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Research Article

THE EFFECT OF STORAGE ON THE NUTRITIONAL VALUE OF *ADANSONIA DIGITATA* L. LEAVES

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ABSTRACT

Adansonia digitata L. leaves are used as vegetables in some parts of Africa. However, the leaves are not available all-year-round, so they are usually harvested, dried, and stored. In this research, the effect of storage on some nutritional components of *Adansonia digitata* leaves was studied. Proximate constituents, antinutrients, vitamins and minerals of leaves were determined using appropriate methods at week 0 (immediately after preparation of sample) and week 4 (after storage). Student's T-test was used to compare the means of the various parameters measured at week 0 and week 4. The results revealed that powdered dried *Adansonia digitata* leaves was still viable as a good source of nutrients after four weeks of storage and some of its nutritional constituents were even improved.

Keywords: *Adansonia digitata, antinutrients*, minerals, nutritional value, proximate, storage, vitamins

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1. INTRODUCTION

Green vegetables of which the leaves of *Adansonia digitata* L. (Baobab) are used as such in some regions, are affected by seasonal weather variations, they thrive well in the rainy season but become scarce and costly during the dry season [7]. After harvest they lose their quality very quickly due to rapid loss of moisture, this results to the wastage of a large quantity of vegetables (estimated to be about 50 % for developing countries). Other factors responsible for wastage include: poor handling, microbial infestation, storage, transportation, and marketing [21]. Since vegetables are a rich source of micronutrients which are needed for normal metabolic functions, a large amount of cheap nutrition is lost in developing countries where it is mostly needed [26].

Adansonia digitata belongs to the Malvaceae family and has been recognized as an underutilized crop in Africa. It is usually a giant tree with swollen stem, stout branches that are tortuous in nature, scanty palmate leaves and large pendulous shaped fruits [23]. The fruits possess a velvet outer coat which vary from green to brown and cause an itch when it comes in contact with the skin [11]. It is commonly called Boabab (in English) *Kuka* (in Hausa), *Ose* (in Yoruba) *Igiose* (in Igbo), *Ibobo* (in Igala).

The leaves, bark and fruit of Baobab are useful as food and medicine in various parts of Africa. Baobab (*Adansonia digitata)* leaves are used throughout Africa either as fresh leaves or dried in the sun [1]. The dried powdered leaves is a staple food in the Sahel, the Hausas in Northern Nigeria use it to make a special soup known as "*Miyan Kuka*". The leaves are a potential protein source which could be used to improve the overall protein quality of local diet. Baobab leaves are also significant sources of minerals [17; 6]. It has been reported to be an important source of iron [23], and has a higher iron content than various other wild – gathered foods, and are a good source of calcium [17].

The leaves have been reported to possess anti-asthmatic, antihistamine and anti-tension properties [23]. It has also been reported that the leaves possess anti-oxidant properties [25]. They are used traditionally in Africa to treat various ailments including, dysentery, urinary tract infections, internal pains, insect bites, guinea worm, ophthalmia and otitis, fatigue and as a tonic in some parts of Africa [23].

The plant is known to endure seasonal fluctuations thereby providing families with adequate nutrients and energy [27]. Due to the increasing demand of food to support the ever growing world population, researchers are directing their efforts towards exploring alternative and underexploited sources of food such as Baobab, which grows in the arid and semi-arid parts of the world [23; 5; 27]. Baobabs are drought resistant and tend to survive under high temperatures and are grown for their sour fruit and leaves [14]. Limited research have been done to evaluate the actual constituents of the leaves. All Baobab trees are deciduous, losing their leaves in the dry seasons, and remain lifeless for about nine months of the year [10], as a result the leaves are harvested and stored for long periods. This work seeks to evaluate the effect of storage on the nutritional value of *Adansonia digitata* leaves.

2. RESULTS AND DISCUSSION

After four weeks of storage the results showed that there was a significant difference ($p \leq 0.05$) in the nutritional value of leaves of *Adansonia digitata.*

2.1 Proximate Composition

After four weeks of storage, there was a significant difference ($p \leq 0.05$) in the proximate composition (%) for all components except for crude fibre. Their moisture and carbohydrate contents decreased significantly ($p \leq 0.05$), while that of ash, crude fat and crude protein increased significantly ($p \leq 0.05$) (Table 1).

The moisture content reduced from 10.80 % at week 0 to 8.95 % at week 4, representing an index of good storage quality (has an increased shelf-life). It is known that loss of moisture improves digestibility, increases concentration of nutrients, and can make some nutrients more available [24].

