BAOFOOD
PROJECT

Enhancing local food security and nutrition through promoting the use of Baobab (*Adansonia digitata* L.) in rural communities in Eastern Africa (BAOFOOD)

Book of Abstracts

Compilation of contributions presented at the final BAOFOOD project workshop, 4-5th September 2019, Kilifi, Kenya

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WP1: SUSTAINABLE USE OF BAOBAB RESOURCES AND INITIATING THE DEVELOPMENT OF DOMESTICATION TECHNOLOGIES

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Evaluation of different propagation methods for baobab (*Adansonia digitata* L.) in Kenya

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Seedlings of baobab (*Adansonia digitata* L.) can be important rootstocks for the propagation of elite trees by grafting. However, baobab seeds are dormant. The objective of this study was to (i) determine the effect of different pre-treatments on baobab seedling emergence and (ii) test different grafting methods on young and mature baobabs. Nine treatments (plus a control) were applied to sets of 75 seeds of 22 baobab accessions each from Kilifi County as follows: (i) soaking in sulphuric acid for 30, 45 or 60 min; (ii) boiling in water for 10 min followed by soaking in cold water for 2, 4 and 6 days; (iii) nicking followed by soaking in cold water for 0, 1 or 2 days; and (iv) control. Pre-treated seeds were then germinated on sterilized sand and seedling emergence recorded after four weeks. Regarding grafting of young baobabs, 84 five-months-old seedlings were grafted using cleft (48 seedlings) and approach (36) grafting with scions of similarly young seedlings. Three mature trees in the field were cleft-grafted (top worked) in the dry (18 grafts) and the wet (18) season, using scions from mature trees.

Seed emergence after four weeks was zero for the control and highly variable for the other nine treatments, ranging from a median of only 6% in the nicked treatment with 2 days soaking to as much as 42% in the 60 min acid treatment. However, within each treatment huge differences among the accessions were recorded, ranging e.g. from 0 to 88% in the 60 min acid treatment. Grafting of seedlings was very effective with 83% successful cleft and 100% approach grafts after 22 weeks. The success rate for grafting mature trees was 44% in the wet and 17% in the dry season. In conclusion, seed pre-treatment with sulfuric acid for 60 minutes increases baobab germination rates best. Grafting of seedlings can help in establishing orchards of superior planting material, but further studies on the performance of the grafted seedlings should be performed. The top working techniques should be improved as they might be useful for conservation and improving the performance of existing baobab trees.

Key words: Accessions, Dormancy, Grafting, Seedling emergence, Stratification, Top working

Baobab population structure across different agro-ecological zones in Kilifi, Kitui and Makueni Counties Kenya

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In Kenya, little is known about structure and health of baobab populations. This study focused on baobab population assessment in 35 randomly selected plots of 0.5 × 3 km each, 14 plots along the C107 road from Mavueni to Mariakani (60 km) in coastal Kilifi County, and 21 plots along the B9 road from Kitui to Kibwezi (130 km) in Kitui and Makueni Counties (lower Eastern Kenya). The roads (transects) covered areas with different agro-ecological zones (AEZs). Baobab trees within the plots were recorded by their position, height and diameter at breast height (DBH). To assess population health, tree abundance, tree density per hectare and DBH size class distributions (SCD) were computed. Non-parametric statistical tests were performed by using SPSS.

599 baobab trees were recorded in the 14 plots at the coastal region and 1351 trees in 21 plots at the lower Eastern region. Tree abundance ranged from 3-148 and 5-156 per plot at the coastal and lower Eastern region, respectively. Mean tree densities were 0.286 trees/ha at the coast and 0.438 trees/ha at the lower Eastern region with no significant differences. There were also no significant differences in juvenile (DBH<1m) and mature (DBH≥1m) tree densities between the two regions. When comparing all the AEZs, LM5 (semiarid Lower Midland) in the lower Eastern region had the highest mean densities of mature (0.424 trees/ha) and total trees (0.588 trees/ha). The proportion of juveniles from total trees was 37 and 41% for the coastal and lower Eastern regions, respectively. All AEZs had reverse J-shaped SCD curves with negative slopes indicating rejuvenation of populations except LM5 that had a bell-shaped SCD curve and the least percentage of juvenile baobab trees (only 28%). Quotients from successive size classes indicated uneven distribution of baobab in the different AEZs but at regional level they indicated stable baobab populations.

At population level, both regions showed reverse J-shaped SCD curves which indicated healthy, rejuvenating populations with relatively high proportions of juvenile trees. The output of this study can contribute to a more sustainable utilization of the resource and aid in conservation of the species in the two regions.

Baobab trees distribution and characteristics in relation to site environmental factors

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In order to promote sustainable management practices for baobab resources, the status and distribution of wild populations of baobab trees was investigated against site environmental factors in Kilifi county and Kitui-Makueni (Lower Eastern) regions of Kenya. Using GIS tools, a total of 35 sampling sites of 3*0.5 km quadrats were mapped and set in a systematic pattern along purposefully selected transects traversing known baobab dominant areas in each of the two study regions. For each quadrat, all baobab trees encountered were described in terms of canopy shape, growth habit, trunk shape and bark colour against site factors of topography, aspect, landform, slope and land use using the ICRAF-Bioversity 'Descriptors for Baobab'. Trees and attributes of site environmental characteristics were overlaid on an agro-ecological zone (AEZ) map of each region to assess spatial differences between the zones.

A total of 599 and 1351 trees were surveyed in the 2100 and 3150 ha in Kilifi and Lower Eastern, respectively. Based on principle component analysis, topography and land use contributed most to the variation in tree distribution for the first and second components, explaining 49.3 and 19.2% of the total variation. Most trees occurred on gently undulating or almost flat land forms and about 80% were on farmed site environments. Most common canopy shapes were round (51%) and semi-circular (44%) while pyramidal shapes were least (2%). Regarding growth habit, trees having a spreading (46%) or erect (43%) growth habit were most recorded. Cylindrical trunk shape was recorded for 71% of the trees, followed by 21% of trees with cone shaped trunks. A Kruskal-Wallis test for differences in occurrence levels of trees under all the factors considered showed that there were significant differences between AEZs for both the study regions. The distribution within AEZs was highly variable for the assessed factors implying a non-uniform population. This information provides a baseline to study more tree characteristics such as ecophysiology or genetic variation. It also suggests that there is the need for protecting rare tree characteristics to maintain viable populations.

Morphological characterization of baobab fruits and identification of elite trees for domestication from Kitui and Kilifi counties

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The aim of this study was to determine baobab tree productivity and perform morphological and chemical characterization of baobab fruits to select elite trees for future domestication. The study was carried out in Kilifi County at the coast and in Kitui and Makueni Counties in lower Eastern Kenya. Fruits were sampled during the harvest seasons in September 2017 and May 2018 in Kilifi and Kitui/Makueni, respectively.

For tree sampling, the same randomly selected quadrats as in the baobab population studies of Orina et al. and Mukundi et al. were used (i.e. 11 quadrats of 0.5 × 3 km in Kilifi and 13 in Kitui/Makueni counties). Seventy-one fruiting baobab trees were randomly sampled in or close by the mentioned quadrats in total; 33 from Kilifi and 38 from Kitui/Makueni counties. Fruits were characterized in the lab using the 'Descriptors for Baobab' (Kehlenbeck et al. 2015) and data analysis was done using SPSS.

