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A value chain analysis of baobab (*Adansonia digitata* L.) products in Eastern and Coastal Kenya

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Abstract

A growing demand for the highly nutritious baobab fruit pulp from Europe and North America raises the question whether the marketing of baobab (*Adansonia digitata* L.) products could be an opportunity as an income source for rural communities in Kenya, or if the increased demand from overseas would disturb domestic baobab use. To gain an idea of domestic baobab use, a value chain analysis of edible baobab products was performed, using qualitative methods. By using a non-probability sampling, 134 baobab value chain respondents from producers to retailers of baobab products were interviewed on sales data, volumes and profits. Results from an additional household survey, key informant interviews and participatory research were used to identify strengths, weaknesses, opportunities and threats of and to the baobab business. The main actors of the baobab value network were farmers, collectors, wholesalers, processors and retailers; 72 % of the respondents were female. The products most traded were unprocessed pulp-covered seeds and mabuyu, a candy made out of baobab pulp-covered seeds, sugar and food colour. The average value of the product along the mabuyu value chain increased from 0.07 USD per kg of raw pulp-covered seeds paid to the farmer to up to 1.50 USD per kg paid by the end consumer for the mabuyu candy. For farmers, the harvesting and trading with baobab products is an additional source of income during the dry season. Increased commercialisation of baobab products and better integration of farmers into value chains may enhance income, particularly of women.

Keywords: Mabuyu, underutilised fruit trees, smallholder farmers, Kenya

1 Introduction

Baobab (*Adansonia digitata* L.) is a multi-purpose tree widely spread in the semi-arid regions of sub-Saharan Africa (SSA). The tree is valued by local communities for its edible fruit pulp, leaves and seeds, as well as a provider of fibre, fodder and medicine (Gebauer *et al.*, 2016). Baobab fruit pulp is rich in nutrients, particularly in potassium, calcium and vitamin C. The leaves are rich in provitamin A, protein and minerals, in particular iron (Sidibé & Williams 2002; Chadare *et al.*, 2008; Stadlmayr *et al.*, 2013; Muthai *et al.*, 2017). Recently, the demand for baobab products was growing in Europe and North America where the fruit pulp is marketed as a super food due to its nutritious characteristics. Already in 2013, more than 300 baobab products were reported in Europe, and a future increasing demand can be expected (Gebauer *et al.*, 2014).

As a response to the growing demand, local and export markets for baobab products are developing in western and southern SSA (Dovie, 2003; Buchmann *et al.*, 2010; De Caluwé, 2011; Venter & Witkowski, 2013). Venter & Witkowski (2013) found that the cash value of baobab fruits (i.e. income generated from sales) is higher than the use value (i.e. subsistence usage) in the Venda area, South Africa, and that the sale of baobab fruits helps to alleviate poverty. This finding is further confirmed by De Caluwé (2011) who states that income from selling fresh and dried baobab leaves and fruits could act as a financial buffer during the dry season and is seen as a valuable employment opportunity in Mali and Benin (De Caluwé, 2011). In the Nuba Mountains of Sudan, Adam *et al.* (2013) found that the sales of baobab fruits reflected the highest earning activity and contributed to more than half of the annual household in-

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come of farmers. Further, baobab products can also play an important role in empowering marginalised people (Venter & Witkowski, 2013), especially women, who are mostly the ones trading baobab products (Buchmann *et al.*, 2010).

While marketing baobab products can be an opportunity in places such as southern Africa, where the local demand for baobab product as a subsistence product has diminished (Venter & Witkowski, 2013), commercialisation may create a conflict, where baobab-based food is still part of the daily diets, e.g. in West Africa (Buchmann *et al.*, 2010).

In Kenya, baobab has been listed by local communities as a high priority food tree for future domestication due to its multiple uses (Kehlenbeck *et al.*, 2013), therefore income generating options for the local rural community can be assumed (Venter & Witkowski, 2013; Kehlenbeck *et al.*, 2013). In addition, baobab has a high potential for product development, value addition and high profit margins in Kenya (Van der Lans *et al.*, 2012; Mwema *et al.*, 2013). So far, baobab is only harvested from wild trees and domestication of the species may increase quantity and quality of baobab fruit pulp for domestic and export markets. Some scientific activities on baobab domestication have been performed in Kenya, more precisely on e.g. the morphological characterisation of baobab trees (Omondi *et al.*, 2019) or their vegetative propagation (Anjarwalla *et al.*, 2017). Compared to the findings from South and West Africa, the market chains for baobab products in East Africa, and particularly Kenya, have not yet been studied in detail.

The main objective of this study was to gain insights into the structure and functioning of baobab product markets and value chains in Kenya, using the examples of the baobab value network originating in Taita-Taveta County. The specific research questions were: i) what kind of value chains for baobab products exist, ii) who is involved in the baobab business and how are the actors interlinked, iii) how are the value addition and net profits distributed along the value chains; and, most importantly, iv) does the trading with baobab products have potential as an income generating activity for smallholder farmers, local microprocessors and other value chain actors? Results of this study can help researchers and policy makers develop frameworks to better integrate rural producers into value chains and to improve the present and future markets for baobab products in Kenya.

2 Conceptual Framework

A conceptual framework was developed, based on existing literature about value chains, baobab markets and on literature about smallholder-based food markets (Porter, 1991; Webber & Labaste, 2010; Russell & Haanoomanjae, 2012). The value chain concept was developed by Porter and was initially developed for firm level application (Porter, 1991; Feller *et al.*, 2006). Nowadays, the value chain concept is used to allow stakeholders and politicians (not only firms) to 'understand the processes of the industry and the costs related to the various steps in the chain' (Russell & Haanoomanjae, 2012).