The carbohydrate content reduced significantly from 51.30 % at week 0 to 47.35 % at week 4. The reduction in carbohydrate content may be due to extended respiratory activity during storage at relatively higher temperatures [16]. Even though there was a reduction in carbohydrate content in stored sample, the value is considered to be sufficient and therefore an indication that it could still be an important source of dietary calories.

The ash content of the sample increased significantly ($p \leq 0.05$) from 12.05 % at week 0 to 13.08 % at week 4. The increase in ash content may be due to the decrease in moisture content.

The shelf life of food has been reported to improve with drying, along with an increase in dry matter [13]. An increase in ash content is also an indication of an increase in the mineral content [22].

The fat content was observed to significantly ($p \leq 0.05$) increase from 4.68 % at week 0 to 5.45% at week 4. The increase in fat content represents a good index of storability. It shows that stored dried powdered *Adansonia digitata* leaves had high resistance to lipids oxidation [22].

Table 1: Proximate composition of *Adansonia digitata* leaves at week 0 and week 4

Proximate composition	**Week 0**	**Week 4**	***p* - value**
Moisture (%)	10.80 ± 0.00	8.95 ± 0.07	0.001*
Ash content (%)	12.05 ± 0.07	13.08 ± 0.11	0.008*
Crude fibre (%)	12.42 ± 0.03	12.60 ± 0.14	0.220
Fat content (%)	4.68 ± 0.03	5.45 ± 0.07	0.005*
Crude protein(%)	8.91 ± 0.04	12.58 ± 0.09	0.000*
Carbohydrate (%)	51.30 ± 0.16	47.35 ± 0.48	0.008*

Values are Mean ± SD, * significantly different ($p \leq 0.05$)

There was a significant increase in the protein content from 8.91 % at week 0 to 12.58 % at week 4. The mild heating effect associated with the storage of dried powdered *Adansonia digitata* leaves may have resulted in the unzipping of hydrophobic forces leading to a partial distribution of primary, secondary, tertiary and quaternary structure of protein molecules, thereby leading to the overall increase in the protein content [19]. The high protein content of the leaves makes it good for body building (for growth and repair of worn out cells and tissues), especially in children [7].

There was no significant difference ($p > 0.05$) in the crude fibre present in the samples at week 0 and week 4. This implies that storage had no significant effect on the crude fibre content of dried powdered *Adansonia digitata* leaves. Fibre is an essential part of diet that enhances bowel movement and helps in cleansing the digestive tract [2].

2.2 Antinutrients

The results on the antinutrional components (Table 2) showed the presence of tannin, oxalate and phytate. Tannin significantly increased from 4.51 mg/g at week 0 to 7.84 mg/g at week 4. The oxalate reduced from 7.57 mg/g at week 0 to 7.06 mg/g after four weeks of storage. The phytate significantly increased from 0.59 % to 0.67 %. Antinutrients such as phytates and oxalates have been reported to reduce the bioavailability of iron and other minerals, and as a result has detrimental effects on the health of individuals mostly those malnourished or at risk, while tannin have been reported to be responsible for decrease in food intake, growth rate, food efficiency, net metabolizable energy and protein digestablity [8].

Table 2: Antinutrient (Tannin, oxalate and phytate) content of *Adansonia digitata* leaves at week 0 and week 4

Antinutrient	Week 0	Week 4	*p* - value
Tannin (mg/g)	4.51 ± 0.03	7.84 ± 0.04	0.000*
Oxalate (mg/g)	7.57 ± 0.01	7.06 ± 0.01	0.000*
Phytate (%)	0.59 ± 0.01	0.67 ± 0.00	0.015*

Values are Mean ± SD, * significantly different ($p \leq 0.05$)

2.3 Vitamins

The results on table 3 shows that the concentration of vitamin A and C reduced significantly ($p \leq 0.05$). Vitamin A reduced significantly from 1.68 mg/g to 0.71 mg/g after four weeks of storage. Vitamin A is relatively more stable in other foods but is known to be readily lost in leafy vegetables [16]. Vitamin C significantly reduced from 4.70 mg/g to 4.34 mg/g. Vitamin C (ascorbic acid) is very sensitive to loss and is oxidized easily into a less active form (dehygro-ascorbic acid) by the enzyme ascorbic acid oxidase as a result of time and temperature in storage [16; 15].