There was high variation among the 71 baobab accessions regarding fruit shapes, quantitative variables and fruit tree productivity. The most frequent fruit shape was ellipsoid (about 60% of all accessions), followed by obovate (33%) in Kilifi and oblong (21%) in Kitui/Makueni. Median productivity in weight of fruits per tree was significantly higher in Kilifi (87.7 kg/tree) than in Kitui/Makueni (29.5 kg/tree; $p<0.001$). Median fruit weight was also significantly higher in Kilifi as compared to Kitui/Makueni (376 versus 155 g, respectively; $p<0.001$). Similarly, median pulp weight was significantly higher in samples from Kilifi than from Kitui/Makueni (61.3 versus 27.2 g; $p<0.001$), while pulp proportion was similar between the regions (median 16.9 %), ranging from 13 to 23%. Fruit weight correlated significantly with pulp weight ($r = 0.948$; $p<0.001$), but not with pulp proportion. Mean pulp °Brix (TSS) was 11.3°, while % acidity (TTA) was 7.3%. The selection of the elite trees per region was based on three traits, the fruit weight (as a proxy for yield), pulp proportion and the sweet taste of the pulp. Further characteristics e.g. vitamin content should be included. The large variation in fruit traits might be due to environmental and genetic factors and their interactions.

***Keywords**: Domestication, elite tree, fruit traits, indigenous fruit tree, pulp proportion*

Socioeconomic Aspects and Indigenous Knowledge Pertinent to Baobab in Kordofan States - Sudan

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One of the main limitations in escalating up the baobab sector in Sudan is the scarcity of knowledge and research about the baobab tree. The current study intended to assess the socioeconomic aspects and indigenous knowledge pertinent to baobab in western Sudan by Kordofan University team as a part of the Baofood Project. Eight villages were selected for field surveys in North and West Kordofan states based on their location and potential resource base. Primary data was collected using focus group discussion and key informant consultation. The baobab collection is gender balanced, while trading activity favours male over female. The 'more than 50 years ' age group represents the larger percentage (50%) among collectors while youth and middle age is meagre (10%). The majority (80%) of collectors are married and obtained primary education. Due to the prevailing customary land use/ tenure systems, most (80%) of collectors are natives, followed (15%) by settlers, while migrants are minor (5%). Most (75%) of the collectors are agricultural producers or livestock raisers. Flowering and fruiting of the baobab trees start at the age of 20-25 years. Flowering takes place during June and July every year. Tree produces leaves during rainy season, loses its leaves in dry season, and remains leafless for rest of the year. Harvesting of fruits takes place during the dry season. The fruit falls to the ground or picked by long stick called *Kunjara*. Harvested fruits per tree is ranging from 80 to 200 fruits. Harvesting of baobab fresh leaves for food purpose (salad) takes place during April-September. Characteristics of superior fruit according to collectors are the yellowish colour of the fruit, besides the easy shatter and scoop out of its pulp. The collectors listed and raked the common uses of baobab tree and its fruit in the area; 10 medicinal, 4 nutritional, 2 construction and many cultural and symbolic uses. The main reasons behind decrease of baobab population in the area are the unfavourable environmental conditions, poor natural regeneration, physical injury, pest infestation and extensive harvesting of baobab leaves. Finally, the study recommended documentation of good practices on baobab resource based on favourable indigenous knowledge and research output elsewhere.

Demographic structure of baobab population regeneration around Elobied city, North Kordofan, Sudan

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This study was conducted on Baobab populations in around Elobied, Kordofan, Sudan during 2014 - 2017. The objective was to describe Baobab structure and to assess natural regeneration. The area was divided into four land use types; farmland, rangeland, silvo-pastoral and rocky outcrops. Field inventory was carried out where systematic sampling method was applied. Thirty plots (1 km X 50 m) along line transects were taken with 100 m intervals and 200 m distances between transects. Diameters at breast heights (1.3 m) were measured and natural regeneration was assessed. R-statistics and Excel were used. Population dynamics and recruitment were analyzed and density was calculated.

The results revealed that Baobab trees grow in *wadis* and *khors* in the form of belts or groups. The average diameter of tree at breast height was 151cm, 217 cm, 171 cm and 323 cm in farmland, silvo-pastoral, rocky outcrops and rangeland, respectively. Density of mature Baobab trees in areas of West Kordofan (2.5 trees/ha) was higher than in areas of North Kordofan (1.63 trees/ha). In contrast, density of juveniles in areas of North Kordofan (0.78 tree/ha) was higher than in the areas of West Kordofan (0.13 tree/ha). The density of Baobab trees was 2.4 ± 0.25 trees/ha in all land use types except in silvo-pastoral which was found to be higher 2.9 ± 0.25 trees/ha. Size class distribution showed positive skewed curves in farmland and rocky outcrops with high recruitment while it showed poor skewed curves in rangeland and silvo-pastoral system with poor recruitment.

The study concluded that the situation of Baobab in North Kordofan was better than in West Kordofan. The study recommended protecting areas as Baobab reserves and regulating the grazing.

Key words: *baobab, population structure, land use type, regeneration, Kordofan*

Mapping and dynamic change of Baobab (*Adansonia digitata* L.) trees in North and West Kordofan States, Sudan

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Mapping the distribution and occurrence of Baobab (*Adansonia digitata* L.) in vast areas are useful in forestry applications. The objectives of the study were mapping of Baobab, assessing its density and characterization of site and land use in North and West Kordofan States, Sudan. The study was conducted in two buffer zones located in North and West Kordofan States with an area of 12610 km^2 and 20556 km^2, respectively. A number of 48 quadrates (500x3000m for each) were randomly distributed within the buffer zones (24 in each state). Total enumeration was conducted in each quadrate measuring: coordinates, circumference at breast height (cm), height (m) and crown diameters (m) for Baobab trees. Site and land use characterization were identified by using Baobab Describer. ArcGIS10.1 was used for producing maps and identifying locations and distribution of Baobab. Tree parameters were analyzed in EXCEL and SPSS18 software.

The results found that Baobabs were present in North Kordofan (14 quadrates) and West Kordofan (10 quadrates) with total number of 307 and 103 trees, respectively. Height, diameter at breast height and crown diameter of Baobabs in North Kordofan were estimated as 13.97±5.54 (m), 1.98±1.27 (m) 11.41±5.40 (m), while in West Kordofan were found as 12.22±4.60 (m), 1.90±1.18 (m) 9.15±4.57 (m), respectively. Density of Baobab in North Kordofan (0.15 trees⁄ha) is higher than in West Kordofan (0.14 trees⁄ha). The results revealed that the baobabs in North Kordofan are occurred in seven topographical sites, where flat site showed the highest (58%), while in West Kordofan were occurred in four sites, mainly in almost flat (33%) and gently undulating (29%) sites. The occurrence of Baobab in land use types in North and West Kordofan States is found in crop agriculture (annual field cropping) (54% and 42%) and forestry (natural forest and woodland) (21% and 37), respectively.

The study concluded that the density of Baobab in North Kordofan was higher than in West Kordofan. Establishment of Baobab reserves and plantations for domestication of Baobab trees are recommended.

Morphological Characterisation of Baobab Fruits from North and West Kordofan Provinces, Sudan

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Adansonia digitata L. (Malvaceae) is an iconic tree of the savannahs of sub-Saharan Africa. The edible fruit is known for its high nutritional values in pulp and seeds. The high morphological variability, particularly of fruits, offers a potential for domestication and development of improved materials. However, the variability in morphological fruit traits of Sudanese baobab has not yet been thoroughly documented. This study aimed at characterising the intra-specific diversity of baobab fruits collected from North and West Kordofan provinces, Sudan. Within the frame of the BAOFOOD project funded by the German BMEL, 93 trees were sampled from two transects (each 30×90 km) during two harvest seasons 2016-17 and 2017-18. From each tree, 10-20 representative fruits were collected and characterised based on the publication 'Descriptors for Baobab'.