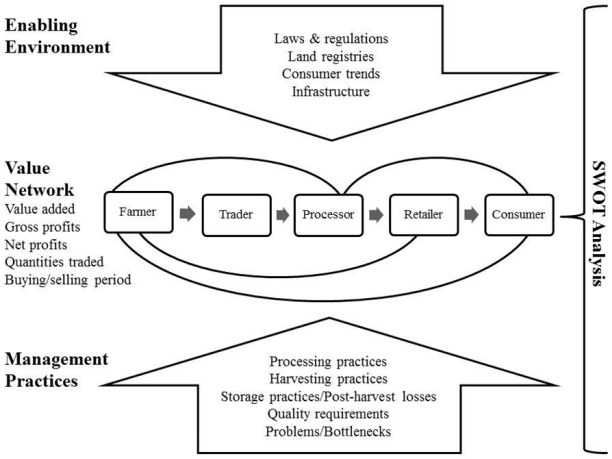


Fig. 1: *Conceptual framework developed by authors*

The term value network is used, instead of single value chains, to emphasize different marketing channels captured by value chains. The value network illustrates the links between different actors along the chain (e.g. from the farmer to the processor) and linkages within the same group of actors (e.g. between farmers) (Trienekens, 2011). The value network is the core of the conceptual framework (see Fig. 1). First, the actors of the value network will be identified and described by stressing possible marketing channels. Second, the value network will be analysed. The value added and net profit margins per actor will be calculated, the buying and selling periods for baobab pulp-covered seeds (in short pulp/seeds), and the quantity traded will be determined.

Third, we analyse factors that directly or indirectly influence the value network: the enabling environment that refers for instance to laws, regulations and the existing infrastructure (Hellin & Meijer, 2006; Bolwig *et al.*, 2010).

The final aim of the value chain analysis is to identify opportunities and constraints for the industry, and thus, to give recommendations to politicians and actors to optimise the market and its enabling environment. Therefore, a qualitative SWOT analysis (strengths, weaknesses, external opportunities, threats) of the markets for baobab products in Kenya is performed. The SWOT analysis is a recommended tool by Webber & Labaste (2010) which can provide a first 'general characterisation of the current state of the industry,

identify issues, and generate discussion'. The SWOT analysis is based on information received from key informant interviews and value chain respondents (a detailed list of key informants is shown in Table A3 in the Appendix).

3 Data and methods

3.1 Research area

As the starting point for the value chain research, Taita-Taveta – a county in the southeast of Kenya (see Fig. 2) – was purposely selected due to the existence of a baobab population. In the semi-arid lowlands of Taita-Taveta more than half of the population lives below the poverty line of 2 USD a day, one-third of children below five years are stunted and 28 % are underweight (Taita Taveta County Government, 2013). Agriculture accounts for 95 % of the income for the local population. Similarly to other semi-arid areas in Kenya, the agricultural sector is affected by long-term environmental changes (landslides, erosion, drying up of rivers), unreliable rainfall, and weather extremes (Ulrich *et al.*, 2012; MoALF, 2016). During the data collection period, the Famine Early Warning Systems Network (FEWS NET) announced a 'stressed' to 'crisis' level of food security for the research area in early 2014 (FEWS NET, 2014).

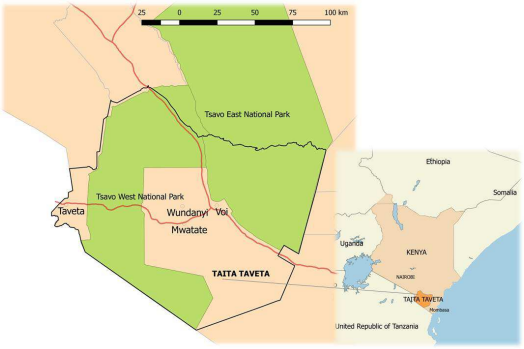


Fig. 2: *Research area Taita-Taveta in Kenya, stretching from Voi towards Mombasa and Taveta. Own illustration based on data from the World Resource Institute, Diva-GIS, Thematic Mapping World Borders and Natural Earth Data.*

Taita-Taveta is divided into four sub-divisions, namely Voi, Mwatate, Wundanyi and Taveta. The Tsavo National Park, covering about 60 % of the counties' land, separates Taveta from the other sub-divisions. In the following, we will use the term Taita when referring to the three sub-divisions Voi, Mwatate and Wundanyi.

3.2 Sampling and methods

Since this study is the first addressing markets for baobab products in Kenya, secondary data about market actors that are involved in baobab marketing was not available. Therefore, a wide set of qualitative survey techniques were used to deepen the understanding of markets for baobab products.

First, during a scoping study, local non-government organisations (NGOs) such as World Vision (Voi) and USAID (Voi), local authorities and extension services were contacted to gain information about the county, the baobab business and potential baobab procurement areas in Taita-Taveta.

Second, a standardised questionnaire was applied to 134 respondents. The survey covered information on baobab collection/harvest, sales data, procurement, processing, storage practices, quality requirements and bottlenecks among others. A non-probability sampling method was chosen for the value chain survey. We purposefully sampled starting point respondents in Taita-Taveta. The criterion was that the starting points played an active role in the baobab value network. Applying the snowball-sampling technique, the respondents identified additional respondents. While the snowball technique is prone to missing out important information, we are confident that it was the most appropriate strategy in our case, given the fact that baobab value chains are scattered and difficult to identify in Kenya.

Using similar key informants (for instance persons that know each other) as starting points may lead to missing important information, and hence, we aimed at diversifying these starting points. Therefore, we surveyed local markets, supermarkets as well as farmers as potential entry points. We inspected all major markets in Taita-Taveta (Voi, Mwatate, Wundanyi, and Taveta) and identified all market vendors involved in the baobab value chain. In addition, we surveyed supermarkets in the major towns of our research area and in Nairobi for baobab products and followed up on the owners of the companies. Based on this search we were able to meet three large-scale mabuyu processors, as well as one baobab start-up in Nairobi. During the interviews in Taita-Taveta, other regions such as Nairobi, Makueni County and Coastal counties (Mombasa, Malindi, Kilifi) were mentioned by the respondents as the main hubs for baobab procurement and markets. Hence, we expanded the research area to the mentioned areas. In total, 41 farmer-traders, 10 collectors, 6 wholesalers, 40 processors and 37 retailers were interviewed (see Fig. A1 in the Appendix for details on the numbers of respondents per county and actor).

