermented to be used as a flavoring agent (daddawa) or roasted and eaten as snacks (Kabore et al., 2011). This study with available cultural or traditional information on multipurpose uses of *A. digitata* L. intended to scientifically carry out comparative laboratory analysis of nutritional content in the leaf, pulp and seed of Baoba tree.

MATERIALS AND METHODS

Questionnaire for survey study, field and laboratory studies were adopted for collection of data during the study.

Survey method

A well-structured questionnaire was adopted to extract information on demographic data and local consumption of *A. digitata* L. parts by different ethnics groups in Adamawa State.

Sample collection

The samples (leaves, pulp and seeds) were obtained from Jimeta modern market in Yola, Adamawa State from traders who sale wild plant products harvested from savannah lands in Northern region of Nigeria.

Sample preparation

The dried leaf samples obtained were prepared by pounding the leaves into powdery form using laboratory motor and pestle. The powdered samples were then sieved to fine texture using 0.005 sieves as described by Munthali and Mkunda (2002). The dried white pulp was also made ready for laboratory analysis by removing the pericarp (hard cover) of the fruit from the inner mesocarp (white pulp) by using stone on the hard ripe pericarp. This was followed by gently pounding the solid pulp to separate it from the seeds without destroying the seeds or avoiding mixing it with the pulp using motor and pestle. The seeds were separated from the powdered pulp by hand picking the seeds and the pulp powder was sieved using

0.005 to remove fibrous particles and fine powder texture was obtained as described in the treatment of leaf samples earlier stated. The separated seeds were soaked to easily remove the husks then washed and sun dried. The seeds were then pounded as described earlier and made ready for laboratory determination.

Laboratory analysis

The laboratory analysis was restricted into two analyses involving proximate and minerals profiles of nutrient groups and essential elements contained in the leaf, pulp and seed samples of *A. digitata* L.

Proximate analysis

Moisture content determination

The moisture content of each sample was determined using moisture analyzer model LSC 60D (Country origin). The analyzer was heated at 120°C and 5 g of each sample was put into the analyzer. After 10 min the samples were removed from the analyzer. Each of the samples was weighed and new weight values were subtracted from the old values (5 g) as described by AOAC (2005).

Ash content determination

The ash content of the samples was determined by the use of mechanical conventional oven and desiccator. The crucibles containing the samples were put inside the oven heated at 105°C for 15 minutes to remove the water content in the samples. The hot samples were then placed in a desiccator to cool. The charred samples were then transferred into muffle furnace for 3 to 4 h at 550°C at constant temperature. After heating, the ash in each crucible were carefully removed and put in the desiccator to cool and after which the ash content in each of the samples were weighed on weighing balance and finally determined (Onwuka, 2005).

Fat content determination

The fat content was determined using Soxhlet apparatus, the weight of 2 g of each samples were put on a filter paper and folded and tightened. This was then transferred into an extractor and an empty weighed extraction flask for each sample was mounted, respectively. Few drops of hexane were added to each sample in the extractor which was trapped with a liquid condenser to allow water to flow freely while the condenser was covered with a cotton wool. The oil was then extracted from each sample in the extraction flask which was weighed after cooling but the hexane was recovered in each samples. The readings of oil in extractor flask were recorded and fat content was determined (AOAC, 2005).

Crude fiber determination

The crude fiber content was determined in the samples adopting the method described by A OAC (2005). Two grams of each samples were put into three beakers, respectively and 2.5 ml of sodium hydroxide (NaOH) per 200 ml of water was added and boiled for 30 min. The solution of each sample was filtered through linen on a fluted funnel and washed with boiling water. The residue of each sample was then put into respective crucibles and dried in a mechanical oven and incinerated for minutes and cooled in a

desiccator. The crucibles were reweighed and readings were taken appropriately for crude fiber determination.

Protein content determination

The protein content was determined adopting method described by Onwuka (2005). Two grams of each samples were digested in 25 ml of sulphuric acid with two Kjeldahi tablets put into digestion tube and mounted on digestion apparatus. The mixture was heated to the temperature of 450°C till black to green cooler was observed. This was followed by steaming the mixture for 15 min in distillation apparatus under a condenser where 98 ml of water containing 2% of boric acid in such way that the condenser tip is under the liquid. This was followed by pipetting of 2 g of each sample via a funnel. This was washed down with distilled water, followed by adding 5 ml of 2% sodium hydroxide. Each sample was steamed for 5 to 7 min to collect enough ammonium sulphate. Each solution of the sample was collected in receiving flask for titration, respectively. For blank titration, 0.1N was used in 150 ml of water and 2 to 3 drops of methyl red indicator were used. The solution of each sample in their respective receiving flasks were titrated using 0.1N per 150 ml against 5 ml of boric acid and the readings were taken for final protein determination.