Mean fruit length per accession ranged from 8.6 to 43.7 cm (total median 15.7 cm) and mean fruit weight from 46 to 403 g (median 128 g). Overall median pulp weight per fruit was 24 g (range 7-122 g per accession), while overall median pulp and seed proportions from whole fruit weight were 18 and 38%, respectively. For 13 accessions we found a very high pulp proportion (22-30%) and for 13 a very high seed proportion (46-53%). Fruit shape was predominantly ellipsoid (51%) with acute apex. Less frequent shapes were oblong-ellipsoid (10%), oblong-globose (8%) or oblong (6%). Pulp taste, based on the four traits sweetness, sourness, bitterness and aroma, was highly variable, but 23% of the sampled accessions had a sweet taste. Fruit length was positively correlated with fruit weight, pulp weight and pulp proportion (r=0.587***, r=0.672*** and r=0.450***, respectively). Fruit length and weight as well as pulp weight and seed proportion were significantly higher in accessions from North as compared to West Kordofan, while pulp proportion did not differ. The morphological variability among our sampled accessions is substantial as expected; nevertheless, the morphological data will be further compared with genetic data. Our study shows that trees possessing highly valuable characteristics such as sweet pulp taste, big fruits, high pulp and lower seed content are available in Kordofan for future use in domestication programmes.

Recommendations on baobab conservation approaches and sustainable management

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Baobab (*Adansonia digitata* L.) is multipurpose fruit tree with very high nutritional and economical value. International interest in the species has intensified following the acceptance of baobab fruit pulp as a food ingredient by the European Union (EC 2008) and the US Food and Drug Administration (FDA 2009). Growing demand in international as well as local markets may offer further income generation opportunities for African farmers. However, this may put the resource base at risk due to overexploitation since baobab fruits and leaves are currently mainly harvested from wild trees.

The objective was to recommend viable conservation and sustainable management strategies for baobab in Kenya and Sudan. The following strategies can be proposed:

1) In situ conservation of natural baobab stands and the legal protection of habitats where baobabs grow naturally. There is need to advocate for legal protection of baobab resources both in Kenya and Sudan. However, this should not undermine sustainable use of the resource by local populations.

2) Ex situ conservation, the integration of baobabs on farms (agroforestry systems). This can be facilitated by vegetative propagation strategies such as grafting of seedlings in order to reduce the period of juvenility. Grafting will also reduce the size of the trees when slow growing rootstocks are developed and used.

3) Storage of valuable baobab germplasm as in vitro cultures under controlled conditions as well as cryopreservation at ultra-low temperature in liquid nitrogen.

Funding of conservation activities can stem both from governmental as well as non-governmental organizations. Maintaining and conserving baobab germplasm will also contribute to environmental protection and adaptation to climate change.

Key words: *Baobab, conservation, forest reserves, livelihoods, Kenya, Sudan*

WP2: NUTRITIONAL VALUE AND BIO-ACTIVE COMPOUNDS OF RAW AND PROCESSED BAOBAB PRODUCTS AND THE DEVELOPMENT OF NUTRIENT-MAINTAINING PROCESSING TECHNOLOGIES AND NEW PRODUCTS

Work under this work package aims to develop marketable baobab products that can contribute to improved nutrition and food security of selected rural target groups by (a) analysing the nutrient content of baobab raw and processed products; (b) reviewing and improving local processing technologies; and (c) analysing the impact of supply chain organisation on nutrient and physical properties of baobab products.

Abstract overview

1) Joyce Chepngeno et al: Identification and quantification of antioxidant compounds of baobab *Adansonia Digitata* from different agro-ecological zones using HPTLC-HR-ESI-MS

2) Margaret James et al: Determination of Microbial Safety in Selected Baobab Pulp and related Products in Kenya

3) Florian Kugler et al: An optimized approach for determination of vitamin C by HPLC in baobab pulp samples from Sudan and Kenya

4) Bickson Gangata et al: Strategy, business models and performance of baobab processing enterprises in Malawi

5) Chopi- Msadala Chifundo et al: Commercialization of Underutilized Wild Fruits: A Case Study of Adansonia Digitata L. In Malawi.

6) Katie Meinhold et al: Processing non-timber forest products as a strategy for rural development – a review

Identification and quantification of antioxidant compounds of baobab *Adansonia Digitata* from different agro-ecological zones using HPTLC-HR-ESI-MS

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The fruits pulp of baobab (*Adansonia digitata*) has attracted widespread research due to its high antioxidant capacity. However, information on the identity of compounds responsible for the high antioxidant capacity in pulp is limited. This study aimed at identifying these compounds in pulp, their quantities as well as their distribution across different agroecological zones of Kenya and Sudan.

High Performance Thin Layer Chromatography coupled with High Resolution Mass Spectroscopy (HPTLC-HR-ESI- MS) and densitometry was used to profile a total of 135 samples. Detection of compounds with antioxidant capacity was done with DPPH, ABTS and anisaldehyde, and quantification done using CAMAG TLC scanner. The resultant chromatograms were analysed using rTLC software, clustering the baobab samples based on retention fronts (RF) of active compounds. The antioxidant capacity of major compounds was expressed as vitamin C antioxidant equivalence.

The compounds according highest capacity were identified as (epi)catechin-O-gallate, procyanidin, ascorbic acid as diketogulonic acid, and their distribution in baobab samples is influenced by origin, thus climatic conditions as well as intrinsic tree characteristic. This information provides an insight of possible processing conditions to maintain the antioxidant properties of the pulp and adds to body of knowledge on its nutritional and pharmacological property.

Keywords: Antioxidants, Baobab, HPTLC, PCA,

Determination of Microbial Safety in Selected Baobab Pulp and related Products in Kenya

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The trade in baobab pulp and related products in receiving increased attention in Kenya following its acceptance as a novel food ingredient and a functional food in the European Union and the United States of America. This has resulted in increased demand of the baobab pulp locally and internationally. Increased demand has however contributed to poor practices such as intensive harvesting, poor drying methods, unscrupulous middlemen, unhygienic handling and processing raising concerns to the food safety of baobab and its products.

This study focused on the determination of the microbial quality of selected baobab products produced by processors registered and unregistered by the Kenya Bureau of Standards (KEBS). Samples were collected randomly from food processors engaged in processing of baobab pulp and related products in Nairobi, Kitui, Kilifi and Mombasa. The collected products were subjected to microbial analyses in three different growth media (Potato dextrose agar, Plate Count Agar and Violet Red Bile Green Agar).

The Total Aerobic Count (TAC) ranged between 2.9542 to 5.6021±0.1795 log CFU/g for the registered products while that of unregistered products ranged between 2.301 to 5.6987±0.2418 log CFU/g. About 70% and 90% of the unregistered processors exceeded the Total Enteric Count (TEC) and yeast and molds safety limits recommended by KEBS respectively. A significant difference was observed between the KEBS registered and unregistered baobab products for Yeast and molds (P= 0.0033) and TEC (p=0.0008). Most of the products from processors were considered to be within acceptable safety levels, other than yeast and molds in which 80% were above the limits recommended by KEBS for dried fruits.

