POTENTIAL ROLE OF BAOBAB IN HOUSEHOLD FOOD SECURITY IN KILIFI AND KITUI COUNTIES OF KENYA

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(Food Science and Nutrition)

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

2019

Potential Role Of Baobab In Household Food Security In Kilifi And Kitui Counties Of Kenya

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A Thesis Submitted in Partial Fulfilment for the Degree of Master of Science in Food Science and Nutrition in the Jomo Kenyatta University of Agriculture and Technology

2019

DECLARATION

The work described herein is my original work and has not been submitted previously to any university in whole or in part for the award of any degree, fellowship or any other academic titles.

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The thesis has been submitted for examination with our approval as university supervisors

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DEDICATION

Glories to the Almighty God for enabling me complete this work successfully. I also dedicate this thesis to my grandmother Margret Mandera; my parents Momanyi Omurwa and Esther Momanyi and my siblings Kefa, Lilian and Deborah for their unending support and encouragement.

ACKNOWLEDGEMENTS

I sincerely thank the Almighty God for the showers of blessings and the favours he has shown me throughout out this work. When I had nobody to lean on, talk to and encourage me, you always stood in for me and shone a light even in my darkest days.

My sincere appreciation to my Dad (Jomo Momanyi Omurwa) for supporting me financially and morally throughout my masters' program. I know I have not told you what it meant to me to have you as a dad, but know that I made it because you were there constantly supporting me in numerous ways unknown to you. To my grandmother, Margret Mandera Omurwa, at your age you still knew the importance of educating a girl. You were proud of my every step. You were worried about me, you were happy for me, you encouraged me and prayed for me. To my beloved mother (Esther Nyamusi Momanyi), thank you for stepping in for me even in my weakest moments. My siblings, (Kefa, Lilian and Deborah Momanyi) and my cousin Becky Mosioma. Every time I looked at you, you gave me reason to work hard so you could get a role model out of me. Being the jokers you are, funny as always, you breathed new life in me every day. Thank you.

My sincere appreciations to Prof Michael, Dr Habte and Esther for supporting me throughout my project work. To you Esther, thank you for teaching me and being patient with me. Thank you for empathizing, sympathizing and supporting me financially even when I was involved in a car accident during my research.

To my esteemed supervisors and mentors, Prof Willis Owino and Prof Anselimo Makokha. It was my pleasure to share my mind with elites like you. Thank you for listening to me, guiding and correcting me. Thank you for reviewing, correcting my work and for giving me input that has pushed my research skills to a higher level. Besides being my academic supervisor you saved my life in the mentioned car accident because that afternoon, I`d actually go home and sleep and allow the pain subside. You were patient with me through the project fieldwork reporting until I was able to stand on my feet once again. Thank you for supporting me financially, emotionally and counselling me.

Gratitude to my enumerator for helping me collect data even in the harsh environment. Sincere gratitude to my respondents for sparing your time to be part of the interview and for giving me responses that have given rise to the piece of work written here.

To my fellow students and friends, thank you for teaching me all that was unknown to me. Thank you for allowing me to teach you too. The moral support, the patience the number of times you worried about my health, visited me and prayed for me. I appreciate.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAS	Atomic Absorption Spectrophotometer
AI	Adequate Intake
ANOVA	Analysis of Variance
ASAL	Arid and Semi Arid Lands
ASAL	Arid and Semi Arid Lands
a_w	Water Activity
BAZ	BMI for Age Z scores
BMI	Body Mass Index
BMR	Basal Metabolic rate
CSI	Coping Strategy Index
ERH	Equilibrium Relative Humidity
FAO	Food and Agricultural Organization
FEWS NET	Famine Early Warning Systems Network
FFQ	Food Frequency Questionnaire
HAZ	Height for Age Z scores
HCl	Hydrochloric Acid
HDDS	Household Dietary Diversity Score
HFIES	Household Food Experience Scale
HPLC	High Pressure Liquid Chromatography
HTST	High Temperature Short Time
KDHS	Kenya Demographic Household Survey
KFSSG	Kenya Food Security Steering Group
KFSSG	Kenya Food Security Surveillance
Kgs	Kilograms
KNBS	Kenya National Bureau of Statistics
MAM	Moderate Acute Malnutrition
MUAC	Mid Upper Arm Circumference