Third, a farmer household survey was conducted throughout Taita-Taveta County to collect information on the season for baobab harvest and product selling as well as annual seasons of food insecurity in the area (N=46). Therefore, a sample area around the Voi-Taveta road was constructed with a width of 10 km on each side of the road, and a total size of 2015 km^2. In the sample area, 49 rectangular transects

(0.5 km x 3 km) were systematically placed using the QGIS software, taking three different land use intensities into account (Anthropogenically Affected Area (AAA), National Park, Sisal). In each of the transects of the AAA (n=24), at least one farming household was randomly selected for the interview. If no household was living in the transect, a household nearby was randomly selected. This led to a diverse group of interviewed farmers, such as those living in areas where baobabs grow and where they do not grow (for more information on the transect sampling method see Fischer, 2015).

Lastly, a combination of key informant interviews and participatory research methods was applied. For instance, the first author visited three rural and three urban processors and prepared the products with them to gain a deeper understanding of the processing of baobab products. In Nairobi, the first author participated from procurement of raw product until selling the produce in the central business district. The visited urban and rural baobab processors included both individual businesses (e.g. one high-level baobab processing start-up in Nairobi) as well as processor groups (e.g. two women groups in Makueni). The results from this participatory research were combined with the results of the value chain and farmer household survey, and were used for the SWOT analysis (see Table A3 in the Appendix for further information about key informants).

The study was performed from May to October 2014. The first author, with the help of a trained local enumerator, conducted the interviews. To identify the final sample size, the concept of saturation was followed. We consistently analysed and coded the data during data collection. Once additional data would not add any new concepts or theories to our research questions, we stopped the data collection (Strauss & Corbin, 1994). The concept of saturation originates from grounded theory and is an essential criterion of rigor qualitative data evaluation (Bitsch, 2005). For instance, it was most recently applied to study institutional challenges for mechanisation in Africa (Daum & Birner, 2017).

3.3 Data analysis

To calculate profits along the baobab value chain, we collected data on units of the product, values per unit at buying and selling stages, and major input and transaction costs (transport costs, stall costs, taxes) for each link of the value chain. The data on volumes and prices given by the respondents were rough estimates as the trade with baobab pulp/seeds is informal at the beginning of the marketing chain, and no standardised units for volumes traded exist. Additionally, baobab fruits vary in size, shape and in the amount of pulp/seeds they contain (Gebauer & Luedeling, 2013). Therefore, measurements were taken at different stages of the chain to validate the information given by the respondents.

We found that baobab pulp/seeds or whole fruits are mostly traded in 90 kg bags. The weight of a standard 90 kg bag filled with baobab pulp/seeds or whole fruits were determined by weighing three filled bags and calculating the respective mean and confirming the measures, with the distributing wholesalers (who weigh the bags on a daily basis). A similar weighing procedure has been applied for processed baobab products. Around 40 samples of processed baobab pulp/seed were collected from different locations. These samples were measured and the average weight was calculated (for a detailed list of measurements, see Table A1 in Appendix). In a next step, the profit distribution along the value chain was calculated. The added value of baobab products in this study was calculated as follows:

$$\textit{Added value} = \textit{Gross profit per kg} = \textit{Selling price} - \textit{buying price}$$

The net profit margins were calculated by:

$$\textit{Net profit margin per kg} = \frac{\textit{Selling price - buying price - other costs}}{\textit{Final retail price}}$$

Other costs included transport costs, taxes/fees paid at the market gate and any input costs such as sugar and food colour for baobab processing. Labour is not included in the calculations as baobab fruits are harvested during the dry season when the opportunity costs are low for the farmers (few other activities on the farms)[1]. Income taxes were not included for the retailers and distributing wholesalers, since raw baobab pulp/seeds and processed mabuyu contribute little to their total income. Since sugar prices undergo seasonal and regional price fluctuations, an average price for one kilogram of sugar was calculated and used to make the profitability of processing comparable.

4 Results: Value chain analysis

4.1 Products

The value chain survey for baobab products identified a candy made from pulp-covered baobab seeds, called

[1] A detailed description on labour requirements for harvesting and processing are provided in Appendix B.

mabuyu, as the only processed baobab product in the research area. Additional products such as baskets (woven from strings made of the fibrous baobab bark), paintings (printed on fibre of baobab bark), seed oil, fruit pulp powder, and ice pops (made from the pulp powder) were found in Nairobi, but traded only in niche markets, mostly for tourists.

Pulp/seeds is the raw product most commonly traded in the research area. The market survey showed that the pulp/seeds were not sold by market vendors who target consumers, but exclusively by wholesalers who sold the pulp/seeds to mabuyu processors. Before selling the pulp/seeds farmers are involved in pre-processing. The first step refers to the harvesting of the fruit either by throwing stones and sticks at the fruits, actively climbing the tree and picking fruits or shaking them off the tree. After harvesting, the farmers crack the woody shell of the baobab fruit by using stones or machetes. The pulp/seeds inside of the fruit are separated from the fibre bundles around them through manual sorting, and finally put into 90 kg bags for storage and/or sale.

Mabuyu

Mabuyu is made out of the pulp/seeds of the baobab fruit. The pulp/seeds are processed to mabuyu by adding a mix of sugar and food colour to them. Sometimes, the processors add cardamom, chili pepper or artificial flavours. The observed processing of pulp/seeds to mabuyu was performed in different steps: first, all remaining fibres needed to be removed from the pulp/seeds. Then, roughly a litre of water was boiled and part of a small container of food colour and half a kilogram of sugar was added to around one kg of pulp/seeds to produce about one kg of mabuyu (Table A1c). Larger and urban processors additionally added spices or artificial aromas to the sugar solution. After stirring the boiling sugar solution, the pulp/seeds were added and mixed with the liquid and some additional baobab fruit pulp to make the candy soft. Then, some processors dried the mabuyu while others packed the mabuyu straight away into small plastic bags (see Fig. A2 in the Appendix for pictures). Removing the fibre and packing the ready mabuyu into small bags were identified as the most time-consuming tasks. These tasks were often done with the help of female family members or friends. Large-scale processors in Taveta owning market stalls removed the fibre and sealed the bags of mabuyu while waiting for customers.