Minerals analysis

Determination of calcium, magnesium, manganese, iron, aluminium and copper

Determination of the minerals was done using atomic absorption spectrometer (Model, company, country origin) (Onwuka, 2005). About 1.0 g of the sample was first digested with 20 ml of concentrated HNO₃; per chloric acid, 20 ml concentrated H₂SO₄ and aliquots of the diluted clear digest were used for atomic absorption spectrophotometer using filters that match the different elements. This was followed by standard solutions preparation for elements under study. The concentrations of the elements were determined using calibration curves.

Determination of potassium and sodium

The two elements were determined using flame photometer as described by AOAC (2005) as cited by Onwuka (2005). The samples were prepared for atomic absorption spectrometry (Model, company, country origin); this was followed by an appropriate dilutions prepared from chloric acid digest for each sample. Each sample was analyzed through the instrument following the instructions provided in the manual. The determination of the elements was done by taking the absorption of Na at 767 nm while K was at 589 nm in line with their concentration standards.

Determination of phosphorus content

Phosphorus was determined in each samples by molybdate method using hydroquinone as a reducing agent as described by Onwuka (2005), followed by addition of 10.05 ml mineral digest, 1.0 ml of ammonium molybdate was allowed to stand for 30 min. Blue color was observed which was used for quantification at calorimeter reading at 660 nm against a standard curve.

Determination of nitrogen content

The Kjeldahl method as described by Onwuka (2005), 2 g of each

Table 1. Demographic data of the respondents.

Tribe	Sex		Educational Level					Age			
	M	F	Informal	FSLC	SSCE	ND/NCE	BSC	30-40	41-50	51-60	61-70
21 (00%)	80.95% (14)	19.05% (4)	19.05% (4)	9.52% (2)	14.39% (3)	14.39% (3)	42.86% (9)	33.33% (7)	28.57% (6)	28.57% (6)	9.52 (9)

Table 2. Survey on local consumption of Baoba tree parts among ethnic groups in Adamawa State

Part	Spice (%)	Medicinal (%)	Food (%)	Water Source (%)	Special Drinks (%)
Seed	66.67	0.00	33.33	0.00	0.00
Pulp	0.00	9.52	14.29	0.00	76.19
Root	0.00	19.05	8.33	8.33	0.00
Leaf	0.00	8.33	85.71	0.00	0.00
Stem	19.05	23.81	0.00	0.00	0.00
Flower	8.33	0.00	28.57	0.00	0.00

samples was weighed into a heating substance with sulphuric acid, which decomposed the organic substance by oxidation to liberate and reduce nitrogen as ammonium sulphate, followed by addition of potassium sulphate to increase boiling point of the medium from 337 to 373°C. This was followed by chemical decomposition of each sample where dark colored medium which gradually became clear and colorless. This was followed by distillation of each sample solution with small quantity of ammonia for blank titration.

Statistical analysis

The methods of data analysis adopted include use of simple descriptive statistics and two-way analysis of variance (ANOVA). The simple descriptive statistic was used to analyze demographic data and local consumption of *A. digitata* parts by different prominent ethnic groups in Adamawa State (Yelwa et al., 2014). The following expression was used to calculate percentage of the ethnic groups' consumption for each parameter under consideration.

$$n/N \times 100\%$$

where n = response on each parameter by all twenty one tribal group representatives and N = total number of tribal group representative (21) which is consonant.

RESULTS AND DISCUSSION

The demographic data in Table 1 unveiled that 21 ethnic groups in Adamawa State were used for the survey where 14 males and 4 females formed the respondents. The gender imbalance was as a result of poor access to women due to lockdown created by Covid-19 pandemic. Educational levels showed that four of the respondents had informal education, four primary school certificate holders, four senior secondary school certificate holders, four ND/NCE holders and nine with degree certificates

and above.