N	Newton
n	Sample size
NACOSTI	National Commision for Science, Technology and Innovation
NDMA	National Drought Management Authority
ODK	Open Data Kit
PEM	Protein Energy Malnutrition
RDI	Recommended Daily Intake
RTEs	Ready-to-eat snack
SAM	Severe Acute Malnutrition
SD	Standard deviation
SPSS	Statistiacl Package Social Software
UNU	United Nations University
US$	US dollars
WAZ	Weight for Age Z scores
WFP	World Food Program
WHO	World Health Organoization

ABSTRACT

Kitui and Kilifi counties in Kenya are marginalized agricultural areas characterized by recurring food insecurity and high prevalence of malnutrition, particularly among children and women. These counties host a huge baobab population that occurs naturally and in abundance. The baobab tree has potential in improving household food security by contributing to the nutrient gap, diversifying and complementing diets. Moreover, the tree serves to improve household income and livelihoods for various rural communities. These commercial and subsistence potential has, however, remained unexploited. Formulation of a ready-to-eat convenience baobab snack made from readily available baobab pulp, sorghum and cowpea may increase baobab utilization; improve household food security; income and nutritional status. A cross-sectional study design to evaluate the potential role of baobab was conducted. The study also assessed the current gaps in food security status, food consumption patterns and nutritional status of children and caregivers. A baobab-based snack was developed and analysed. In this design, 216 caregiver/child pairs were randomly selected and interviewed. The Households Food Insecurity Experience scale (HFIES) was used to assess food security status. A quantitative 24-hour recall, non-quantitative Food Frequency Questionnaire (FFQ) and a household dietary diversity score (HDDS) were used to access food consumption patterns. Anthropometric measurements of height and weight for children and caregivers were also taken. Despite the majority (81.5% in Kitui County and 57.4% in Kilifi County) of the households` owning the baobab tree, its uses were limited. Availability of the tree, harvesting, consumption and sale of its products did not have a significant effect on food security status. Lack of knowledge ($p = 0.01$) and perceived health problems caused by baobab ($p = 0.05$) significantly reduced its utilization. The majority (98.2%) of the households were food insecure. In addition, the prevalence of stunting (28.6 %,), wasting (11.6 %,) and underweight (25 %) among children was high compared to national statistics and about 2% of the children were reported to be overweight Caregivers also reported a high prevalence of over weight (18.8%), obesity (9.1 %) and under-nutrition (14.8 %). A consumer acceptable ready-to-eat snack that is able to meet more than one third of the total daily requirements for children (6-9 years) and adolescents (9-13 years) for protein, vitamin C, zinc and Iron was developed from popped sorghum and baked cowpea. Baobab has a huge untapped potential in Kilifi and Kitui counties. Creating knowledge and awareness on its subsistence potential as part of the household's diets and commercial potential as a value-added product is necessary for promoting its utilization. This may, in turn, increase household food security status and improve the nutritional status of household members living in this habitat.