The high percentages of baobab products below acceptable safety levels indicate poor sanitation, unhygienic processing and poor postharvest handling. The yeast and molds counts were high in both registered and unregistered processors which could be due to poor transportation conditions as well as storage conditions. Despite baobab being considered the new super food, appropriate microbial safety procedures must be incorporated in handling operations along the baobab value chain.

An optimized approach for determination of vitamin C by HPLC in baobab pulp samples from Sudan and Kenya

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Vitamin C is one of the most valuable compounds which can be found in relatively high concentrations in the pulp of baobab fruits. Due to the importance of vitamin C for both human nutrition and food technology, the present work aimed at developing and validating an optimized analytical method for quantification of vitamin C in baobab pulp samples.

The prepared extracts were analyzed by RP-HPLC applying gradient elution with aqueous formic acid and acetonitrile as eluents. Thus, chromatographic separation of vitamin C – which was detected at 244 nm – from co-eluting compounds could be achieved for most of the samples. Peak impurities were monitored by means of absorption spectra and coupled mass spectrometry. Application of different temperature conditions revealed that degradation of vitamin C during extraction procedure, sample preparation as well as standing time of samples in the HPLC autosampler could be considerably reduced by continuous keeping up a temperature of 4°C. Furthermore, it could be demonstrated that in contrast to a single extraction procedure a twofold extraction of baobab pulp resulted in higher vitamin C yields.

The developed improved method for determination of vitamin C in baobab pulp samples is considered to be an adequate tool for future investigations into vitamin C concentrations of baobab pulp taking into account reliable extraction of the analyte as well as considering and limiting the degradation of vitamin C during sample preparation and analysis.

Strategy, business models and performance of baobab processing enterprises in Malawi

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Malawi has witnessed an intensive commercialization of baobab for the past two decades. However, the industry has not been described with regard to structural and performance indicators. The aim of this study was to investigate relationship between business strategy (BS), business model (BM) and performance of baobab processing enterprises in Malawi. Findings provide important lessons pertaining to establishment and further development of the baobab processing sector.

The study was conducted in five districts of Malawi. Data was collected using semi-structured questionnaire from a sample of 137 enterprises. Enterprise performance was the dependent variable and was operationalized as gross margin (GM) and Firm firm growth index (FGI). BS and BM were independent variables. BS was measured using Miles and Snow's strategic types. Descriptive statistics was used to analyse structure of the sector. Cluster analysis was done to identify the BM archetypes. Regression analysis was used to determine if firm BS and BM could predict firm performance.

Results show that predominate products were freezes, followed by powder and sweets. 94 percent of baobab processing enterprises were informal. 67 percent of the enterprises were using business to business model while the rest were using business to customer (B2C) model. 82 percent of baobab processing enterprises were using a reactor strategy which is characterized as an inferior strategy.

The mean GM for formal and informal enterprises is 60 and 59 % respectively. The mean FGI for formal and informal enterprises is 2.6 and -0.162 respectively. Results are inconclusive on the causal relationship between BS, BM and enterprise performance but rather describe the current dichotomy of baobab business sector into formal and informal categories.

Commercialization of Underutilized Wild Fruits: A Case Study of *Adansonia Digitata* L. In Malawi.

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The baobab *Adansonia digitata* L. is among the underutilized wild fruits with high commercialization potential in Malawi. Its fruit is being used in the country to produce baobab juice, sweets and cosmetic products. However, the commercialization of these products had not been expansively analysed. The study purposed to investigate the consumer preferences on baobab quality attributes and the effect on pricing of these quality attributes.

A total of 141 consumers, 132 products, 19 processors and 78 different product brands were assessed in formal and informal markets of baobab processed products across nine districts of Malawi. A mixed approach was adopted. Key informants among processors and suppliers provided marketing mix data through in-depth interviews. A customer survey and product survey was conducted for assessing preferred quality attributes of baobab juice and the attributes influencing its price respectively. Qualitative data was analysed using content analysis while quantitative data was analysed for descriptive statistics, cross-tabulations and step-wise multiple regression.

It was found that four different types of processed products were available on the Malawi markets, namely juices, powdered products, sweets and confectionaries and cosmetics. Prices of juice products (500ml bottle) were 200-500% higher in formal retail outlets than in informal outlets. The formal products were sold mainly in hyper supermarkets, superettes, groceries and gas stations. The informal markets retail outlets were primary schools, road sides and church yards. The formal juice market had high income, tertiary educated customers. 97% of the informal market customers were low income primary school children. Packaging quality, health and nutritional labelling were important for the high income juice consumers whilst 100% of informal consumers preferred sweet taste. In terms of price determinants, packaging sealing, labelling, MBS seal, health claims and essential minerals attributes positively influenced prices for baobab juice. Although additives, packaging volume and retail outlet were not significant variables for juice products, they were positively significant for powdered products. It was also found that packaging labelling was mutually significant in a positive manner for both juice and powdered products. The MBS seal variable was also mutually significant for juice and cosmetics products but showed a positive and negative directions of the β coefficient respectively. It was therefore concluded that age, income and education differences delineated customer preferences in the formal and informal markets of baobab juice. The study showed that processed baobab products are attracting significant demand from urban consumers belonging to diverse socio-economic strata and are moving from traditional, low-value foods to higher-value segments. The study recommends that processors adapt their promotional and pricing strategies to create competitive packaged products for the more affluent, well-educated and health conscious consumers. It is also recommended that policies are put in place to improve awareness of and access to cheap nutritious baobab foods for school children.

Processing non-timber forest products as a strategy for rural development – a review

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NTFPs such as wild foods, medicinal plants, or raw materials for handicrafts, make significant contributions to rural livelihoods in the developing world. NTFPs can help fulfil households' subsistence and consumption needs, serve as a safety-net in times of crises, and provide cash income. In particular processing of NTFPs has often been suggested to positively influence sustainable economic development in rural areas. However, despite rising interest and recognition of the potential contribution of such industries as a key source of employment and their strategic role in overall growth strategies of developing countries, many NTFP processing enterprises remain in the informal sector and in-depth understanding of underlying factors remains limited.

This review synthesizes the current evidence base examining the contribution of commercialised NTFPs to livelihoods and factors positively affecting NTFP commercialisation and SME development in contrast to subsistence use. Despite the diverse nature of NTFPs a number of constraining as well as enabling factors affecting NTFP processing and commercialization were identified. The former includes aspects such as lack of resource access (finances, skills, technologies, etc.), market information or basic infrastructure, the latter amongst others the role of key entrepreneurs, cooperation across the value chain, amongst producers, and members of the institutional environment or an abundant resource base. Moving from small-scale NTFP commercialization in local markets to more mature NTFP value chains reaching export markets the increasing role of cooperation as well as having a supportive institutional framework in place becomes apparent. Overall, however, successful NTFP processing strongly depends on the socio-economic and environmental context in question, asking for a holistic approach tailored to the respective context and value chain.

WP3: HUMAN NUTRITION AND FOOD SECURITY

Work under this work package aims at assessing (a) the nutritional value of baobab pulp and leaves (b) nutritional status of the population in baobab belt in Kenya and Sudan (c) food and baobab feeding habits and preferences (d) the role of baobab in food and nutrition security (d) the role of baobab in emergency food strategies.

