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Research Application Summary

The nutrient diversity of baobab *Adansonia digitata* L. across different geographic zones in Eastern Africa

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Abstract

Food and nutrition insecurity is a common occurrence in arid and semi-arid regions of sub-Saharan Africa, with communities resorting to wild foods and forest products such as baobab in times of scarcity, to derive energy and nutrition. The nutrient dense baobab pulp is accepted in the US and European Union markets as a food ingredient, with potential to curb micronutrient deficiencies, while generating income to stakeholders, and reaching wider markets if value added. Demand for nutrient and safety information on baobab is rising following increased uptake and growing commercialization. Information on nutrient quality of baobab in East Africa is currently limited. The objective of this study was to profile the nutrient composition of baobab pulp in specific locations in Sudan and Kenya for potential utilization as a superfood. Information based stratified sampling for high baobab density was done for fruit collection. Fruit pulp was analysed for Vitamin C, antioxidant capacity, total phenols and flavonoids using HPLC, DPPH, Folin Ciocalteau and flavonoid-aluminium chloride complexation methods, respectively. Vitamin C content ranged between 17.34 - 401.17 mg/100g. The means were 271.2, 243.98, 181.6 and 113.1 mg/100 for North and west Kordofan regions of Sudan, and Kitui and Kilifi counties in Kenya, respectively. The IC50 value of methanolic extract ranged between 0.5- 2.5 mg/ml. Higher variations were observed between than within locations for all parameters tested. The total phenols and flavonoids followed similar trends. These findings point towards existence of localized baobab morphotypes, a high environmental influence on the nutrient content of baobab pulp and ability to confer health benefits.

Key words: Antioxidant capacity, baobab, Eastern Africa, flavonoids, vitamin C

Résumé

La pulpe de baobab dense en nutriments est acceptée sur les marchés des États-Unis et de l'Union européenne comme ingrédient alimentaire, avec le potentiel de réduire les carences en micronutriments, tout en générant des revenus pour les parties prenantes et en atteignant des marchés plus larges si la valeur y est ajoutée. La demande d'informations sur les nutriments et l'innocuité du baobab est en train d'augmenter à la suite d'une absorption accrue et d'une commercialisation croissante. Les informations sur la qualité nutritive du baobab en Afrique de l'Est sont actuellement limitées. L'objectif de cette étude était de profiler la composition nutritive de la pulpe de baobab dans des endroits spécifiques au Soudan et au Kenya pour une utilisation potentielle comme superaliment. Un échantillonnage stratifié basé sur l'information d'une densité élevée de baobab a été effectué pour la récolte des fruits. La pulpe des fruits a été analysée pour la vitamine C, la capacité antioxydante, les phénols et les flavonoïdes totaux en utilisant respectivement les méthodes de complexation HPLC, DPPH, Folin Ciocalteau et flavonoïde-chlorure d'aluminium. La teneur en vitamine C variait entre 17,34 et 401,17 mg / 100 g. Les moyennes étaient de 271,2, 243,98, 181,6 et 113,1 mg / 100 pour les régions du Nord et de l'Ouest du Kordofan au Soudan, et les comtés de Kitui et Kilifi au Kenya, respectivement. La valeur IC50 de l'extrait méthanolique se situait entre 0,5 et 2,5 mg / ml. Des variations plus élevées ont été observées entre que dans les emplacements pour tous les paramètres testés. Les phénols et flavonoïdes totaux ont suivi des tendances similaires. Ces résultats indiquent l'existence de morphotypes de baobab localisés, une forte influence environnementale sur la teneur en nutriments de la pulpe de baobab et la capacité de conférer des avantages pour la santé. L'insécurité alimentaire et nutritionnelle est un phénomène courant dans les régions arides et semi-arides de l'Afrique subsaharienne, avec les communautés recourant à des aliments sauvages et à des produits forestiers tels que le baobab en période de pénurie, pour obtenir de l'énergie et de la nutrition.

Mots clés: Capacité antioxydante, baobab, Afrique de l'Est, flavonoïdes, vitamine C

Introduction

Hidden huger remains a wide spread challenge in Africa, constituting nutrient and mineral deficiency especially during periods of drought. At such times, non-timber forest products, that are drought tolerant are a source of income and food for these populations (Gebauer *et al.,* 2016). During these seasons which are often accompanied by hunger and famine, the communities derive their nutrition from natural resource exploration, including edible wild fruits and trees. These indigenous fruit trees significantly contribute to their livelihoods and health, supplying essential nutrients (FAO, 2011).These trees are often adapted to their environments, which have adverse conditions, and often not favorable for the conventional and exotic crops during certain times of the year (FAO, 2011).