CHAPTER 1

INTRODUCTION

1.1 Background information

While much attention in combating food insecurity has focused on increasing production of staple crops in Kenya (Mcmullin & Kehlenbeck, 2015), farming is able to provide only about one-third of the total food requirements of the country. This is partly because 80% of Kenya`s landmass has been classified as arid and semi-arid (WFP, 2016). Food insecurity affects an estimated 36.5% of the population in Kenya (FAO, 2018) most of whom are characterized by a low dietary diversity (< 4 food groups per day) (FAO, 2010). The burden of food insecurity disproportionately affects children and women especially in developing countries (FAO, 2010; Girard *et al.* 2012). According to the USAID report 2019 and the seasonal assessment by the Kenyan Government 2019, about 2 million people in Kenya require food assistance due to consecutive seasons of below average rainfall. The levels of acute food insecurity have been heightened by average harvests and limited households incomes. The situation in ASAL regions has deteriorated to crisis phase (USAID, 2019). As a result, the estimated prevalence of stunting, wasting and underweight among children in Kenya stands at 26%, 4%, and 11%, respectively (KDHS, 2014). Kitui and Kilifi counties, however, had higher stunting prevalence of 46.8% and 39.1%, respectively. The average Mid Upper Arm Circumference (MUAC) for children in pastoral and marginalized agricultural areas of <135mm indicate a worsening nutrition situation. About 9% of women aged 15-49 years in Kenya were reported undernourished (BMI <18.5 kg/m^2) (KDHS, 2014) with 32.6% in Kitui and 19.0% in Kilifi (KDHS, 2014). Indigenous crops such as baobab (*Adansonia digitata L.*,) are getting increased attention in attempts towards addressing nutrient deficiencies and improving food security in the country (Stadlmayr *et a.,l* 2013).

Kilifi and Kitui counties host a large population of baobab trees with limited or non-existent information on population density, availability, use and harvesting patterns. Such information is crucial in evaluating baobab potential for future development and use in the areas. Its subsistence and commercial role have also been largely untapped and unexploited. Activities such as intensive fruit harvesting leaf and bark harvesting could describe the unlimited use of the tree (Schumann *et al*., 2012; Venter & Witkowski 2011; Gebauer & Luedeling 2013). However, in most parts of Africa, only a few uses of the tree have been mentioned. In Taita Taveta for instance, the leaves are only used as fodder or as medicine (Fischer, 2015). Use of leaves as food is virtually unknown unlike in other population in West Africa where the leaves have been used as a staple diet (Buchmann *et al*. 2010). Use of the bark in Taita Taveta was also limited. Most trees had healed from debarking showing low debarking frequency. Consistent harvesting and selling of fruits in large amounts was uncommon. Unlike in Sudan where heavy pruning and storage of the baobab leaves was done, in Taita Taveta pruning was done to control bush growth and rarely to facilitate its harvest. Elsewhere, baobab has been used to complement and diversify the typical staple based diets in vulnerable dry land ecosystems in the face of drought (Gustad *et al*., 2004; Chadare *et al*., 2010; Jensen *et al*., 2011). In addition to improving household dietary diversity, the nutritious baobab fruits and leaves have potential of increasing nutrient uptake, preventing nutrient deficiencies and improving the nutritional status of household members (Kaboré *et al*., 2011; Gebauer & Luedeling 2013). Income from baobab has been seen to support thousands of livelihoods in rural areas (Gruenwald & Galizia 2005; Venter & Witkowski, 2011; Fischer, 2015).

Having seen that most baobab in Kenya is underutilized and that most arid and semi-arid lands (ASAL) are characterized by recurring episodes of food insecurity, malnutrition and poor food consumption patterns, there is need to explore non-conventional sources of food products that come in handy in improving consumption patterns and food security status of households and meeting the energy, protein and micronutrient need for such vulnerable populations. One such food product is a ready to eat snack consisting of readily available and drought tolerant crops such as sorghum and cowpeas that are easily produced in the ASAL regions. Use of baobab in the snack could increase its utilization given that baobab has remained underutilized in Kenya. Snacks are a form of food that are widely acceptable by most populations as a convenient, cheap, nutritious and readily available form of food to keep up with the changing dietary patterns and the fast paced lifestyles.