Table 3: Vitamin (A and C) content of *Adansonia digitata* leaves at week 0 and week 4

Vitamins	**Week 0**	**Week 4**	***p* - value**
Vitamin A (mg/g)	1.68 ± 0.04	0.71 ± 0.03	0.001*
Vitamin C (mg/g)	4.70 ± 0.06	4.34 ± 0.04	0.016*

Values are Mean ± SD, * significantly different ($p \leq 0.05$)

2.4 Minerals

The mineral composition shown in table 4 indicates that the leaves are rich in minerals and that there was a significant difference ($p \leq 0.05$) in the mineral content of leaves after four weeks of storage. Sodium, potassium and iron reduced significantly ($p \leq 0.05$) from 68.50 ppm to 65.15 ppm, 115.65 ppm to 113.65 ppm, and 48.20 ppm to 46.19 ppm respectively. Magnesium, Calcium and Phosphorus increased significantly from 208.00 ppm to 210.00 ppm, 674.20 ppm to 680.60 ppm and 113 ppm to 117.38 ppm respectively. Kramer (1977) [16] reported that storage generally had a minimal effect on mineral content of foods, however the bioavailability, especially of iron, may be affected by prolong storage. The result obtained showed that calcium was the most abundant mineral in the leaves when compared to other minerals present with values ranging from 674.20 ppm at week 0 to 680.60 ppm at week 4. Thus, baobab leaves are a good source of calcium which makes it highly beneficial to pregnant women, lactating women, and children. Calcium and potassium are associated with the development of strong bone, muscles and teeth. Magnesium helps in the Calcium metabolism in bone, it is also an important mineral element associated with the proper functioning of the circulatory system. Iron is needed for the formation of haemoglobin and its deficiency may result to anaemia [20].

Table 4: Mineral content (Na, K, Mg, Ca, Fe and P) content of *Adansonia digitata* leaves at week 0 and week 4

Minerals	Week 0	Week 4	*p* - value
Na (ppm)	68.50 ± 0.14	65.15 ± 0.07	0.001*
K (ppm)	115.65 ± 0.35	113.65 ± 0.21	0.021*
Mg (ppm)	208.35 ± 0.21	210.00 ± 0.00	0.008*
Ca (ppm)	674.20 ± 0.14	680.60 ± 0.28	0.001*
Fe (ppm)	48.20 ± 0.14	46.19 ± 0.02	0.003*
P (ppm)	113.00 ± 0.00	117.38 ± 0.11	0.000*

Values are Mean ± SD, * significantly different ($p \leq 0.05$)

3. MATERIALS AND METHODS

3.1 Plant Collection and Preparation of Sample

Fresh and matured leaves were obtained from a tree in Samaru Zaria, Nigeria (Lat. 11°14′ N, Long. 7°72 ′ E) in March 2019. The leaves were washed and dried to remove all dirt. The leaves were sundried, grounded to powder, stored in an air tight black polyethylene bag and kept at room temperature.

3.2 Determination of Nutritional Components

The proximate constituents (moisture, ash, crude fibre, fats, proteins, and carbohydrates), antinutrients (tannins, oxalate and phytate), vitamins (vitamins A and C), and minerals (Na, K, Mg, Ca, Fe, and P) of the sample were determined using standard methods. Parameters were measured at week 0 (immediately after preparation of sample) and week 4 (after storage). All experiments were carried out in duplicates.

3.3 Determination of Proximate Composition

The proximate composition (moisture, crude lipid, crude protein crude fibre, ash and carbohydrate) of the sample were evaluated according to the methods of AOAC (1990) [3; 4]. The percentage difference in weight of sample after oven drying at 100°C to a constant weight was used to evaluate the moisture content. The percentage difference in weight of sample after been calcined in a furnace at 550°C for 8 hours was used to evaluate the ash content. The direct solvent extraction method using soxhlet apparatus was used to evaluate the crude lipid content. The micro – kjeldahl method was used to evaluate the crude protein content. The percentage difference in weight of samples after digesting in sulphuric acid and sodium hydroxide, and calcination, was used to evaluate the fibre content. All other proximate values were added and subtracted from 100 to get the Carbohydrate content.

3.4 Determination of Antinutrients

Oxalate : Total oxalate was evaluated using the method of Fasset (1996) [12]. One gram (1g) of sample was soaked in 100 ml of distilled water and allowed to stand for 3 hours and filtered through a double layer of filter paper to obtain oxalate extract. Standard solutions of oxalic acid (ranging from 1 – 10pmm) were prepared, their absorbances were measured using a spectrometer at 420 nm, and a standard curve was drawn. The absorbance of filtrate from the sample was also read on the spectrophotometer (Spectronic 20) and its concentration was determined using the standard curve.