In rural areas, mabuyu is most commonly sold in small packages that cost 5 KES (equivalent to 0.05 USD in Oct 2014, see Table A2, Appendix) but can also be purchased in larger bag sizes in Nairobi and Mombasa and in supermarkets. The market survey showed a heterogeneous group of people, but especially children and pregnant women, consume mabuyu. The market survey also revealed that mabuyu is available throughout the year but can become scarce during Ramadan, Christmas and other festivities when the demand for mabuyu is high. Mabuyu is processed and sold not only in Kenya, but also in Tanzania (including Zanzibar) and Uganda.

4.2 Value chain actors

Farmers, collectors, collecting wholesalers, distributing wholesalers (mostly in Mombasa and Nairobi), small-scale and large-scale processors and retailers were identified as actors of the value network for mabuyu (Table 1). The descriptive statistics show that farmers selling pulp/seeds and processors of mabuyu were predominantly female.

4.3 Value network for pulp/seeds

Based on the data collected during the value chain survey, the value network for baobab products was identified, mapped, and selling and buying prices were calculated (Fig. 3). The value network analysis, which is the core of our conceptual framework, builds on the sales of baobab pulp/seeds in Taita and Makueni, excluding the observations from other areas due to major differences in the structure of the network. For instance, markets for baobab pulp/seeds were established along the Mombasa Road (especially around the towns of Kibwezi (Makueni County) and Voi), while marketing activities were less frequently reported in Taveta, where farmers sold the whole baobab fruit instead of the already pre-processed pulp/seeds (either in 90 kg bags or per single fruits). The value chain for baobab fruits is shorter than the value chain for baobab pulp/seeds described above since it does not involve wholesalers and takes place locally. Figure A3 in the Appendix shows further details on the value network for baobab products in Taveta.

Value addition: Farmer

Out of 25 surveyed farmers, the majority sold baobab pulp/seeds to collectors (n=10) or processors (n=8), mainly at the farm gate. Selling and buying prices for baobab pulp/seeds depended on whether the farmers sold their pulp/seeds to a collecting wholesaler for a mean of 10 KES per kg pulp/seeds (0.1 USD) (which involved transport costs to the assembly markets) or to a local collector for a mean of 11 KES per kg pulp/seeds (on-farm). Due to transport costs, the farmers who actively tried to sell pulp/seeds at the market earned the same or less than the farmer selling on-farm (Fig. 3). On the assembly market in Voi, baobab pulp/seeds were demanded by collecting wholesalers from

Table 1: *Activities, marketing channels and characteristics of the 134 interviewed mabuyu value chain respondents in Kenya*

Value chain actors	*n*	*Activity*	*Main marketing channel*	*Characteristics*
Farmer	41	• Harvesting • Pre-processing	• Sell mostly at farm gate	• 71 % female • 29 % male
Collectors	10	• Harvesting • Pre-processing • Collecting and bulking pulp/seeds • Transport pulp/seeds to markets	• Buy from neighbours • Sell to spot market	• 60 % female • Senior women • 40 % male • Unemployed young men
Collecting wholesalers	2	• Search for baobab pulp/seeds • Transport pulp/seeds to larger markets (Voi/Mombasa)	• Buy pulp/seeds in villages or local markets • Sell to large-scale processors or distributing wholesaler in urban areas	• 17 % female • 83 %male
Distributing wholesalers	4	• Own shops or fixed stalls at urban areas of Nairobi and Mombasa	• Buy pulp/seeds from collecting wholesalers • Sell to large-scale urban processors	
Large-scale processors	23	• Procure pulp/seeds • Prepare mabuyu • Sell mabuyu	• Sell to retailers • Exist in urban and rural areas	• 73 % female • 27 % male • Main activity petty trade
Small-scale processors	17		• Sell directly to consumers • Exist only in rural areas	
Retailers	37	• Purchase mabuyu • Sell mabuyu to customers	• Buy mabuyu from processors who deliver (50 %) or buy mabuyu at the market from wholesaling processors (50 %) • Sell directly to consumers	• 85 % female • 15 % male • Main activity petty trade of sugar, oil, vegetables, flour and other candies

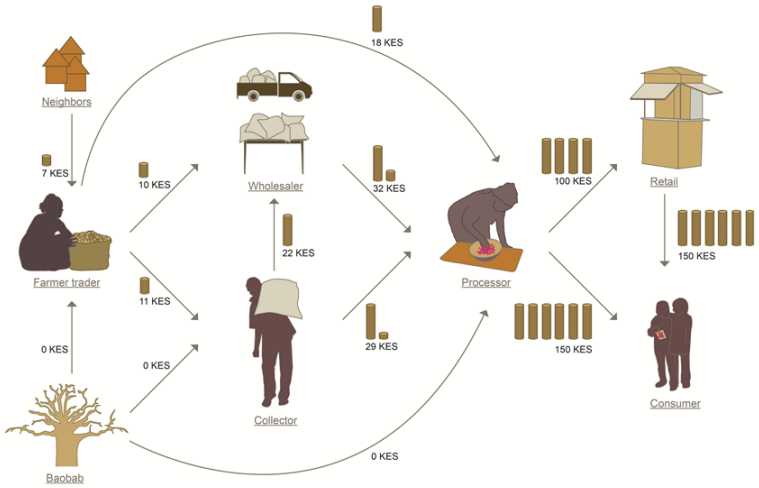
Mombasa or Kibwezi and local processors. Contractual arrangements were not observed and farmers were in a comparably weak bargaining position because additional transport costs arose if they decided not to sell the pulp/seeds and bring their bags back home. The wholesalers bought at prices similar to the on-farm prices. It was observed that farmers selling on-farm (n=11) accepted low prices such as 3 KES per kg of pulp/seeds (observed most often in the area around Kibwezi).

Three respondents sold their baobab pulp/seeds directly to wholesalers based at large wholesale markets in Nairobi (Eastleigh) and Mombasa (Kongowea market). These farmers either sent bags of pulp/seeds via bus to the destination or traveled personally with their produce to the urban wholesaler (selling price was 10 KES per kg of pulp/seeds).