In recent times, food product developers have incorporated legumes into traditional cereal formulations. This combination produces a complementary nutrient diversified cereal formulation that may reduce the incidence of Protein energy malnutrition (PEM) among vulnerable groups (Usman & Okafor, 2016). Popped sorghum is one ready-to-eat snack whose use as a base in the development of cereal-based convenient ready to use food has been limited. Addition of cowpea (*Vigna unguiculata or V. sinensis*) in the development of such a snack would increase its protein quality because of its rich amino acid profile particularly lysine (Dlamini & Sciences, 2016). The high nutritional value of baobab would reduce micronutrient malnutrition. Its high Vitamin C content (Braca *et al*., 2018) particularly draws attention to its use in ready-to-eat snacks which have been processed using elevated temperatures resulting to loss of the heat labile vitamin C. This type of home processed ready-to-eat snacks has a great market potential as a convenient health product as consumer needs are changing towards more convenient foods as well as less refined or polished grains.

This study investigated the potential role of baobab in addressing household food insecurity; investigated the current food security situation, food consumption patterns and nutritional status of children and caregivers among rural households residing along the baobab belt in Kitui and Kilifi counties of Kenya. The study also formulated and analysed a ready-to-eat baobab based snack bar from popped sorghum and baked cowpea blend.

1.2 Statement of the problem

The population in Kitui and Kilifi counties are prone to recurring episodes of food insecurity due to prolonged droughts, which affect cultivation, and yield of the main staple foods. They largely depend on short rains during the months of October - December, which are mainly below average and marked by poor temporal distribution (FEWS NET, 2017). According to the Kenya Food Security Steering Group (KFSSG), About 2 Million people are in urgent need of assistance to meet their basic food need in Kenya (USAID, 2019) About 31% of households in Kenya do not have enough food or money to buy food with 38% of these occurring in the eastern region of low agricultural potential. Households in these areas are characterized by poor dietary diversity (consumption of less than 4 food groups daily). A report by the Kitui County Government reported a dietary diversity of < 4. A decline in households having acceptable food consumption scores from 59% in 2015 to only 35 % in December 2016 was reported in Kilifi County (FEWS NET, 2017).

Poor nutritional status among school-aged children and women remain a major threat in Kenya. The situation is dire in marginalized areas where the agricultural potential is limited. The estimated prevalence of stunting, wasting and underweight among children stands at 26%, 4%, and 11%, respectively. These statistics were highest among children residing in rural areas (37 %) as opposed to urban areas (26 %) (Waswa, *et al*., 2015). Malnutrition, which occurs early in life leads to poor cognitive, physical and mental development in children (Morgan, 2015). Among school going children, malnutrition has been associated with low school enrolment, absenteeism from school, poor performance and school dropout (Fiorentino *et al*., 2016).

In Kenya, 9% of women aged 15-49 are undernourished (BMI <18.5 kg/m^2) (Survey, 2014). This comprises 32.6% in Kitui County and 19.0% in Kilifi County (KDHS, 2014). Malnutrition among women has been associated with depression, poor health, children of low birth weight and anxiety. Given the significant role of women in household food security and nutritional status of households members, their nutritional status merits special attention (Madjdian & Bras, 2016).

The contribution of baobab to household's food security, nutrition status, dietary adequacy and household income is limited. In addition, it is not acknowledged in poverty reduction strategies in food security (Stadlmayr *et al*., 2013; Gebauer *et al*., 2016). There is limited knowledge on the role of baobab in enhancing food security and improving household income among households residing along the baobab belt. Its utilization has, therefore, remained relatively low despite the tree occurring in abundance in the two counties. Multiple taboos and cultural beliefs associated with baobab tree have left the tree untouched and their products unused. For instance, baobab forests in some communities are considered sacred with restrictions symbols such as stones placed permanently under the tree. This implies that more effort is required to promote the use of such a crop for food security and income generation.

Most snacks such as biscuits, deep fried and extruded snacks are low cost, ready to eat convenient foods consumed widely. Most of these are considered less nutritious and have been linked with increasing prevalence of adiposity, high body mass index and poor diet quality. Since snacks contribute to 15%-30% of the total energy intake in the world there is a need for novel healthy snacks targeting low-income earners. Most snacks are made from wheat and maize ignoring the use of indigenous cereals such as sorghum, which is relatively more drought tolerant. Moreover, the use of baobab in snack preparation, despite its nutritional value is limited.

