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Phytochemical, Elemental and Proximate Analyses of Stored, Sun-Dried and Shade-Dried Baobab (*Adansonia digitata*) Leaves

Chukwuma C. Ogbaga[*1], Fatima A. Nuruddeen[1], Olatunbosun O. Alonge[2], Onyinye F. Nwagbara[1]

[1]Department of biological sciences, Nile University of Nigeria, Abuja, Nigeria
[2]Department of biological sciences, Baze University, Abuja, Nigeria
chukwuma.ogbaga@nileuniversity.edu.ng

***Abstract*— Baobab (*Adansonia digitata*) leaves are usually used in dry form in the preparation of a soup known as 'miyan kuka' in Northern Nigeria. The leaves are believed to have nutritional and medicinal benefits and have been used for those purposes in Africa and Asia. However there has been limited research on the detailed constituents of the dry leaves. In this study, phytochemical, elemental and proximate analyses of stored, sun and shade-dried baobab leaves were conducted. The results revealed a great variation in the nutritional contents of the leaves. The study reveals that the leaves are rich in phytochemicals such as glycosides, saponins, steroids and flavonoids while alkaloids, tannins and resins are absent. Also, they are important source of minerals such as zinc, copper, iron and manganese. In addition, they are rich in fibre, crude protein, nitrogen and ash. Contrasting responses were obtained in the samples studied. The implications of these responses are discussed in relation to crop yield.**

Keywords—baobab; phytochemistry; elemental constituents; proximate analysis; nutrition

I. INTRODUCTION

Green vegetables are susceptible to seasonal weather fluctuations, growing well in the rainy season and usually scarce and costly during the dry season. They lose their quality very rapidly after harvesting due to rapid loss of moisture. As a result, during peak periods, a large proportion of vegetables estimated to be about 50% for developing countries are wasted [1]. Other factors that contribute to waste are microbial infestation, inefficient handling, transportation, storage and marketing [1, 2]. Since these vegetables are possible sources of micronutrients which are especially necessary for normal metabolic functions, a great deal of cheap nutrition is lost in developing countries where it is mostly needed.

Baobab (*Adansonia digitata)* leaves are used throughout Africa either as fresh leaves or dried in the sun [3]. The plant is known to survive seasonal fluctuations providing families with adequate nutrients and energy [4, 5]. In view of the increasing demand for adequate nutrients and energy to support the growing world population, researchers have directed their efforts at exploring new and underexploited sources of food such as Baobab that grow in the arid and semiarid land parts of the world [5-7]. Baobabs are resistant to high temperatures and long continuance of drought, and are grown for their sour fruit and leaves [8, 9]. However, limited reports have evaluated the actual constituents of the leaves. The aim of this research was to ascertain the phytochemical, proximate and elemental composition of baobab leaf powder. The study focused on ground baobab leaves that were stored, dried under the sun or shade which were analysed during the harmattan season.

II. MATERIALS AND METHODS

A. General Experimental Procedures

The metals were determined using Atomic Absorption Spectrophotometer 205 (Buck Scientific, East Norwalk, Connecticut). The specifications, settings and manufacturers' operational conditions were followed. Analytical grade reagents and metal stock standards (1000 mg/L) were purchased from Sigma-Aldrich (Dorset, United Kingdom).

B. Collection and Identification of Samples/Plant

Young and large fresh Leaves of *Adansonia digitata* were collected from the tree situated at Garki 2, Abuja Municipal Area Council (AMAC) Unguwar Hausawa, Apo, FCT, Abuja. The leaves were identified by Biological Science Department herbarium, Nile University of Nigeria, FCT, Abuja. The samples analysed in this study were grouped into three: stored, sun-dried and shade-dried sample. All analyses were performed in the research laboratory in new site, Faculty of Agriculture, Bayero University, Kano State, Nigeria.

C. Preparation of Samples/Plant Materials

The fresh leaves of *Adansonia digitata* collected were washed under running tap water and drained to remove dust particles. The fresh leaves were subsequently separated into 2 portions of 50g each (4 replicates) i.e. a total of 200g per portion. To obtain shade dried samples, the leaf tissues (first portion) collected were spread in shade where there was no exposure to sunlight. The second portion was dried under the sun. Both samples were dried for 7 days. The sun and shade dried leaves were ground separately in a ceramic mortar and pestle into a powdered form. The grinding was repeated continuously until a fine powder was obtained to ensure homogeneity. Both samples were sieved separately through fine mesh sieves to remove any remaining residue. The ground and sieved powder was then transferred into air tight plastic containers and brought to laboratory and labelled accordingly. For the stored sample, it was collected and kept at home at room temperature for five months. 50g each i.e. a total of 200g of the stored samples was also ground and sieved as performed earlier for sun and shade-dried leaves.

D. Preparation of Plant Extract

A sample of 5g of each powdered plant material was soaked in 100ml of distilled water for 48hrs. The solution was filtered using approximately 11cm diameter whatman filter paper. The extract was subsequently collected after 24hrs and immediately used for phytochemical analyses [10].