Abstract overview

1) Esther Evang et al: The role of baobab (*Adansonia digitata* L) pulp consumption on the nutritional status of Kenyan schoolchildren: A randomized controlled intervention trial

2) Dorah Momanyi et al: Development, Nutritional and Sensory Evaluation of a Baobab Fruit Based Ready-to-Eat Sorghum and Cowpea Blend Snack Bar

3) Wanjeri Nyutu et al: Accessibility, Availability and Consumption of Baobab During Food Emergencies; A Case Study of Baobab in Kilifi and Kitui Counties of Kenya

4) Sulieman Abdalgader et al: Nutritional value of baobab (*Adansonia digitata*) leaves from Kordofan, Sudan

5) Tsige-Yohannes Habte: Gaps in Knowledge Associated with Nutritional and Health Effects of Baobab

The role of baobab (*Adansonia digitata L*) pulp consumption on the nutritional status of Kenyan schoolchildren: A randomized controlled intervention trial

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Poor dietary intake and diversity contribute to micronutrient deficiencies in Sub-Saharan Africa. An example is iron deficiency in Kenya, which is widely spread among children, and negatively affects their physical and mental development. Since baobab pulp contains significant amounts of vitamin C, which enhances iron bioavailability, the role of vitamin C in alleviating iron deficiency problems was examined. The study aimed to investigate the impact of baobab pulp consumption on the iron status in Kenyan children in rural Kitui.

The single-blind randomized controlled intervention trial was implemented daily among apparently healthy schoolchildren aged 6-12 years with haemoglobin (Hb) level <12.4 g/dl and without undernutrition. Over a period of 12 weeks children in the intervention group (n=31) received a drink containing 20 g baobab pulp (comprising 33 mg vitamin C), while the control group (n=31) received an isoenergy drink without baobab pulp. In addition, each child was offered a standard portion of a school meal containing 7.6 mg iron. At baseline and endline, Hb, serum ferritin, serum soluble transferrin receptor (sTfR), anthropometric measurements and dietary intake were assessed. Median and t-test were used to determine differences at baseline and development of parameters between groups, respectively.

At baseline, median values for anthropometric data, Hb and iron status did not show significant differences between groups. On the onset of the intervention, median adequacy ratio of energy and nutrient intake were significantly higher in the intervention group for vitamin C *(p<0.001)* and calcium *(p=0.005)*. Mean Hb level increased between baseline and endline (0.33 g/dl) in the intervention group, while it decreased (0.18 g/dl) in the control group. The differences were at a significant level *(p=0.026)*. Mean level of sTfR remained unchained in the intervention group (0.02 mg/L), but slightly worsened in the control group (0.26 mg/L).

Consumption of baobab pulp improved the intake of the critical nutrients vitamin C and calcium. Furthermore, preliminary results indicate a tendency increased mean Hb levels in the intervention group. Low sensitivity of the research was due to the unexpected low prevalence of anaemia and tissue iron deficiency in the study population.

Development, Nutritional and Sensory Evaluation of a Baobab Fruit Based Ready-to-Eat Sorghum and Cowpea Blend Snack Bar

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Sorghum, cowpea and baobab are underutilized drought-tolerant crops that are grown and occur in abundance in marginalized agricultural areas in Kenya. The objective of this study was to develop and analyse the physical, nutritional and sensory attributes of baobab based ready-to-eat sorghum and cowpea blend snack bars. Popped sorghum, baked cowpeas and baobab pulp powder were blended in five different formulations (45:55:0; 50:45:5; 55:35:5; 55:35:10; 60:25:15; 65:15:20). A mixture of popped sorghum and cowpeas was first compacted using melted honey and baobab sprinkled to the mix to produce ready-to-eat (RTE) snack bars. The nutrient composition, physical properties and sensory qualities of the bars were analysed and significant difference between means determined by Tukey test, at $p < 0.05$.

Crude protein in the formulations ranged between 11.38 ± 0.35g/100g and 21.35 ± 0.89 g/100g), total fat content ranged between 2 ± 0.03 and 3.26 ± 0.13 while crude fibre ranged between 1.59 ± 0.12 g/100g and 2.76 ± 0.02g/100g. The carbohydrate content of the RTE snack varied significantly between 61.1 ± 3.32 g/100g and 73.25 ± 0.31 g/100g while the energy content ranged between 1502.71 ± 43.7KJ and 1524.06 ± 30.47KJ. A significant increase in vitamin C concentration between 8.76 ± 0.49g/100g and 21.16 ± 2.03g/100g with increasing baobab content was observed. Iron concentration of the snack ranged between 4.34 ± 1.80g/100g and 5.76 ± 1.78g/100g while Zinc concentration (1.65 ± 0.35g/100g and 2.76 ± 0.14g/100g) was statistically different between the formulations. The sensory evaluation of the product revealed that colour, taste, texture, aroma, appearance and overall quality were in acceptable range with mean scores of above 5. Generally, snack bars with low baobab concentration were the most preferred with RTEs3 being the most preferred.

The readily available drought tolerant crops used in the formulation of the baobab snack bars can serve to diversify diets and increase the nutrient intake of households particularly, during food scarcity since it is an easy home to make snack. In addition, the snack having an acceptability score of 5 has a great market potential as a convenient food, as consumer needs are changing towards more convenient foods as well as less refined grains.

Accessibility, Availability and Consumption of Baobab During Food Emergencies; A Case Study of Baobab in Kilifi and Kitui Counties of Kenya

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Erratic weather conditions, increasing climate changes in areas such as Kilifi, Kitui and coastal regions have resulted to persistent droughts, storms, irregular seasonal patterns of unreliable rainfall and floods. During emergency situations, households are unable to get income as their livelihoods may be destroyed and are unable to produce food. Wild fruits such as baobab can come in handy during such periods. The adaptability of the Indigenous Fruit Trees (IFTs) such as baobab, makes them hardy and usually yield even when food crops fail. Baobab can thus be adopted to alleviate the suffering of communities during food crisis and emergency situations.

This research was designed determine the accessibility of baobab in emergencies, income from sale, determine the preparation, use, processing and storage of baobab and its products. The study was carried out in Kitui and Kilifi Counties Kenya. Descriptive analysis was used to describe the social economic characteristics of households. About 94% of households in Kitui were food insecure. Households had an average of four (4) baobab trees in Kitui and five (5) in Kilifi. The mean number of bags harvested in Kitui was 139.78 kgs with a standard deviation of 212.129. None of the respondents used baobab leaves in Kitui while 98.2% of respondents in Kilifi County used baobab leaves. About 90.3% did not give any treatments to baobab fruits before storage in Kitui County. There was a significant difference in mean consumption between the two counties. The mean (±1SD) amount of baobab pulp consumed was 361.3(±1,117.8) g in Kilifi while in Kitui the mean amount was significantly higher, 1,296.7(±4,946.6) g ($p<0.0001$)

Baobab fruit pulp was available and accessible during lean seasons and mainly consumed without any form of processing as a snack. The pulp was also utilized in making different food recipes during times when many other foods were not available for the households. A number of households sold baobab fruits to augment their income. Promotion of baobab and its value-added products could improve income, nutrition status and help communities in overcoming food insecurity in emergency situations in these counties.