1.3 Justification

Information on household food security and nutritional status of households living along the baobab belt is important for agencies and governments in developing, implementing, monitoring and evaluating food security and nutritional projects in these vulnerable areas. This information is often either not available or grossly out-of-date especially in marginalized areas in Kenya (Einstein, 2005).

The baobab tree is a multipurpose tree with highly nutritious and healthy leaves, fruits and seeds. The tree has been shown to complement the typical staple diets among vulnerable households. In addition, the baobab tree is now commercialized and exported to most countries in Europe and the USA improving income and livelihoods of most households. As a food the fruit is eaten fresh, used in cooking as a condiment, added in sugarcane juice to aid fermentation and the fruit pulp emulsion has been mixed with milk to make an enriched drink (Bamalli, 2014). Knowledge on the importance of baobab is relevant in promoting its use as part of people's diets and as a major source of improving livelihoods among poor households. In the process, households may be able to cheaply acquire a diversified diet, particularly during food shortages. This would then translate to nutritionally balanced diets and food secure households. (Mwaniki, 2006).

Development of a ready-to-eat baobab based cereal snack may increase utilization of baobab and sorghum, which are readily available in these habitats. This may increase the dietary diversity of households and improve compliance to daily dietary recommendations for most nutrients reducing deficiencies associated with them thereof. In addition, the ready to eat snack can be sold as a value-added product as well as a convenient food. Income from such a venture could increase household income and improve the livelihoods of people living along the baobab belt.

1.4 Objectives

1.4.1 Main Objective

The main aim of the study is to investigate the role of baobab in improving household food security in Kilifi and Kitui counties in Kenya and develop a ready to eat baobab based cereal snack

1.4.2 Specific Objectives

1. To determine the current food security, food consumption pattern and nutritional status of households residing along the baobab belt
2. To assess the household baobab availability, accessibility and role in improving household food security and income
3. To estimate the total harvest, consumption and contribution of the sales of baobab products to household food security and income
4. To enhance utilization of baobab fruit through formulation and analysis a baobab based cereal snack

CHAPTER 2

LITERATURE REVIEW

2.1 Food security situation

The definition of food security has evolved over time since 1970s from focusing on global and national food security to focusing on food security at household and individual level. Food security exists as when all people at all times have physical and economic access to sufficient, safe and nutritious food that meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). It encompasses four important concepts; (a) Food availability defined as the sufficiency in calories required to live a healthy and happy lifestyle, (b) the accessibility of food defined as the ability to produce, purchase or receive food as foreign aid or gifts, (c) utilization and (d) stability which is defined as the period in which a household can be termed food secure (Maxwell, 2006). Note that, one dimension of food security does not guarantee a food secure household, rather, a combination of this food security dimensions reflect food security status and consequently nutritional status of individuals in households (Mwaniki, 2006).

Food is a core element and an indicator of adequate standards of living as defined by the Universal Declaration of Human Rights in 1948. Over 40 countries have the right to food incorporated in their constitution today (FAO, 2006). Nonetheless, in developing countries more particularly in Africa this is not the case. This is because this countries have faced recurring episodes of food insecurity (Godfray *et al*., 2012). Food insecurity exists when there is a limited capability to obtain nutritionally adequate, safe and acceptable food in ways that are collectively acceptable by the community. It is characterized by lack of sufficient and quality food which translates to hunger and malnutrition (Bickel *et al*., 2000).