Phytate : Phytate was evaluated according to the method of Maga (1993) [18]. Two grams (2 g) of sample was measured and soaked in 100 ml of 25% concentrated hydrochloric acid in a conical flask, it was allowed to stand for 3 hours, and filtered through a double layer of hardened filter paper. Fifty millilitres (50 ml) of the filtrate was poured into a 250 ml beaker and 100 ml of distilled water was added to make it acidic, and 10 ml of 0.3% ammonium thiocyanate solution was added which served as an indicator. This was then titrated against a standard iron (II) chloride solution which contained 0.00495 g of iron per millilitres. The end point was a slightly brown yield, which lasted for about 5 minutes.

Tannin was determined according to the method of Dawra *et al.*, (1988) [9]. About 0.2g of sample was measured into a beaker, soaked with solvent mixture (80ml acetone and 20ml glacial acetic acid), and allowed to stand for 5 hours, and filtered through a double layer of filter paper to obtain tannin extract. Standard solutions of tannic acid was prepared ranging from 0 – 10 ppm, their absorbance was measured at 720 nm using a spectrophotometer (Spectronic 20), and a standard curve was drawn. The absorbance of the filtrate was also read at 720 nm spectrophotometer (Spectronic 20), and its concentration was determined using the standard curve.

3.5 Determination of Vitamins

Vitamin A: One gram (1 g) of the sample was measured and soaked in 20 ml of n-hexane in a test tube and allowed to stand for 10 minutes. Three millilitres (3 ml) of the supernatant was poured into a dry test tubes and evaporated to dryness. After this, 0.2ml of acetic anhydride chloroform reagent, and 2ml of 50% trichloroacetic acid (TCA) in chloroform were added. The absorbance was measured using a spectrophotometer (Spectronic 20) at 15 seconds and 30 seconds intervals at 620nm according to the methods of AOAC (1990; 2010) [3; 4].

Vitamin B: About 0.5g of the sample was measured and soaked in 10 ml of 0.4% oxalic acid in a test tube and allowed to stand for 10 minutes, centrifuged for 5 minutes and the resulting solution filtered. One milliliter (1 ml) of the filtrate was poured into a dry test tube, 9 ml of 2,6- dichlorophenol indophenol was added, and the absorbance was measured using a spectrophotometer (Spectronic 20) at 15 seconds and 30 seconds interval at 520 nm according to the methods of AOAC (1990, 2010) [3; 4].

3.6 Determination of Mineral Elements

Mineral analysis were determined from solution obtained by first dry-ashing the samples at 550°C and dissolved in the ash in 10% HCL filtered and make up to 50mls in a volumetric flask using deionised water and the different elements (Na, K, Mg, Ca, Fe, and P) were determined separately using Atomic absorption spectrophotometer (Varian company USA) according to the methods of AOAC (1990; 2010) [3; 4].

3.7 Statistical Analysis

Student's T-test was used to compare the means of the different parameters measured at week 0 and week 4 of the experiment. Values were expressed as mean ± SD (Standard deviation); results were considered significance at $p \leq 0.05$. Data was analyzed with Statistical Software for Social Sciences (SPSS Version 20) developed by International Business Machines (IBM).

4. CONCLUSION

It can be concluded from this study that storage had a significant effect on the nutritional value of dried powdered *Adansonia digitata* leaves. For the proximate constituents, there was a significant ($p \leq 0.05$) decrease in the moisture and carbohydrate content, while there was a significant ($p \leq 0.05$) increase in the ash, fat, and crude protein content, after four weeks of storage. There was no significant ($p > 0.05$) difference in the Crude fibre content after four weeks of storage. For the antioxidants, there was a significant ($p \leq 0.05$) decrease in concentration of oxalate, while there was a significant ($p \leq 0.05$) increase in that of tannin and phytate, after four weeks of storage. For the vitamins, there was a significant ($p \leq 0.05$) decrease in vitamin A and C, after four weeks of storage. For the minerals, there was a significant ($p \leq 0.05$) decrease in the concentrations of Na, K and Mg, while there was a significant ($p \leq 0.05$) increase in that of Ca, Fe and P after four weeks of storage. Even though storage (after four weeks) resulted in a significant decrease in most of the nutritional constituents of powdered dried *Adansonia digitata* leaves, it was still viable as a good source of nutrients. In fact, storage resulted in the improvement of some of its nutritional constituents such as the fat, protein, Mg, Ca, and P.

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