Value addition: Collector/wholesaler

The seven interviewed intermediary traders in Taita and Makueni approached the farmer directly and bought the product on-farm. After collecting the pulp/seeds the collectors sold the produce either to wholesaling agents (n=6) or processors (n=1). In addition to selling their own baobab pulp/seeds, which gave them the highest returns of 22-29 KES per kg of pulp/seeds (Fig. 3), they bought the pulp/seeds from neighbours in small quantities. They compiled the pulp/seeds in 90 kg bags and transported them to Mombasa via bus, by either sending the bags or going personally, and selling the produce to wholesalers.

Three out of the four interviewed collecting wholesalers supplied distributing wholesalers at larger markets in Mombasa or Nairobi. One collecting wholesaler supplied a processor directly. Three interviewed distributing wholesalers sourced their pulp/seeds from collecting wholesalers. Fig. 3 shows that wholesalers had different ways to procure the baobab pulp/seeds and the value added depended on the source, varying between 10-22 KES per kg of pulp/seeds.



Actor	Market channel	Value addition (KES)
Farmer (F)	Tree → F→ Wholesaler	10
	Tree → F → Collector	11
	Tree → F → Processor	18
	Neighbours → F → Wholesaler	3
	Neighbours → F → Collector	4
	Neighbours → F → Processor	11
Collector	Tree → Collector → Wholesaler	22
	Tree → Collector → Processor	29
	F → Collector → Wholesaler	11
	F → Collector → Processor	18
Wholesaler	F → Wholesaler → Processor	22
	Collector → Wholesaler → Processor	10

Actor	Market channel	Value addition (KES)
Processor	Tree → Processor → Consumer	150
	Tree → Processor → Retailer	100
	F → Processor → Consumer	132
	F → Processor → Retailer	82
	Wholesaler → Processor → Consumer	118
	Wholesaler → Processor → Retailer	68
	Collector → Processor → Consumer	121
	Collector → Processor → Retailer	71
Retailer	Processor → Retailer → Consumer	50

Fig. 3: *Mabuyu value network and its actors (top) as well as prices of 1 kg baobab pulp/seeds (or mabuyu) along the value chain in Makueni and Taita (bottom). The prices are averages calculated from buying and selling prices given by each actor.*

Value addition: Processor

The surveyed processors (n=26) gained the highest possible value addition compared to other actors of the value net of baobab pulp/seeds (value addition in KES per kg of baobab pulp/seeds varied between 68 and 121 KES; Fig. 3). The processors procured the pulp-covered seeds from collecting wholesalers (n=15) and directly from farmers (n=9). Rural processors acted on a local level and engaged in the mabuyu business occasionally during the baobab season.

Value addition: Retailer

The value added by the interviewed retailers (n=37) was on average 50 KES per kg of mabuyu. The retailer gained one-third of the total value added of 150 KES, and typically bought small packages in dozens from the processors. The price for a dozen was on average 40 KES in all surveyed areas of Taita Taveta and Kibwezi. One package was then sold for 5 KES to the consumer. This price was the standard retail price in all field sites. The retailers stated various reasons for selling mabuyu: children liked it, the demand was high, it was profitable, and it attracted customers. The retailers stated that mabuyu was available all year round and that sales increased during school days, sports events, when mangos were not in season and during Ramadan. Almost 80 % of the retailers started to sell mabuyu less than five years ago. Sixty per cent of the respondents said that mabuyu contributed less than 10 % to their whole business.

Net profit distribution among actors along the longest chain

Fig. 4 illustrates the profit distribution of baobab pulp/seeds when it passes through the hands of every possible actor along the mabuyu value chain (longest chain). The net profit margins of the farmers were larger than the margins of the intermediary traders. The processors had additional costs of on average 51 KES per kg of mabuyu. These included transport costs and all inputs (sugar, food colour, cardamom or other flavour, firewood for boiling, water, etc.). The most expensive input was sugar (on average 38 KES per kg pulp/seeds), followed by food colouring agents (on average 8 KES per kg pulp/seeds). The remaining 5 KES were shared between other inputs. The input costs of 51 KES per kg of mabuyu led to a net profit margin of 18 % (or 17 KES per kg of

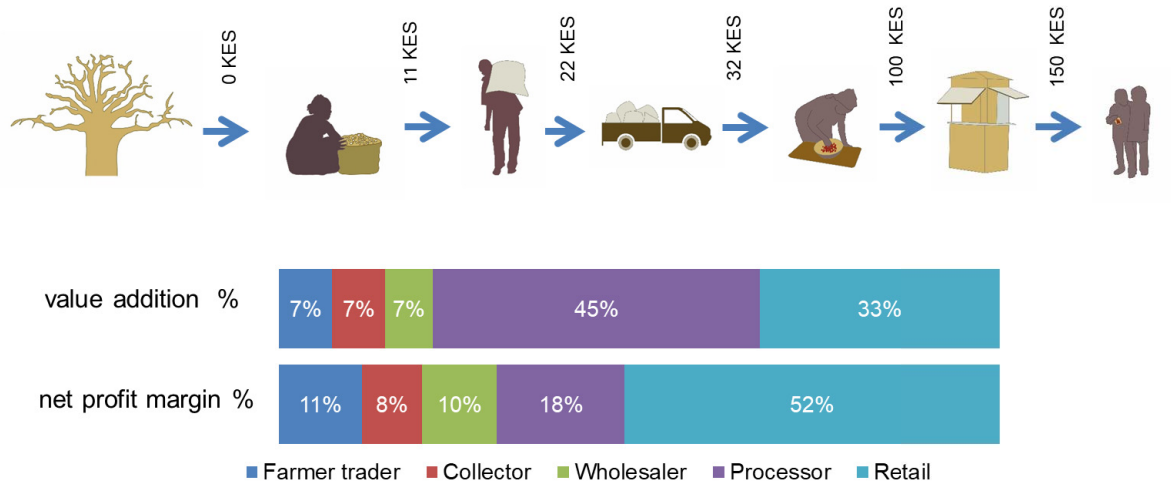


Fig. 4: *Mean value addition and net profit margins of 1 kg pulp/seeds (and mabuyu) per actor along the longest value chain for baobab pulp/seeds in Taita and Makueni in %. Farmer n=10; Collector n=7; Wholesaler n=6; Processor n=15; Retail n=37. Respondents who did not engage in the longest chain (e.g. farmers processing and selling mabuyu themselves) were excluded.*

mabuyu produced) for the processors. In addition to inputs, processors had to pay 1200 KES per year for a medical certificate that ensured that processors were free from diseases and were allowed to handle food. The certificate applied to large and urban processors.