The data in Table 2 indicated that 66.67 and 33.33% of the ethnic groups in Adamawa State used seed as spices popularly called dawadawa, and fried as food, respectively while 19.05 and 8.33% used stem and flower to prepare local potash, respectively. 14.29 and 76.19% used pulp as food and special yoghurt drink, 8.33% eats the young roots as food, especially during famine period, while 19.05% root and 23.81% stems are used as medicinal. 85.71 and 8.33% used fresh leaves as food and medicine, respectively. 28.27% eat fresh flower of Baoba though reported only among children. This result agreed with the findings of Shuaibu and Rabi (2014), who opined that 56 out of 76 respondents obtained from six local government areas of Katsina State, Nigeria were reported to use Baoba as food.

Field survey reported during the interview revealed that pulp powder is applied on open wounds for faster healing and leaked for treatment of cough. While the stem and root barks are boiled and used for treatment of gastro-intestinal fungal infection among children below the age of three years and are also used for treatment of tooth infections. This followed the assertion that *A. digitata* L. is a small pharmacy because its parts (fruits and leaf) are used for treatment of numerous diseases in Africa which include asthma, allergic skin, paralysis conditions, mosquito repellent, diarrhea, malaria and cough (De Caluwe et al., 2009). In preparation of special drinks, 76.19% of the respondents established that local drinks like yoghurt can be prepared from pulp of Baoba fruit and Fulani ethnic group supplement cow milk with Baoba pulp in times of scarcity (Yaro et al., 2014).

The results of laboratory analysis for both proximate and minerals profile revealed that the parts of Baoba tree under study contained some amount of nutritional elements and other key classes of food that can support

Table 3. Proximate composition of the leaf, pulp and seed of *Adansonia digitata* L. (baoba tree).

Nutrient	Leaf (%)	Pulp (%)	Seed (%)
Moisture	9.02	10.12	8.06
Ash	11.00	6.30	7.00
Crude fiber	1.00	1.30	3.00
Fat	3.50	1.00	10.50
Crude protein	38.18	17.57	48.49
Carbohydrate	37.30	63.71	22.95

Table 4. Minerals profile in the leaf, pulp and seed of *Adansonia digitata* L. (Baoba tree).

Nutrient	Leaf (mg/l)	Pulp (mg /l)	Seed (mg/l)
Na	0.870	0.879	1.029
K	4.118	3.748	7.250
Ca	0.780	5.425	4.823
Mg	1.260	126.620	50.300
Fe	3.640	54.120	43.880
Mn	0.409	0.298	0.105
Al	0.006	0.006	0.004
N	0.278	0.366	0.454
P	0.162	2.944	2.494

nutrient requirement of the human body. This is evident in Tables 3 and 4. Table 3 shows that proximate composition results of the leaf, pulp and seed of *A. digitata* L. which showed higher content of protein amounting to 38.18, 17.57 and 48.49, respectively. The result obtained on protein in the three samples fell almost within same range (17.22 - 46.24%) with leaves of *Allium porrum* and *Spilanthes acimellia*, *Catsetum cernuum*, *Moringa oleifera* and cashew nut for crude protein (Abelrumand, 2011; Tapans et al., 2013). These figures are more than average daily body protein requirement for human beings because average sedentary man and woman need 56 to 91 g (5.6 - 9.1%) and 46 to 75 g (4.6 - 7.5%) per day, respectively. People like athletes, who engaged in vigorous activities need more proteins than the one required for average sedentary persons (Kris, 2018). The carbohydrate content showed similar results indicating 37.30, 63.71 and 22.95% in the leaf, pulp and seed samples, respectively. The figures are in agreement with results obtained on proximate composition of the leaves of *Hmyriatha* (60.02%), *Elaeis guineensis* (59.70%), *Abelmoschus esculentus* (55.23%), *Talinum triangulare* (50.59%), *Vernonia amygdalina* (62.1%) (Dike, 2010; Igwe et al., 2015). The moisture and ash contents in the three samples under study ranges between 6.30 and 11% but the crude fiber recorded the least in quantity ranging from 1 to 3%. The figures mentioned though lower but showed higher nutrients content as compared to the findings of Simon et al.

(2015) on four leafy vegetables (*Ficus thoninngii*, *Emillia coccinia*, *Hibiscus sabdariffa* and *Annona senegalensis*) commonly consumed in Benue State, Nigeria. The figures obtained for all the four plants indicated closed relation to crude fat content (0.05 - 0.716%), crude fiber (1.30 - 20.15%), and ash (1.06 - 2.37%) except for the values of carbohydrate (4.16 - 15.12%) and crude protein (0.03 - 0.33%) that are very low while moisture content (62.32 - 93.38%) appeared to be very high in the samples of Baoba under study. The ANOVA Table 5 indicated that there was significant difference in the content of nutrients in the three parts of *Adansonia digitata* L. and in each nutrient groups showed significant difference ($p < 0.05$).