Nutritional value of baobab (*Adansonia digitata*) leaves from Kordofan, Sudan

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The present research was conducted to study the nutritional value of baobab leaves *Adonsonia digitata L.* The fresh leaves samples were collected from five villages each in North and West Kordofan, Sudan. The collected sample was dried under a shade. Proximate composition and minerals content from baobab dry leaves were analyzed and amino acids profile was also investigated. The result showed that the mean values of baobab leaves were: Moisture 7.08%, crude protein content ranged between 13.68 – 14.78% and ash content ranging between 7.50 – 8.66%. Also baobab dry leaves were consider as important source of minerals such as calcium, copper, iron, magnesium, manganese and zinc, calcium with a range of 2241.8 – 3641.8 mg/100g. Statistically the results showed that there were significant ($p \leq 0.05$) differences found between the different locations in minerals content. In additional they were found eight essential amino acids namely lysine, histidine, threonine, methionine, valine, isoleucine, leucine, and phenylalanine were qualified and quantified in present investigation. Leucine, valine and phenylalanine which were highest value for essential amino acids for baobab dry leave samples, whose mean values were 1.23%, 1.00% and 0.85%, respectively. This study concluded that baobab dry leaves can be considered as a cheap source of minerals and protein which had most essential amino acids, therefore they have the potential to be utilized as good source of nutrients.

Gaps in Knowledge Associated with Nutritional and Health Effects of Baobab

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Baobab products were characterized based on chemical and biological analysis. Some gaps of knowledge are observed besides the major findings. These include wide variations in the mean values of nutrient composition, causes of low efficiency of nutrient utilization, and the decline of the shelf life of vitamin C.

The mean calcium, magnesium, iron, vitamin C (ascorbic acid) and beta-carotene values of different baobab samples were extremely variable. The calcium content of baobab pulp and that of the leaves from the baobab belts in Sudan and Kenya, for example, differ in the range of 237 – 480mg/100g DM and 1132mg – 4519mg/100g DM respectively. The ratios of Ca:Zn and Fe:Zn are so high that the dominant mineral can hinder the bioavailability of the minor elements. A disproportionally high level of calcium can depress the bioavailability and utilization of magnesium as well.

Baobab fruit pulp and leaves supply essential minerals and vitamins but they are poor in protein content. Mixing them with leguminous crops (pigeon peas, beans, lentils), nuts, and cereal have complementary effect that results in the provision of adequate protein. Quality protein is essential for the absorption, transport, utilization and storage of minerals. A diverse diet consisting of baobab, cereals and legumes has the potentially to curve hidden hunger and improve the nutritional and health status of a community.

Vitamin C content of baobab pulp diminishes with time. In fresh form baobab contains four times more vitamin C than orange. Its exposure to air and processing conditions like temperature (>73 0C), intensive agitation, and moisturizing of the pulp reduce the concentration of vitamin C dramatically. It is hypothesized that protecting the pulp from oxidation by quick and proper packaging and keeping it in dark and cool place increases the shelf life of Vitamin C.

Baobab has a long history of ethno-medicine, among others, in the prevention and therapy of diabetes mellitus. However, conclusive evidence is still missing.

WP4: ASSESSING DEMAND, MARKETS AND VALUE CHAINS FOR BAOBAB

Work under this work package aims to (a) determine rural and urban fruit consumption and purchasing patterns, customer segments and consumer preferences; (b) analyse the baobab market (structure, conduct and performance) and recommend market development and marketing strategies; and (c) analyse baobab supply chains including governance structures and quality standards, distribution of risk and economic rents; and d) identify critical points constraining the performance of baobab supply/market chains.

Abstract overview

1) George Kaimba et al: Supply Response of Underutilized Indigenous Tree Fruits to Price and Non-Price Incentives: The Case of Baobab Pulp on Seed in Kenya

2) George Kaimba et al: Marketing Channels for Underutilized Indigenous Fruit Trees Products: The Case of Baobab Pulp on Seed in Kenya

3) Collins Kiprotich et al: Consumer Awareness and Attitude Towards Baobab Products in Kenya

4) Mervyn Kimathi Muriungi et al: Profit Efficiency among Baobab Processors in Kenya

5) Ismail Adam et al: Livelihood strategies and the role of baobab fruits in poverty alleviation in dry lands of Sudan

6) Ismail Adam et al: Commercialization of Baobab (*Adansonia digitata* L.) fruits in North and West Kordofan and Blue Nile States of Sudan

7) Hassabelrasoul Saeed et al: Sudanese Perception, Behaviour and Preferences towards Baobab (*Adansonia Digitata* L.) Fruit and Pulp Consumption

Supply Response of Underutilized Indigenous Tree Fruits to Price and Non-Price Incentives: The Case of Baobab Pulp on Seed in Kenya

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In developing countries, reliance on cereal grain crops has not adequately tackled the problem of food insecurity, malnutrition, and poverty. More diverse diets, drawing from a wider range of micronutrient-rich underutilised indigenous food products, such as baobab pulp, need to be integrated into the rural household food portfolio in arid and semi-arid lands. Despite the baobab fruit pulp being recognized globally for its high nutritional content and income generation opportunities, it is still underutilized and under-commercialized in Kenya. This study applies the restricted normalised translog profit function to analyse the supply response of baobab pulp to price and non-price factors using a primary dataset of 270 baobab collectors from three counties in Kenya. Findings reveal that baobab collectors significantly respond to price and non-price inducements. Supply elasticities of baobab pulp with respect to its own price is significantly positive while input costs related to wage rate, transport, and packaging show significant negative effects. Non-price incentives such as other household incomes, number of baobab trees in a household's farm, number of buyers known to the collector, experience of selling and number of children in the household show significant effects on output supply. The study concludes that higher output prices and lower input costs are essential for increasing baobab supply, and to consequently reduce food and nutrition insecurity, increase incomes and reduce local poverty. Since direct price control is not feasible, incremental increases in supply can be attained through market development, baobab research and education, and the expansion of physical infrastructure that indirectly shifts the baobab's price upwards.

Key words: *Indigenous fruit trees, Elasticities, Poverty, Food insecurity, Incomes, Translog profit function model*

Marketing Channels for Underutilized Indigenous Fruit Trees Products: The Case of Baobab Pulp on Seed in Kenya

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Baobab tree provides incomes and supplements diets for local communities living in the Arid and Semi-Arid Lands in developing countries. In the past decade, the tree has generated much attention owing to its nutritive attributes. Despite its potentials, the tree is neglected by research and its products remain underutilized in Kenya. This study therefore analyses the determinants of baobab collectors´ participation in different marketing channels using 270 baobab collectors in three counties in Kenya. A multinomial logit regression is employed in the empirical analysis. The results show that baobab collectors only participate in the domestic markets through five marketing channels, namely assemblers, rural wholesalers, urban wholesalers, urban retailers and processors. Majority (86%) of the collectors participate through the rural markets (assemblers, rural wholesalers) and 14% through the urban buyers (urban wholesalers, urban retailers and processors). Collectors' participation through processors and retailers is minimal and export channels are conspicuously missing from the chain. Human capital factors such as gender, age, number of children, marital status, other incomes, number of trees, collection point, selling experience and number of buyers known; transactional factors which include price of baobab, wage rate, transport cost, packaging costs distance to market, product form and price awareness in other markets; and institutional factors such as access to credit and training significantly influence collectors' marketing channel decision. The main policy recommendation include building capacity around new market development, sensitization, training, road networks and institutional services in order to create more profitable channels for income generation, hence enhancing local food security, and reduction of malnutrition.