After subtracting the costs, the retailers received the largest net profit margin along the mabuyu value chain. Retailers had low costs because mabuyu processors delivered their products to the retailers and other costs such as taxes per unit of mabuyu were relatively low.

Net profit distribution along the shortest chain: The small-scale rural processor

Respondents that were active in the shortest possible chain-processors who owned baobab trees or could collect baobab pulp/seeds freely – were mostly female and lived in rural areas (n=8). They processed the pulp/seeds at their homes and sold mabuyu at schools or sports events in their villages. On average the net profit margin of one kg pulp/seeds was 66 % (100 KES), varying with the amount and the kind of inputs used. The small-scale rural processors saved transport costs because they sold mabuyu close to their homes. In addition, they saved raw material costs and used fewer inputs (e.g. less sugar) than the large-scale processors due to limited means or difficulties in accessing them. Compared to larger, urban processors, they did not use spices such as chili pepper or cardamom or artificial aroma. It was reported that food colour, as well as plastic bags used for packing the rations, were often not available in small rural shops, leading to a further reduction of input costs. Quality differences between mabuyu made by rural processors and mabuyu found in larger cities were observed: the rural mabuyu, for example, was processed on simple stoves using not well-dried firewood and thus the mabuyu took on the smell of the smoke produced during processing.

4.4 *Quantity and prices*

Analysis of traded quantities and average prices is based on all observations along the mabuyu value chain except for the wholesalers. Processors were actors with the highest net profits and largest quantities sold (median almost 1,000 kg pulp/seeds, ranging between 8 and 8000 kg). Their median annual net profit was around 40,000 KES (range 463-972,800 KES) which was equivalent to around 440 USD. Rural processors (n=8) reported a higher median annual net income of 49,000 KES (range 450-260,000 KES). The surveyed collectors (median 455 kg pulp/seeds per year, range 710-7000) traded the second largest quantity. In addition, the collector had the second highest median annual net profit (6,815 KES, range 1100-226,666 KES).

The 37 interviewed retailers sold the lowest quantities of all actors (median 100 kg mabuyu per year, range 19-1,500 kg) but had markedly higher annual net profits (median 4,385 KES/year, range 560-75,000 KES) compared to farmers (988 KES/year). The 41 surveyed farmers sold a median of two bags of baobab pulp/seeds per year (140 kg, range 7-3,500 kg) and gained a median annual net profit of around 987.5 KES (range 100-27,500 KES) from that activity.

4.5 *Availability of baobab fruits*

Results of the farmer household survey showed that the main harvest season for baobab fruits was from May to

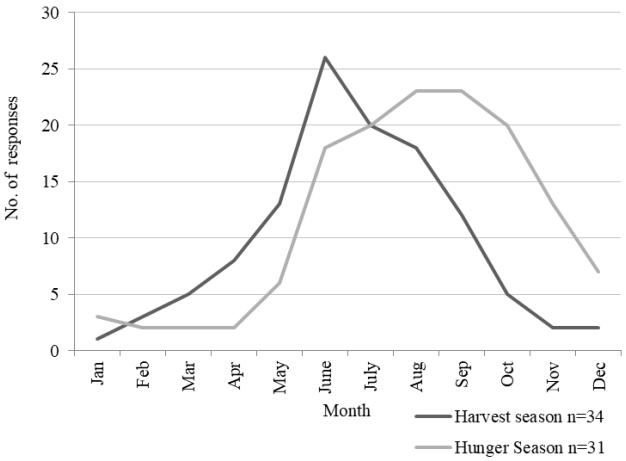


Fig. 5: *Number of households suffering from food insecurity and number of respondents mentioning that baobab fruits are ready for harvest per month in Taita-Taveta County. Data based on a survey of 46 farmer households.*

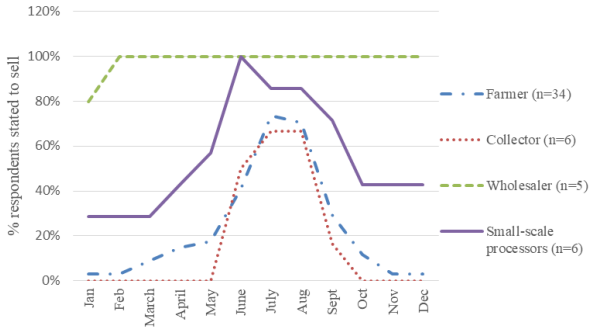


Fig. 6: *Selling periods of baobab pulp/seeds and mabuyu by value chain actor in Taita-Taveta and Kibwezi (in 2014). Small-scale processors are defined as processors that are not involved in wholesaling activities.*

August, while the season of food insecurity lasted from June to October (Fig. 5). Hence, the harvest season of baobab partly overlapped with the time of high food insecurity. The household survey revealed that 32 % of the respondents consumed baobab pulp/seeds as a snack, while 13 % consumed mabuyu and 10 % mixed the pulp/seeds into their porridge. Additionally, the interviewed farmers considered the baobab fruits rather as 'food of the poor' or 'snack' and not as an essential part of their daily diet. The main baobab selling periods mentioned by respondents of the value network interviews overlapped with the harvest season. The lengths of the selling periods increased from actors at the beginning of the value chain to the end of the chain (Fig. 6). While the farmers and collectors sold the pulp/seeds for a period of three months on average, the small-scale processors mentioned to operate on average in the frame of five months, while wholesalers, large-scale processors, and retailers operated throughout the year.

Respondents, operating on a small-scale, were not able to give details on maximum and minimum prices, since they sold the baobab pulp/seeds immediately when it is available from May to August (see Fig. 6). Respondents that sold larger quantities of baobab products identified price peaks, which were reported to be driven by the higher demand for mabuyu during religious festivities, that is Ramadan around August in 2013 and Christmas at the end of December. Comparing the selling periods and the price peaks, one can conclude that farmers and collectors sold baobab pulp/seeds when prices were low.