E. Phytochemical Screening

The extracts were screened for alkaloids, glycosides, saponins, tannins, steroids, resins and flavonoids using qualitative method according to Hassan, et al. [10] and El-Mahmood and Doughari [11] as follows:

1) Test for alkaloids

1ml of 1% Hcl was added to 3ml of the extract. The mixture was treated with few drops of Meyers reagent. A creamy white precipitate indicated the presence of alkaloids [11].

2) Test for glycosides

2 ml of acetic acid was added to 1 ml of the extract and then cooled in an iced bath at 40°C. 1 ml of concentrated tetraoxosulphate (vi) acid (H_2SO4) was added drop-wise to the mixture. The formation of oil layer on the top of the solution indicated the presence of glycosides [11].

3) Test for saponins

5 drops of olive oil were added to 2ml of the extract. The formation of a stable emulsion in each extract indicated the presence of saponins [10].

4) Test for tannins

2 drops of 5% $FeCl_2$ were added to 1ml of the extract. A dirty green precipitate indicated the presence of tannin [10].

5) Test for steroids

1ml of concentrated tetraoxosulphate (vi) acid (H_2SO4) was added to 1ml of the extract. A red coloration indicated the presence of steroids [10].

6) Test for resins

5 ml of copper acetate solution was added to 5ml of the extract. The mixture was shaken vigorously and then allowed to separate. A reddish-brown precipitate indicated the presence of resins [11].

7) Test for flavonoids

3 drops of ammonia solution was added to 1ml of the extract. 0.5 ml of concentrated Hcl was further added to the mixture. A pale brown coloration indicated the presence of flavonoids [11].

F. Elemental Analyses

The elemental analyses were determined using Atomic Absorption Spectroscopy analysis (AAS) in plant samples by ashing procedure. Wet digestion method was used to determine Zn, Cu, Fe, Mn in the three samples according to Koirtyohann [12].

G. Proximate Analyses

Ash, moisture, crude protein, crude fibre, nitrogen free extra and fat (ether ester) were determined in the three samples according to the methods of Association of Official Analytical Chemists [13, 14].

H. Statistics

Statistical analyses were performed using SPSS STATISTICS 20 software (IBM United Kingdom, Portsmouth, UK) to determine if there are differences between the sample types. Where significance was indicated, a One-Way ANOVA with a Tukey post-hoc test was conducted. Different letters represent significant differences at $P<0.05$.

III. RESULTS AND DISCUSSION

Baobab leaves are staple food for many people in Africa particularly in the Central region of the continent [15]. In Northern Nigeria, the leaves usually dried are used for a soup known as miyan kuka [5]. In order to improve the nutritional contents of baobab-derived foods and enhance the crop yield, there is need to understand the phytochemical, elemental and proximate contents of the leaves dried differently. In this study, baobab leaves that were sun-dried, shade-dried and stored were analysed and compared for the aforementioned contents.

The results obtained revealed a great variation in the nutritional contents of the leaves. According to Chadare, et al. [16], the variations might be due to the quality, age and the origin of the sample. It might also be due to the treatment before analysis, storage condition, processing methods, soil structure, chemical composition of the soil, and also genetic variation [17].

Fig. 1 Freshly cut *Adansonia digitata* leaves. Leaves were collected from the tree situated at Garki 2, Abuja Municipal Area Council (AMAC) Unguwar Hausawa, Apo, FCT, Abuja.

A. Phytochemical Constituents

The result of the phytochemical screening presented in table 1 showed that baobab leaf powder (stored, sun-dried & shade-dried) are rich in the phytochemicals- glycosides, saponins, steroids, and flavonoids while alkaloids, tannins, and resins were absent. The phytochemicals are found in plant cells and are very crucial in the maintenance of electrolyte level, antioxidant activities and protection against infections [5]. Alkaloids have a wide range of pharmacological activities (including antimalarial and antibacterial) while glycosides are stored in the gut flora where they may have a beneficial effect in animals perhaps in cholesterol reduction [5, 18]. The presence of the highest number of glycosides specifically cardiac-glycosides in shade-dried samples relative to other samples suggest that the former have higher cholesterol lowering properties (Table 2). Similarly, steroids which were also detected have been reported to be involved in cholesterol reduction and may possess a hypocholesterolemic activity in mammals [18]. Further, steroids are believed to increase the tolerance of crops to abiotic stress [19]. Saponins are thought to have antimicrobial, anti-inflammatory, anti-oxidant and immune-stimulating properties. In addition, ubiquitous flavonoids which have high antioxidant properties were detected in the samples with the highest amount found in shade-dried samples. The presence of saponin and flavonoids suggest that the samples may be beneficial in the reduction of cancer risk and heart diseases [20]. Tannins and resins known to have bitter antioxidant properties and herbivory roles (to prevent entrance of pathogens) respectively were however absent in the samples studied [21, 22].