2.1.1 Global food security situation

The root concern in food security dates back to the global food crisis of 1972-1974. Today, it is bigger than we perceive it. It affects those who are already hungry and those at a risk of becoming hungry in developing as well as in developed nations. The global hunger crisis in 2008 marked a projected increase in hunger cases by 133 million people and today about 1 billion people are hungry globally (Sasson, 2012). This represents a regional distribution of people suffering from hunger as follows by the year 2010: 578 million in the Asia Pacific region; 239 million in sub-Saharan Africa; 53 million in Latin America; 37 million in North Africa; and 19 million in developed countries (Godfray *et al*., 2012). The figure rose to 1.2M people after 2011 global food crisis. This is attributed to abject poverty and volatility in food prices (Sasson, 2012).

2.1.2 Food security situation in Africa

Africa, Asia and Pacific accounts for 89% of the worlds hungry population. Africa is home to 15 countries out of the 16 countries where the prevalence of hunger exceeds 35%. This is mainly affected by the increase in food prices experienced between 2007 and 2009. Sub-Saharan Africa alone has 24 million people who are hungry (AU, 2012). The prevalence of malnutrition varies across regions in Africa. In the horn of Africa, about 12million people suffer from hunger and starvation. Areas in remote Madagascar reported 40% of the population suffering from hunger and starvation in the year 2008. This has been gradually deteriorating due to the unreliable rainfall and failed maize harvest (WFP, 2008). A whooping 38 million people in Northern Nigeria, Kenya, Somalia, Yemen, Ethiopia, and Southern Sudan are severely food insecure. These countries are characterized by drought like conditions (GNP, 2017).Statistics show that 70% of food insecure households in Africa live in rural areas. This is despite the fact that they contribute about 90% of total food supply in the continent. Another majority include the landless poor, illiterate and the urban poor (Mwaniki, 2006).

2.1.3 Food security situation in Kenya

Agriculture contributes about 30% of the total GDP in Kenya yet country still depends on imports of the main staple foods, maize, rice and wheat to sustain its constantly growing population who are food deficient (WFP-FAO, 2017). This is partly because of the high trade barriers and international price fluctuations that make the country vulnerable to being food insecure (WFP, 2016). Moreover, declining market food supplies coupled with increasing food demand has heightened food insecurity. Approximately 80% of Kenyan land is arid and semi-arid. These areas receive unreliable rainfall due to the changing climatic patterns. This has led to a reduction in the production of the main staple food such as maize (FEWS NET, 2017). In 2007 the government Economy review of agriculture reported that 51% of Kenyans lack access to adequate food.

Marginalized mixed agricultural areas of the coastal regions of Kilifi and South Eastern regions of Kenya such as Kitui areas in Kenya have registered a decline in food security due to the significantly low unreliable rainfall which has reduced crop production and led to depletion of food stocks (FEWS NET, 2017). Kitui County located to the Eastern region of Kenya mainly depend on the short rain between the months of October and December for optimum crop production. However, since 2016 the rains have been one month late, below average and temporally distributed. This reduced crop production in Kitui for instance, by 89% and on-farm opportunities for casual labourers which significantly reduced household income (FEWS NET , 2017). Kilifi County on the other hand is a mixed farming agricultural zone characterized by erratic unpredictable rainfall and massive crop failure. About 70% of its population still depend on agriculture as the main source of livelihood (Kilifi County Integrated plan, 2017). In 2016 the County recorded a 95%, 88%, 93% and 84% drop in maize, cowpea, cassava and green grams' production respectively. Similar to Kitui County, on farm casual labour which is the main source of livelihood has decreased by 70-90% reducing the purchasing power of most households. Reduced household's stocks and increased demand has lead to an increase in price of food to above average. As result many poor rural households are able to meet the minimum food requirements with some localized poorer households not able to meet their food needs at all (FEWS NET, 2017).