4.6 SWOT Analysis

Strengths, weaknesses, opportunities, and threats of the baobab value network results are based on collected data from farmer households and value chain surveys, as well as data from key informant interviews and participatory research methods (for more details see Table A3 in the Appendix).

Strengths

The returns on the processed mabuyu sweets are high according to the interviewed processors, especially for rural processors that have free access to own baobab trees. The costs of the needed ingredients to produce mabuyu are low and the demand sometimes exceeds the supply. Urban consumers are often not aware that mabuyu is actually a product of the baobab tree and of the negative connotation of the 'fruit of the poor' (participatory research, while first author was selling mabuyu close to Jamia mosque, Nairobi). Another advantage is that the baobab fruits are harvested during the dry season when the opportunity costs for farmers are low (few other activities on the farms). In general, an advantage is that baobab fruit pulp is naturally dry and therefore storable for long periods (results from key informant interview with baobab start-up in Nairobi).

In addition, mabuyu contains vitamin C, even after processing, transport and storage. A preliminary analysis of eight mabuyu samples collected during the present study showed a mean vitamin C content of 26.4 mg per 100 g of edible portion of mabuyu (range 15.2-52.5; analysed in the labs of the World Agroforestry Centre ICRAF in Nairobi, Kenya, by using titration and following AOAC 967.21; source: Katja Kehlenbeck, unpublished data, see Table A4 in Appendix). Although the vitamin C content of raw baobab pulp is much higher (273 mg/100g; Stadlmayr *et al.*, 2013), the

mean content of the baobab candy mabuyu can still be regarded as considerable.

Weaknesses

A main weakness of the baobab market was the poor quality of the raw material: pulp/seeds were often not properly cleaned from remaining fibre, contaminated with sand and dust, or infected by insects such as weevils and termites due to insufficient storage techniques applied by all actors from farmers to processors. In addition, fruits were sometimes harvested too early, resulting in poor taste and mould on the stored immature pulp/seeds (results from interviews of large-scale wholesalers in Nairobi, as well as large-scale mabuyu processors in Nairobi and baobab start-up Nairobi).

Other reasons for quality related weaknesses are related to limited information flows along the value chain (quality requirements did not trickle down). An initial good quality of the pulp/seeds could easily be compromised during mabuyu processing, e.g. by using wet, smoky firewood or by overcooking the mabuyu sweets. Furthermore, sugar, food colour and sometimes flavour were added to the pulp/seeds and thus a possible lack of quality of the raw material could be 'camouflaged' to some extent with regard to taste or appearance, but not with regard to poor nutritional quality or even potential contamination with aflatoxins in moulded pulp/seeds (results from participatory research while first author was cooking mabuyu with rural processors). The lack of quality can hinder the development of new products for which the quality matters such as baobab fruit pulp powder. In addition, some respondents regarded baobab as 'food for the poor', which has a negative impact on the development of the mabuyu business together with the currently poor packaging and labelling practices. Labelling the ingredients used for processing, and normed packaging for baobab products could be improved.

Opportunities

The value chain survey in Taveta revealed that marketing of baobab products took place on a limited scale and trees remained unharvested. These areas leave room for future business opportunities to satisfy the increasing demand from Nairobi and neighbouring countries as mentioned by respondents. Local businesses started to set up during the time of the interviews, targeting the middle class/upper middle class as new customers with products such as pure baobab fruit pulp powder or baobab oil for cosmetics (results from the key informant interview with baobab start-up Nairobi). In areas close to the Nairobi-Mombasa highway, marketing channels for the baobab pulp/seeds already exist and could be used for new innovative products such as baobab oil or extracted baobab pulp powder.

Threats

A main factor threatening the future baobab markets is a decrease in natural resources through active cutting of baobab trees. Further, quality standards demanded from foreign investors may be difficult to meet by the farmers since most of them were not aware of any standards. In addition, competition from Tanzania may be threatening the Kenyan baobab business since the Tanzanian prices for both mabuyu and baobab pulp/seeds were cheaper than in Kenya and it was observed that Kenyan large-scale wholesalers started sourcing the pulp/seeds and mabuyu from Tanzania (information based on market research in Taveta).

5 Discussion

5.1 Value network

Results revealed that the baobab value network is characterised by a local demand that is satisfied by scattered small-scale suppliers. During peak seasons (Ramadan, other festivities) the demand for pulp/seeds and mabuyu exceeds supply. Farmers and collectors sold baobab pulp/seeds when they were available (i.e. during harvest season), although they could get significantly higher prices when storing the fruits and selling the pulp/seeds later during the year. Immediate sales of baobab pulp/seeds can potentially be driven by the fact that the harvest season takes place during the dry season, when additional income to address food insecurity and other challenges is most needed and labour is relatively abundant (FEWS NET, 2014). These findings are in line with the results from Mithöfer & Waibel (2003) who identified the harvest of indigenous fruits as a highly seasonal activity in Zimbabwe. Similarly, Dovie (2003) documented that baobab-based activities regarding bark harvest and processing are highest during the dry seasons, and during times of droughts and economic instability in Zimbabwe.

Processing of mabuyu can be considered as an interesting income opportunity. For instance, the poverty line as well as the daily wage for an agricultural labourer was around 1.90 USD (200 KES) in 2014. Keeping in mind that the processing of mabuyu is a part-time occupation next to farming and processing of other products (e.g. popcorn, groundnuts), the median annual net profit of processors of around 40,000 KES can be interpreted as a considerable contribution to the daily household income. Similar to this study, in Mali and Benin farmers sold the fruits only during the dry harvesting season, while traders and processors engaged in

the business with baobab pulp/seeds throughout the year (De Caluwé, 2011).