Baobab (*Adansonia digitata*), is one of the tree species of interest in sustainable utilization of indigenous fruit trees for economic and nutritional empowerment (FAO, 2011). The African baobab is native to arid and semi-arid regions of west Africa, Sudan, Angola, East Africa and Southern Africa (Munthali *et al.,* 2012) and is dominant in the African savannahs (Wiehle *et al.,* 2014). The massive deciduous tree towering at 25- 30 meters in height and diameter of up to 10 meters depending on age is widely appreciated by most of the communities where leaf, fruit seeds and bark are used as components of the diet (Assogbadjo *et al.,* 2012; Wiehle *et al.,* 2014). The surplus of these baobab components are usually sold in local markets, generating income for rural communities.

The baobab tree bears fruits that vary in shapes and sizes, with a woody epicarp. Upon maturity, the pulp is dehydrated, and appears as powdery flakes surrounding the numerous seeds. Fibres that are red in colour are found segmenting the pulp, which has a natural acidic taste. Pulp extraction is usually by mechanical processes, where the woody epicarp is first opened up, and the pulp separated from the seeds using pestle and motor (Gebauer *et al.,* 2016).The baobab dominates specific geographical locations of Kenya's landscape from Gatunga in Tharaka Nithi country through Kitui, Makueni, Taita Taveta and Kilifi counties. There are other baobab populations along the coastal region from Malindi to Kwale and other population from around Voi to Taveta region. In the Sudan there are baobab populations. In the Sudan baobab populations exists in the Kordofan, Darfur, Jebel ed Dair in central Sudan, Wiehle Blue Nile, Upper Nile (South Sudan) and Bahr El-Ghazal (South Sudan).

Although the nutrient profile of baobab pulp has been documented in a number of studies, little information is currently available on baobabs from eastern Africa. This study aimed at profiling nutrient composition of baobabs in specific locations in Kenya and Sudan, and provide a basis for nutrition information with regard to the species in this region.

Materials and Methods

Information based stratified sampling was adopted for the study, where regions of high baobab densities were used as study cites. A road running across the identified region was then used as a base line and transects of 1.5 km by 0.5 km and 3 km were laid using GIS, alternatingly on both sides of the road. This was followed by random sampling for three fruit bearing trees within the transect for fruit collection, and for nutrient profiling. In Kenya, fruit sampling was done in August to September of 2017, and May 2018 in Kitui. In Sudan, fruit collection was done in both North and West Kordofan States from November 2016 to February 2017, the major baobab season in the area. Fruits from each tree were labelled and packed separately before delivery to the Fruits and Vegetable workshop of Jomo Kenyatta University of Agriculture and Technology

Pulp extraction. The fruits were inspected for wholeness, absence of cracks, holes and signs of disease before pulp extraction. Pulp from fruits of each tree were pooled together to make a single sample, after preliminary analysis indicated that there was no significant difference in nutrient composition in fruits from the same tree.

Ascorbic acid. Ascorbic acid commonly referred to as vitamin C is an essential nutrient in the human diet, helping to boost immunity as well as absorption of essential minerals such as iron. The ascorbic acid content in the samples was determined by HPLC method according to Vikram *et al.* (2005). About 2 g of sample was weighed and extracted with 0.8% metaphosphoric acid. This was made to 20 mL of juice. The juice was centrifuged at 10000 rpm. The supernatant was filtered and diluted with 10 mL of 0.8% metaphosphoric acid. This was passed through 0.45 μ filter and 20 μL injected into the HPLC machine. Various concentrations of ascorbic acid standards were also made to make a calibration curve. HPLC analysis was done using Shimdzu UV-VIS detector. The mobile phase was 0.8% metaphosphoric acid, at 1.2 mL/min flow rate and wavelength of 266.0 nm.

Total phenols. The total phenolics contents in methanol extracts was determined using Folin–Ciocalteu's reagent (FCR) following the assay of Damodar (2011) with small modifications. 0.5 ml of the extract were mixed with 0.1ml FCR (diluted 1:2 v/v), incubated for 15min, followed by the addition of 2.5 ml of 0.7 M sodium carbonate solution. The final volume of the tubes were made up to 10 ml with distilled water, allowed to stand for two hours at room temperature and the absorbance measured at 750nm. A standard curve of gallic acid was also freshly prepared. The results were then expressed as μg Gallic Acid Equivalents/g sample.

Flavonoids. Aluminium chloride colorimetric method was used for determination of flavonoids (Jagadish *et al.*, 2009). To 10 mL volumetric flask 4 mL of distilled water and 1 mL of plant extract were added. After 3 minutes, 0.3 mL of 5 % sodium nitrite solution was added. After 3 minutes, 0.3 mL of 10 % aluminium chloride was added. After 5 minutes, 2 mL of 1 M sodium hydroxide was added and the volume made up to 10 mL with water. Absorbance was measured at 415 nm using UV-Vis spectrophotometer (Shimadzu model UV – 1601 PC, Kyoto, Japan). The amount of total flavonoids was calculated from Calibration curve of standard prepared from quercetin.

TTA, TSS and pH. The titratable acidity was determined according to AOAC (2000) method, using 0.1N sodium hydroxide and phenolphthalein indicator, while TSS was done using Antago handheld Refractometer. The pH was measured using a pH meter, calibrated at 25°C with buffers 4.0, 7.0 and 9.1.