2.2 Nutritional status

2.2.1 Global nutrition status

Malnutrition remains a global problem with at least one in three people experiencing some form of malnutrition. Statistics in the global nutrition report reported 88% of countries globally facing some form of malnutrition. The double global burden of malnutrition is largely felt by lowest income and developing countries. Globally, 925 million people are undernourished (FAO, 2010) with Africa and Asia accounting for nearly all global stunting. Despite a decrease in the number of children who are malnourished globally, the global progress is not rapid enough to be able to meet internationally agreed nutrition targets including ending all forms of malnutrition by 2030. Africa, however, is the only continent in the world that has registered an increase in the prevalence of stunted children despite a global decrease since 1990 (GNP, 2017). Obesity is increasingly becoming a problem among women and men. Globally, about 1.5 billion adults were reported to be overweight in 2008 (WHO, 2011). About 33% and 34% of men and women respectively are overweight in North America (GNP, 2017). Hidden hunger affects one out of three people in developing countries (WHO, 2009).

2.2.2 Nutrition status in Africa

Africa is home to about 216 million undernourished children. This is equivalent to 30% of the total population of undernourished children globally. Out of this, 57 million are stunted. This represents 32% of the total stunted children in developing countries which is a 4% decline from 40% in 1990 (AU, 2012). However, the absolute number has increased by 9 million owing to the increasing population which does not keep up with the rate of decline of stunting (AU, 2012). About 26% of African children under five are underweight. The prevalence of underweight varies between 6% in Northern Africa and

35% in Eastern Africa. The situation in Eastern, Northern and Western Africa regions have shown improvement since 1990 while in South Africa, the situation has been constant (AU, 2012).

In Sub- Saharan Africa 33% of people are undernourished (FAO, 2006) with chronic under nutrition accounting for up to 2million deaths and worse statistics recorded in the Eastern regions of Africa (Béné & Heck, 2005). Somalia for instance, recorded the highest rates of malnutrition in the world with about 50% of the population suffering from severe malnutrition in 2011 (Sasson, 2012). These statistics in sub-Saharan Africa are projected to worsen in the next two decades if urgent food security interventions are not put in place (Supply, 2006). With the increasing reality of famine in most countries and in Africa`s Nigeria, Somalia, Southern Sudan, Ethiopia and Kenya in particular, efforts to reduce malnutrition particularly wasting pose a great challenge. In these countries, 1.796 million children under five have severe acute malnutrition (SAM) while 4.960 million have moderate acute malnutrition (MAM) (GNP, 2017).

2.2.3 Nutrition status in Kenya

Stunting among children is defined as a relatively shorter stature in a child relative to that of healthy well-nourished children of the same age. The main causes of stunting are inadequate energy and nutrient intake over a long period of time and recurring episodes of illness. More than one third (26%) of children in Kenya are stunted with a higher burden being among male children 37% than female children 33%, children who live with undernourished mothers (45%) and those living in rural areas (37%) compared to those in urban areas (26%). Stunting rates are highest (36%) among children between 18-23 months and lowest 10% in children less than 10 months. Highest proportions of stunting rates have been reported in West Pokot and Kitui (46%), Kilifi (39%), Mandera (36%), Bomet (36%) (KDHS, 2014).

Wasting or thinness is an indicator of recent acute starvation or recent disease such as diarrhoea. It is characterized by severe weight loss. About 4% of Kenyan children are thin with 1% being severely thin. Wasting rates are high among children between 6-11 months (7%). The most vulnerable children to wasting are those being introduced to complementary feeding and those living in households with illiterate caregivers. Wasting has also been seen to be inversely proportional to household wealth. Turkana has the highest (23%) wasting rates. In Garissa, Wajir, Mandera, Marsabit, Turkana, West Pokot and Samburu, the wasting rates are more than 11%. Siaya and Kisumu Counties have the least wasted children less than 1% (KDHS, 2014).

Underweight is a reflection of acute or chronic malnutrition. An underweight child is described as being slightly lighter than children of the same age. In Kenya, 11% of the children are underweight with 2% classified as being severely underweight with peak prevalence being among children between 24-35 months. Similarly, male children (12%) and those living in rural areas (13 %) reported higher underweight levels than female children (10 %) and those living in urban areas (7 %) (KDHS, 2014).