Key words: *Baobab pulp, Marketing Channels, Malnutrition, Poverty reduction, Market development, Kenya*

Consumer Awareness and Attitude Towards Baobab Products in Kenya

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Baobab (*Adansonia digitata L.*) shows high market potential in arid and semi-arid areas of Kenya. It is widely traded by few actors, but its products occupy a small market share. The benefits of baobab products are yet to be communicated to consumers. This study aimed to examine awareness and attitudes of rural and urban consumers in Kenya towards baobab products. Data on socio-economic characteristics, baobab product awareness, and attitude towards baobab products was collected from 353 consumers in rural and urban markets in Kenya. A pretested questionnaire was administered to each consumer through personal interviews. Descriptive statistics were used to analyse awareness level on baobab products. Zero truncated Poisson regression model was used to asses factors influencing awareness of baobab products. The results showed a mean awareness score of 5.92 and 6.45 for urban consumers and rural consumers respectively, this is a clear indication of low awareness level compared to the maximum awareness score of 21. The model results revealed that age ($p<0.05$), gender ($p<0.01$) and group membership ($p<0.01$) influenced consumer awareness positively, while income level ($p<0.01$) had a negative influence. Exploratory factor analysis pointed out four factors with regards to consumer attitudes towards baobab pulp in Kenya. These are; 'Availability, affordability and income value', 'Trust, taste and nutritive value, cultural perception', 'Cultural values and health difference' and 'Age and freshness'. Group membership is essential, it provides links to access a variety of information that is vital in raising baobab products awareness level. Finally, improvement of product labelling, certification and freshness, awareness creation through formal and informal education will positively shape consumers attitudes.

Keywords: *Baobab, attitudes, awareness, urban and rural consumers*.

Profit Efficiency among Baobab Processors in Kenya

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This study looked at the profit efficiency of baobab processing, an indigenous tree which has gained enormous popularity from its economic potential, nutritional and health benefits. The study was conducted in Kitui, Mombasa, Nairobi, Kilifi and Makueni counties. Purposive and snowball sampling was employed to select a sample size of 307 respondents. Structured questionnaires were used to collect information from the respondents. Stochastic frontier analysis was adopted to establish the factors influencing profit efficiency of baobab processors, while logit regression was used to determine processor's choice of product to process. Descriptive results revealed that 92.5% of the respondents were female while male were at 7.5%. Baobab candy was the most processed product at 90.5% followed by ice cream at 4.6%, juice at 3.6%, powder was at 1% and sauce at 0.3%. The stochastic model result revealed that age, information access and level of non-processing income ($p<0.05$) influenced profit efficiency negatively while number of processing years, credit access and access to training ($p < 0.05$) had positive influence on profit efficiency. The logit result showed that total awareness score and age ($p <0.05$) favoured processing of other products compared to candies while years of processing increased the chances of candies being processed compared to other products (juice, ice cream, powder and sauce). The study concludes that providing women with productive resources is important in commercializing baobab processing and improving the welfare of rural women. Moreover, increasing research on baobab products, new market development, creating awareness on baobab processing quality and standards and sensitizing people on importance of baobab will promote baobab processing hence increasing processors' earnings and living standards.

Key words: Profit efficiency, processing, stochastic frontier analysis, candies

Livelihood strategies and the role of baobab fruits in poverty alleviation in dry lands of Sudan

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The study aims were to (i) assess the contribution of baobab fruits to rural income and poverty alleviation; (ii) analyse the pursued livelihood strategies by rural households, and (iii) identify the factors that influence household's choice livelihood strategies in rural Sudan. Data from surveyed 374 households at West Kordofan, North Kordofan, and Blue Nile were collected in 2018 and 2019. We employed a class cluster analysis to determine the optimal number of livelihood clusters and assigned individual households to particular cluster; and regression models were used to examine the factors influencing the livelihood strategy choices. The results showed that baobab fruits contribute to 7% to 18.5% of total annual household income in the study areas. The additional income from baobab fruits contribute to reduction of the poverty headcount index and the income inequality in the study area. The results also revealed a high diversity index of income activities through the livelihood strategies groups in the study areas. This study also provides evidence that households' asset endowments and contextual factors have an important influence on the choice of household livelihood strategy. The results of regression indicated that the gender of household head, primary and secondary level of education, tropical livestock unit, and land size were positively significantly associated with the selection of the livelihood strategies. However, age of household head, household size, and distance to the market were negatively correlated with the livelihood strategies selection. The study concluded that the baobab fruit play an important role in supporting livelihoods, and therefore provide an important safety net, contributing to reduced income inequality and poverty. This study highly recommends that policies should focus on enhancing the productivity of agricultural land plots owned by households rather than increasing households' access to common property resources. In addition, effective pro-poor policies should be targeted towards assisting the poor to shift to higher-return activities, such as wage employment and non-farm (business) by investing in education and improving the road infrastructure in rural areas.

Commercialization of Baobab (*Adansonia digitata* L.) fruits in North and West Kordofan and Blue Nile States of Sudan

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Baobab is an abundant resource in Sudan and has a great potential for commercialization, which can drive rural development. In view of these realities, this study aims to measure the level of household involvement in baobab fruit commercialization, identify market places, and analyse the determinants of the factors influencing market orientation. Results are based on the analysis of data collected from 374 households surveyed in 24 districts of three regional states of the country in 2017 and 2018. Descriptive statistics, commercialization index and double hurdle models were used to analyse the data. The results showed that the commercialization index ranged between 49% and 75% which indicated a moderate commercial index. The econometric analysis results from this study show that for the probability model, ownership of mobile phones and radios, household size, gender of the household head, and non-farm income have positive and negative influences on marketed surplus. Similarly, for the probability model, age, household size, non-farm income, primary education, TLU, and ownership of mobile phones and radios also had negative and positive influences on the smallholder farmers' decision to participate in the baobab fruit market. This study strongly recommends that the development of policies should be more supportive of different types of households of different sizes, and that expansion of land among farmers may enhance the commercial engagement of producers and improve the accessibility of baobab resources for commercial production.

Perception, Behaviour and Preferences towards Baobab (*Adansonia Digitata* L.) Fruit and Pulp Consumption in Sudan

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Baobab is a non-timber forest product collected from the wild in Sudan and is highly commercialized as well as widely traded. This study examined consumer perception, behaviour and preferences with regards to baobab fruits and pulp in fives markets of Sudan. Data was collected by means of a standardized consumer survey in one rural market of El Obeid and four urban markets in the Khartoum area. The consumer survey was complemented by focus groups discussions and key informant interviews with processors. A total sample of 449 people were interviewed and of that 216 and 233 in El Obeid and Khartoum respectively. The results shows that consumers have a positive attitude towards baobab fruits and pulp consumption. They believe baobab fruits and pulp are healthy, nutritious, tasty, available, sustainable and ethical. On the other hand consumers believe that baobab fruits and pulp are expensive. Small grocery stores are the preferred place of purchase baobab fruits and pulp with a percentage of 50.9%, 27.1%, 44.1%, 55.1% and 77.5% for El Obeid market, Shaabi Khartoum market, Omdurman market, Bahri market and Shaabi market respectively. Regarding to gender perspective in two studies areas, male were dominated the sample profile of El Obeid market, Omdurman market, Bahri market and Shaabi market. While, in sample profile of Shaabi Khartoum market female were higher number than male. The results of factor analysis revealed that factors such as (attitudes, social influence, familiarities, and attributes beliefs) have significant positive influence on consumer's decision-making toward baobab fruit and pulp frequency consumptions.

Keywords: Baobab; underutilized fruits; Consumer study; socio-economic factors; Sudan

WP5: COMMUNITY CAPACITY DEVELOPMENT AND IMPLEMENTATION

Work under this work package aims to (a) assess community capacity and initiate participatory technology development; (b) develop extension materials for various target groups; (c) conduct trainings and extension activities; and (d) establish a community-based pilot production of a sample baobab product in Kenya.