The results of minerals profile in Table 4 revealed that leaf sample of potassium and iron recorded the highest with 4.118 and 3.640 mg/100 g, respectively, followed by magnesium 1.260 mg/100 g, sodium 0.870 mg/l and calcium 0.780 mg/100 g. These figures fell within normal range (0.11 - 3.00 mg/100 g) of standard values for leafy fruit tree analysis of pear, plum, apple, peach, cherry sour and cherry sweet for macro-minerals Na, K, Ca, Mg P and N (Joseph, 2004). The contents of manganese, aluminium, nitrogen and phosphorus ranged from 0.006 to 0.409 mg/l. The elements content in the pulp samples showed great variation from records observed in the leaf content. Magnesium and iron significantly recorded highest, amounting to 126.620 and 54.120 mg/100 g, respectively, followed by calcium 5.425, potassium 3.748 and phosphorus 2.944 mg/100 g while contents of

Table 5. ANOVA for hypotheses tests of between-subjects effects.

Dependent Variable: Nutrient Source		Type I Sum of Square	Df	Mean Square	F	Sig.
Treatment	Hypothesis	4990.015	3	1663.338	4.379	0.040
	Error	3189.644	8.397	379.838 ^a	-	-
Factor	Hypothesis	4280.791	5	856.158	6.043	0.008
	Error	1416.776	10	141.678 ^b	-	-
Treatment * Factor	Hypothesis	1416.776	10	141.678	-	-
	Error	0.000	0	. ^c	-	-

a. 0.333 MS(Factor) + 0.667 MS (Treatment × Factor); b. MS (Treatment × Factor); c. MS(Error).

Table 6. ANOVA table for hypothesis tests of between-subjects effects.

Source		Type I Sum of Squares	Df	Mean Square	F	Sig.
Treatment	Hypothesis	5566.796	3	1855.599	2.471	0.093
	Error	14146.516	18.841	750.843 ^a	-	-
Factor	Hypothesis	10451.972	8	1306.497	2.762	0.040
	Error	7568.267	16	473.017 ^b	-	-
Treatment × Factor	Hypothesis	7568.267	16	473.017	-	-
	Error	0.000	0	. ^c	-	-

a. 0.333 MS(Factor) + 0.667 MS (Treatment × Factor); b. MS (Treatment × Factor); c. MS(Error).

manganese, aluminium, nitrogen and sodium ranged between 0.006 mg/l and 0.879 mg/100 g. The seed sample also recorded significant changes in the quantity of elements in the pulp and leaf *A. digitata* L. where magnesium and iron recorded 50.300 and 43.880 mg/100 g, respectively. The high figures of Mg and Fe in the leaf and pulp samples agreed with this results (Mg=27.51 - 288.65 and Fe=16.43 - 39.04 mg/100 g) in the fluted pumpkin (*Oleifera occidentalis*), roselle plant (*Hibiscus sabdariffa*), smooth amaranths (*Amaranthus hybridus*), bitter leaf (*Veronia amygdalina*), India spinach (*Bosella alba*) and bush buck (*Gongronema latifolia*) (Asaolu et al., 2012), followed by potassium 7.25 mg/l, calcium 4.823 mg/l, and phosphorus 2.494 mg/l. The elements in the seed of *A. digitata* L. recorded with lower content included aluminium 0.004 mg/g, nitrogen 0.454 mg/g, and manganese 0.105 mg/l. The ANOVA Table 6 indicated that there is no significant difference ($p > 0.05$) in the minerals distribution in the three parts of *A. digitata* L. but in between the elements, there is significant difference ($p < 0.05$).

Conclusion

The scientific and survey studies carried out on *A. digitata* L., showed it can be established that the three

parts (leaf, pulp and seeds) of the plants studied contained important nutrient groups and minerals that are good for human consumption and can also be supplements for improving human dietary intake.

RECOMMENDATIONS

Considering the huge potentials discovered in Baoba tree, there is need to harness these resources for sustainable livelihoods through adopting appropriate policies and laws that will ensure both *in situ* and *ex situ* conservation of *A. digitata* L. in savannah regions of the world. The samples studied can be harvested by food production industries for better standard processing methods that will guarantee better markets for income generation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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