5.2 Gender dimensions

We found that farmers selling pulp/seeds and processors of baobab pulp/seeds were predominantly female. In contrast, De Caluwé (2011) found for Mali and Benin that the farmers were predominantly male. Research on Shea (*Vitellaria paradoxa*) products in Burkina Faso, has shown that an increase in commercialisation of a formerly underutilised product can compromise the current important roles of women (Rousseau *et al.*, 2017). Further, intra-household conflicts between male and female family members may occur if commercialisation of baobab products leads to a higher value of the baobab fruits (Venter & Witkowski, 2013). Men may claim their right to take over the baobab business and women would lose cash income and have a lower budget to buy food for the household, which could negatively affect the nutritional situation of the households. Our results from Kenya, however, rather suggest that the product criteria of mabuyu and baobab pulp/seeds remain favourable to women, also in a long term. First, the consumption and the process of preparing the candy was associated with women. Secondly, the fruit is considered as the 'fruit of the poor' and changing this negative perception, in particular for men, might take time.

5.3 Potential consequences of commercialisation

Increased commercialisation of baobab pulp/seeds may have side effects such as a conflict with the family consumption of baobab pulp/seeds as reported already from western Africa, or possible problems with access to baobab on community land or unsustainable harvest practices (Buchmann *et al.*, 2010). The findings of the present study, however, rather showed that conflict between commercialisation and consumption is unlikely to take place in the context of Kenya due to the observed current underutilisation of baobab fruit.

From a consumption and food security perspective, commercialisation of baobab in the research area can also mean that rural poor get the chance to participate in markets, earn cash income and gain the freedom to buy the food they prefer (Sibhatu *et al.*, 2015). Hence, we assume that the marketing of baobab products can be an opportunity as the local demand for baobab product as a subsistence product has diminished in our research area. These results are similar to the results from South Africa (Venter & Witkowski, 2013).

While in other regions of Africa baobab trees are under threat because of land use intensification and overharvesting (Shackleton & Shackleton, 2004), trees remained partly un-harvested in our research area, especially in Taveta. The negative connotation of the baobab as the 'fruit of the poor' and its relative unimportance for the local consumption and for income generation, can lead to the cutting of baobab trees. This might negatively affect the baobab population that is already threatened by global warming and a lack of young trees for regeneration in many parts of Africa (Sanchez *et al.*, 2011; Venter & Witkowski, 2010; Assogbadjo *et al.*, 2005). Hence, an increase in commercialisation could benefit the baobab population, as farmers could derive a value from the trees thereby increasing their conservation efforts. This assumption would be supported by Schumann *et al.* (2012) for instance, who have shown that baobab trees in eastern Burkina Faso are well preserved and managed as people attribute an important use to them.

6 Conclusion

A growing demand for the highly nutritious baobab fruit pulp from Europe and North America raises the question whether the marketing of baobab (*Adansonia digitata* L.) products could be an opportunity as an income source for rural communities in Kenya or if the increased demand from overseas would rather disturb domestic baobab use. The only products traded in the research area were baobab pulp/seeds and mabuyu (a candy made out of baobab pulp/seeds). Harvesting, trading and processing of baobab pulp/seeds was found to be an income strategy, especially for the rural women in semi-arid areas of Kenya, however the profitability of trading and processing varies among network actors. While mabuyu net profits can considerably contribute to the daily household income of large-scale processors all year round, the trading of baobab pulp/seeds has the potential to act as a buffer and additional source of income for farmers during a limited time of the year. Overall, farmers derive a low value from the baobab tree which can potentially have negative effects on the baobab population in south-eastern Kenya. Commercialisation of baobab products has the potential to increase the value of the baobab for the local population and could be used as a conservation strategy for this species. Before however thinking about export markets, the enabling environment should be strengthened, and the increasing local demand should be targeted. Building sustainable relationships along the value chain actors, improving the information flows, decreasing transaction costs and establishing quality requirements are necessary conditions for a bright future of baobab, the 'Candy Tree' in Kenya.

7 Policy recommendations

While our study is the first study that gives insights of markets for baobab products in Kenya, further research is

recommended. The marketing of baobab products can be an opportunity because the local demand for baobab product as a subsistence product has diminished, but more research is needed to test if this assumption is correct.

The applied snowball-sampling technique is prone to missing out important information and does not allow statistical inference from our sample to the whole population. We followed a qualitative research approach and we are confident that it was the most appropriate strategy in our case, given that our study was the first focusing on baobab value chains, which are scattered and difficult to identify in Kenya. Future research could build on our findings and follow a more rigorous sampling procedure to confirm our results and quantify the role baobab products play for rural livelihoods in Kenya.

To provide sufficient and uniform quantities and qualities of baobab pulp to growing markets, natural baobab populations need to be screened, individual trees characterised (e.g. by using the 'Descriptors for Baobab' by Kehlenbeck *et al.*, 2015) and trees with superior characteristics (high yields, big fruits with few fibres and sweet fruit pulp) identified for domestication. It can also be recommended to collect more detailed data on labour costs and post-harvest losses to calculate the profitability of the production of different baobab products.

So far, the number of baobab products identified in Kenya are limited compared to other African countries. This suggests that the consumption value of baobab products is low in the researched area since the pulp/seeds are not considered as part of the local diet. Development agencies could train farmers to use baobab in different ways. Designing a recipe book with baobab dishes could spread the knowledge about baobab uses and increase the awareness of the rural population in Kenya. Besides that, workshops could be implemented by research organisations or NGOs to show the rural population how to produce baobab products - for example baobab jams or honey - and how to prepare the leaves in order to promote the multi-functionality of the tree and create awareness for the nutritional benefits. The Kenyan Government is already implementing 'Home grown school meals programs' since 2009 in Kenya. The aim is to provide children with nutritious food and generate income activities in the local communities (local production of food, preprocessing of meals etc.) (Government of Kenya, 2012). These programs would give a platform to integrate nutritious wild fruits including baobab pulp/seeds into the daily meals.

To meet the international food standards, farmers would need to be trained in sustainable baobab management practices, especially harvesting and hygiene. The training could focus on the correct handling of baobab pulp/seeds, i.e. demonstrating, how proper handling for baobab pulp/seeds or fruits look (e.g. drying wet fruits before packing them into plastic bags), and how to reduce the risk of spoiling seeds.

Supplement

The supplement related to this article is available online on the same landing page at: https://doi.org/10.17170/kobra-20191030732 .

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Conflict of interest

Authors state they have no conflict of interests.

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