Abstract overview

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Farmers' baobab (*Adansonia digitata* L.) knowledge and utilization practices in Kilifi, Kenya: Implications for designing information and training interventions

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In marginalized areas of Kenya where the baobab tree can commonly be found, communities are yet to realize the full potential of this natural resource as a means to achieve food security and improve their living standards. A survey was therefore conducted in Kilifi County, Kenya to assess community knowledge and training needs on baobab production and utilization. Primary data was collected using predetermined questionnaires from a sample of 120 households using a systematic random sampling technique. The raw data was analysed using descriptive and inferential methods. While a majority of households (69.2%) owned naturally occurring baobab trees on their land, the baobab pulp was seldom used as an ingredient in food preparations (15% of households). Only 34.2% of respondents have ever been involved in making one or more baobab products. The majority of households (55%) owned below 10 baobab trees. Yet, most of these trees were not only actively managed as only 10% of the households in Kilifi undertook any baobab husbandry and management activities. There was generally very limited knowledge among farmers on the various products that can be derived from baobab, and their nutritional value; all this courtesy of inadequate agricultural extension services. Over 70% of the sampled households did not receive any kind of agricultural information, indicating the potential for improving current practises. The inferential analyses investigated the influence of various socio-economic characteristics (e.g., tree tenure, household food security status, presence of baobab traders etc.) on the farmers' knowledge about the baobab tree and their management and utilization practices, as well as the association between knowledge and actual practices. It could be demonstrated that farmers with larger farms, of younger age, more aware of various processed baobab products, and with better knowledge of baobab management and with other baobab users in their social networks were more likely to harvest baobab. Temporary food shortage was significantly linked to higher knowledge of drying/ storing/ packaging and processing for sale, and higher information needs regarding processing for sale. The study derives recommendations and priorities for tailor-made education, awareness and capacity building interventions addressing local communities and beyond to make farmers appreciate the nutritional and economic value of the baobab tree and its products.

Keywords: Baobab products; training needs assessment; knowledge gap analysis.

Development of baseline farmer and training of trainers (ToT) capacity building materials and training implementation

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The development of the training materials and the implementation of the capacity building efforts for baobab farmers and training of trainers (ToT) was guided by the outcomes and recommendations of the information needs assessment and knowledge gap analysis which was carried out in Majajani/ Mavueni locations of Kilifi County, Kenya. The overall aim was to develop extension materials for various target groups and conduct trainings and extension activities to enhance baobab utilization and management practices in the region.

The methodology used to develop the training materials included gathering relevant requisite information through desk research, consultations with experts from the entire baobab value chain and organizing the materials into different training modules with relevant illustrations for extension agents and farmers. The draft manuals were then shared with Baofood project partners for review and production of the final version. After finalization of the training materials, the actual capacity building efforts were carried out. The overall objective for conducting the trainings for farmers and extension agents was to impart knowledge, skills and attitude to improve production practices, value addition, nutrition and marketing of baobab products.

A total of one hundred and eighty six (186) community workers were assessed for the ToT and a total of sixty (60) were trained as extension agents. Selection of trainees was based on their educational background (KCSE minimum) and originating from the designated project area. After the training the ToT participants were expected to strengthen the capacity with regard to baobab in their communities and to disseminate and share with partners the lessons learnt to foster knowledge and skills in the use of baobab as a food security crop. It was evident from the oral and written evaluation test scores (Av 65%) that the ToT had helped gain the requisite knowledge to enable the community workers to train and significantly influence the attitude of the rural baobab communities in the target area. Additionally, between May and December 2018 a total of one hundred and ninety nine (199) farmers were assessed and a total of sixty (60) farmers trained. The criteria for identification of the farmers was their use and/or marketing of baobab products and possession of baobab trees on their farms. After the training equally the farmers showed willingness to be registered as contact farmers and suppliers of raw materials to the community based pilot processing plant at Wild Living Resources. The farmers also demonstrated an enhanced understanding of basic product handling skills and hygienic practices with regard to baobab products.

Keywords: training manual; knowledge gaps; extension materials; skills; attitudes

Establishment of community-based pilot processing unit for baobab products in Kilifi, Kenya

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Processing agroforestry food products such as baobab by rural producers or small-scale enterprises can considerably contribute to local food security, employment, alternative household income and improved livelihoods. Thus, the Baofood project aims to establish a community-based processing unit to sustainably produce and supply highly nutritious baobab products for home consumption and local and regional markets.

Approx. 80 farmers with baobab on their agricultural land are being involved in the community-based processing unit. These farmers are currently being trained in the sustainable production, harvesting, and processing of baobab. The overall strategy of the processing unit is to focus primarily on local and regional markets as well as high quality raw materials for further value addition in the communities. With guidance from private sector players of the baobab industry a detailed business plan was established and standard operation procedures (SOPs) defined. The latter cover aspects from fruit collection, storage, transport and traceability, processing, packaging, up to cleaning the processing equipment. As such it is aimed to ensure that important groundwork has been set to be able to fulfil standards with regard to food quality or organic certification. This will make it easier in the future to rapidly upscale when market opportunities become apparent. Furthermore, novel ideas for the integration of baobab into traditional Kenyan recipes for dietary enrichment have been developed, tested, and showcased to the communities to give further ideas of potential upgrading and business establishment. This approach gives local baobab producers and processors, often characterized by limited resources and expertise for product and business development, the opportunity to collaborate with stakeholders across the baobab value chain, research institutions, or regulatory bodies. While traditionally the development of new, marketable products has primarily been approached from the perspective of the companies involved in production and sale of such products, it is increasingly recognized that successful product innovation is the outcome of a collective and interactive effort rather than the achievement of a single person or firm.

Baobab product development

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There is a widespread availability of baobab fruits as a local resource in Kenya. However, although these fruits are already being used for some specific applications such as "mabuyo" sweets" - which consist of the dried pulp around the seed prepared in a mix of sugar and food colourings - overall they can still be regarded as an underutilized food resource. Apart from some minor logistic and in some cases superstitious constraints it is mostly a lack of knowledge, which prevents wider applications of this nutritious food resource.

Preliminary laboratory tests have revealed that baobab powder is a highly versatile food ingredient, which can easily be introduced into various foods and recipes, especially where some slight acidity is advantageous. Furthermore, it can provide thickening and gelling properties. It is not suitable for bright and clear liquids as it causes turbidity.

Against this background, this study aimed to apply baobab fruit powder as an additional and/or substituting ingredient in local food products and recipes and subsequently test their acceptance amongst the local population. On the basis of an traditional Kenyan cooking book a variety of sweet and savoury recipes were selected. These recipes were modified with baobab powder in varying quantities up to ~ 30 % and underwent a preliminary sensory evaluation. The most promising recipes which contained baobab powder up to 15 % were chosen for a detailed sensory test with local people in Kilifi, Kenya. These sensory tests were conducted with farmers during two training workshops on baobab in September and December 2018.

These recipes, e.g. different types of cookies, savoury sauces or pancakes all proved to be highly accepted by the involved test persons. For example, 19 of 25 test subjects gave the highest rating on a 9-point-scale (= extremely like) for pancakes with 5 % baobab powder. 27 out of 28 test subjects rated easy sugar cookies with 14 % baobab powder with a 7, 8 or 9 on the same scale. However, it remains to be seen whether developed recipes will be taken up by the local communities, which may be fostered via further dissemination activities.