Table 1. Qualitative phytochemical analysis of *Adansonia digitata* leaf powder
Keys: Gly = Glycoside Sap = Saponin Ste = Steroid Flav = Flavonids Alk =Alkaloid Tan = Tannin Res = Resin. + = Present - = Absent

Sample ID	Gly	Sap	Ste	Flav	Alk	Tan	Res
Stored	+	+	+	+	-	-	-
Sun-Dried	+	+	+	+	-	-	-
Shade-Dried	+	+	+	+	-	-	-

Table 2. Quantitative phytochemical analysis of flavonoids, cardiac glycosides and saponins detected in *Adansonia digitata*

Sample ID	Cardiac Glycosides (%)	Saponins (%)	Flavonoids (%)
Stored	0.17^{a}	0.24^{a}	0.15^{a}
Sun-Dried	0.09^{b}	0.25^{a}	0.12^{b}
Shade-Dried	0.33^{c}	0.21^{b}	0.22^{c}

B. Elemental Composition

For the elemental composition of *A. digitata*, zinc, copper, iron, and manganese were analysed. The elemental composition shown in table 3 overall indicated that the leaves are important source of minerals. Specifically, the result obtained showed that the stored sample had the least proportion of zinc but the highest copper content. The sun-dried sample on the other hand had the highest proportion of zinc and manganese but the least iron content (table 3). The shade dried sample had the highest iron content and the least copper content. Comparatively, in all the three samples, zinc, copper, iron and manganese were markedly detected. Since iron deficiency (anaemia) is common in African region where baobabs grow, the leaves represent an important source of iron [17, 23]. The result suggests that shade-drying is the most appropriate method for optimal iron content. According to Glew, et al. [4], the mineral contents of dry baobab leaves constitute 18.7 µg/g zinc, 20,000 µg/g copper, 155 µg/g iron and 31 µg/g manganese. Baobab leaves are valuable and important in the diet of urban and rural people. They are also good sources of iron, zinc and copper unlike the seed and fruit pulp [24]. A serving portion (30g dry weight leaves) contributes 62.7%, 45%, 84.4%, and 106% to the recommended dietary allowance (RDA) of zinc, copper, iron and manganese respectively [25]. Thus, baobab leaves are a good source of zinc and calcium for children, pregnant woman and lactating women [15].

C. Proximate Analysis

The proximate analysis of *A. digitata* shown in table 4 revealed that the stored sample had the highest proportion of moisture, crude protein, crude fiber and ether extract but the least nitrogen free extra content. In contrast, the sun-dried sample had the least ash, moisture, crude protein and ether extract content but the highest nitrogen free extra. The shade dried sample on the other hand had the least crude fibre content and highest ash content. This result is consistent with the work of Abiona and co-workers which showed that baobab leaf is rich in fiber (2.45%) and protein (13.6 %) [26]. The presence of fiber has been explained to contribute to the reduction of cardiovascular disease and lowering of high blood cholesterol [26]. Other reports in the literature revealed that baobab leaf contains 13-15% protein, 16% ash, 3-10% fat and around 11% fibre which are again consistent with our data and with the leaf being a pool of essential growth and storage compounds [7, 27].

Table 3. Elemental composition of *Adansonia digitata* leaf powder in (mg/kg/dry weight)
Keys: Zn= Zinc Cu= Copper Fe= Iron Mn=Manganese

Sample ID	Zn	Cu	Fe	Mn
Stored	2.941[a]	6.758[a]	19.231[a]	1.25[a]
Sun-Dried	7.353[b]	5.405[b]	17.308[b]	2.50[b]
Shade-Dried	4.412[c]	4.054[c]	21.150[c]	1.25[c]

Table 4. Proximate composition of *Adansonia digitata* leaf powder in percentage
Keys: Ash = Ash Mt = Moisture CP = Crude protein CF = Crude fibre Ee = Ether extact NFE = Nitrogen free extract

Sample ID	% ASH	% MT	% CP	% CF	% Ee	% NFE
Stored	4.88[a]	12.24[a]	13.02[a]	3.07[a]	2.31[a]	76.72[a]
Sun-Dried	3.92[b]	7.82[b]	11.55[b]	2.97[b]	1.98[b]	79.59[b]
Shade-Dried	5.42[c]	8.91[c]	12.15[c]	2.48[c]	2.06[c]	77.89[c]

IV. CONCLUSIONS

It has been shown that baobab leaves are a pool of essential and protective compounds and minerals. Understanding the endogenous levels of these compounds and minerals could be beneficial in improving the nutritional quality of baobab. Future work could focus on studying mutants of this important food crop as this would undoubtedly add to scientific knowledge which could enhance the improvement of the nutritional quality and yield of the crop. Also, more attention should be given to accuracy and precision of the drying methods used in the analyses of the plant. In other words, the treatment before analysis, storage conditions and processing methods should be considered. In addition, the origin, quality and age of sample should be well known and identified before analysis. Further research should be carried out on the medicinal properties of baobab leaves and other parts of the trees.

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