Statistical analysis. For chemical analysis, each tree sample was analysed in triplicate. Results were analysed using two way analysis of Variance (ANOVA), to check for region and individual levels of variation. Means Separation was done using DMRT in Genstat version 16.

Results

Baobab fruit pulp constitutes the most important part of baobab tree (Parkouda *et al.*, 2011). It is against this backdrop that nutrient analysis is done for potential utilization in value added products.

Ascorbic acid. Vitamin C in the baobab pulp ranged between 17.34 mg/100 g to 401.2 mg/100g across all the agro-ecological zones. The mean values of each zone are as indicated in the Table 1 below.

Table 1. Table of mean vitamin C in mg/100g across the agroecological zones

Country	Region	Mean Vitamin C (mg/100g)
Kenya	Kilifi	113.1^{a}
	Kitui	181.6^{b}
Sudan	West Kordofan	243.9^{c}
	North Kordofan	271.2^{c}
SE	48.78	
%CV	26.6	
F	<0.001	

*Means with different alphabet subscript show significant variation at P≤0.005

The vitamin C range observed in this study concur with those of Simbo *et al.* (2013). The results show that there was variation in the vitamin content according to regions. Similar observations were made by Assogbadjo *et al.* (2012) in west Africa, and they attributed the cause to soil types as well as climate of the regions where samples were obtained.

Total flavonoids and phenols. Phenols and flavonoids have an excellent antioxidant capacity. As such, foods with high contents of the compounds are presumed to confer health benefits through their capacity for radical scavenging. The regional variation of these compounds in this study are as shown in Table 2.

Table 2. Total phenols and flavonoids (methanolic) extract of baobab samples from different agroecological zones

Country	Region	Total Flavonoids µg/g QE	Total phenols (µg/g GA
Kenya	Kilifi	277.78[c]	43.31[c]
	Kitui	125.91[a]	40.29[b]
Sudan	West Kordofan	178.55[ab]	38.05[ab]
	North Kordofan	230.61[bc]	36.61[a]
SE		36.05	1.75
%CV		23.4	7.2
F		<0.001	<0.001

*Means with different alphabet subscript in the same column show significant variation at P≤0.005
QE is quercetin Equivalence and GA: Gallic acid equivalence

Regional diversity was observed in phenols and flavonoids, with highest means in Kilifi, and the least in Kitui for flavonoids. Similarly, the phenols were also highest in Kilifi Kenya. These findings are similar to those obtained by (Nhukarume *et al.,* 2009).The fruits of baobab are a rich source of phenols and flavonoids, comparable to those or oranges as observed by (Vertuani *et al.,* 2002). This suggests that baobab fruit can be used as an antioxidant dietary supplement.

TTA, TSS and pH. These parameters are key and preliminary indicators towards processability and the shelf life stability of product against microbial degradation.

Table 3. Table of Total Titratable acidity (TTA), pH, and Total soluble solids (TSS) in baobab fruit pulp

Country	Region	TTA	pH	TSS
Kenya	Kilifi	13.92[b]	2.93[a]	1.81[a]
	Kitui	9.85[a]	3.01[b]	1.77[a]
Sudan	West Kordofan	9.70[a]	2.97[ab]	1.95[b]
	North Kordofan	9.79[a]	3.03[b]	1.96[b]
SE		6.181	0.0183	0.0949
%CV		55.6	0.6	5.1
F		<0.001	0.006	<0.001

Means with different alphabet subscript in the same column show significant variation at P≤0.005

Soluble solids, acidity and pH play important role in the stability of raw as well as processed products. Higher acidity and soluble solids result in products without addition of artificial preservative.

Discussion

The variation in nutrient composition found within and between populations in this study is similar to those documented by Parkouda *et al.* (2011), in West Africa, for indicators in selection of superior mother trees for future propagation. The existence of large variation in essential nutrient composition within a geographical region point towards existence of individualistic traits between the trees. Variation in fruit parameters at the level of the provenance indicates that genetic variation exists within the species since the environment is similar (Simbo *et al.,* 2013). Regional variation is also observed, indicating that the climate and environment have an influence on the nutrient composition. The Kilifi pulp samples portray distinctive characteristics for all the parameters analysed. As this is the only region in the study near the coast, this variance can be attributed to coastal effect and possibility of soil salinity. Vitamin C tends to increase with progression towards the drier northern zones covered by the study, which is similar to the findings of (Simbo *et al.,* 2013) in Mali. These fruits also tend to be smaller than those in the southern regions of the study.

Conclusion

Based on the above findings, it is evident that a number of factors influence nutrient composition of baobab pulp. Baobab is a rich source of essential nutrients, proofing to be a good candidate in the process of combating micronutrient deficiencies. It is an excellent raw material for product development, based on the pH, TTA and TSS values, components important in product development especially in fruit juices and jams. The wide range similarly is an indicator of existence of superior trees, and this avenue can be exploited towards baobab commercialization and value-added products. Linking this information with genetic data provides an avenue for selection of trees with superior traits.

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