The nutrition status of the population in the Kitui County remains poor as a result of frequent drought resulting to food insecurity at the household level, sub-optimal infant and young child feeding practices, poor child care practices, inadequate access to health services and poor hygiene and sanitation practices in the communities. Wasting rates among children less than five years are at 4.6 %. Stunting is currently at 38.2 % (Kitui Nutrition Survey Sept, 2013) that is way above the national average of 26%. Prevalence of underweight is 20.7 % as compared to the national average of 16 %. The prevalence of moderate stunting, wasting and underweight in Kilifi County was 39.1 %, 2.8 %, 16.9 % respectively while the prevalence of severe stunting, wasting and underweight was 13.6 %, 0.9 %, 3.1 % respectively (Kilifi County Integrated plan, 2017).

2.3 Food Consumption patterns

Africa has the largest number of countries (19) with dietary energy consumption of less than 2,200Kcal per day (WFP, 2016). While majority (88 %) of Kenyans have acceptable food consumption, about 12 % of the households have unacceptable consumption, which translates to mainly a staple flavoured with green vegetable and oil. Nationally, almost 10 % of rural households have low dietary diversity score that is they consumed four or fewer food groups. The prevalence is however, high in Marsabit (37 %) followed by 33 % prevalence in Turkana County (WFP, 2016). According to food consumption indicator, Turkana still stands out as the most food insecure County with one out of five households (19 %) having poor consumption scores and a further 24 % being on the borderline. The next food insecure counties after Turkana are Samburu, Tana River, West Pokot, Busia and Siaya. Rural households (36 %) are more likely to experience food shortages than urban households (23 %) (WFP, 2016).

When faced with food shortages, households tend to cut on food quality and quantity and/or quantity. Poor households will adopt severely irreversible strategies. In counties such as West Pokot, Muranga, Kitui and Wajir, more than 60 % of the households` consume non-heme iron rich foods. On the other hand, most Kenyan households (83 %) consume food rich in Vitamin A but in Turkana only 62 % of the households interviewed consumed food rich in vitamin A in their diets (WFP, 2016). The household dietary diversity score (HDDS) in Kitui was 4.7 %, with 95.2 % of households accessing food through purchasing (Kitui Nutrition Survey, 2012). More than 6,000 people enrolled in the Supplementary Feeding Programme and children also benefitting from a School Meals Programme (Kitui County Climate Information Services Strategic Plan, 2015.

2.4 The baobab tree

Traditional indigenous crops occur in relative abundance in Sub-Saharan Africa particularly in arid and semi-arid areas with harsh and dry climatic conditions where cultivation of exotic crops is almost impossible. This is partly because they are well adapted to the local harsh environments and can produce irrespective of the season of the year. These indigenous crops can therefore be used in the face of famine and food security to improve household food security and income. Despite their importance and adaptability, its exploitation has remained largely minimal. One such crop is the African baobab (Stadlmayr *et al*., 2013).

The baobab tree occurs naturally in Sub-Saharan Africa (Sidibe *et al*., 2004). There is a notable presence of the tree in some parts of South Asia, India and Sir lanka which have been associated by the African migration and moslem trade centuries ago. Baobab is the most known member of the genus Adansonia. Some related species occur naturally in Madagascar and Australia. It is classified in genus Digitata that is attributed to the finger like leaflets of the baobab compound leaves. Baobab is a massive tree with thick short branches and deciduous leaves, which fall off most part of the year as shown in figure 2.1 a and b (Rashford, 1987). It is mainly associated with the Savannah type of climate in the drier regions of Africa. In Eastern Africa, it occurs along the Kenyan Coast southwards to Mozambique. In Tanzania, baobab has survived in the upland plateau where extensive cultivation has occurred (Sibide *et al.,* 2004). In Kenya it occurs in form of a Y shape and runs through various counties including Kitui and Killifi.

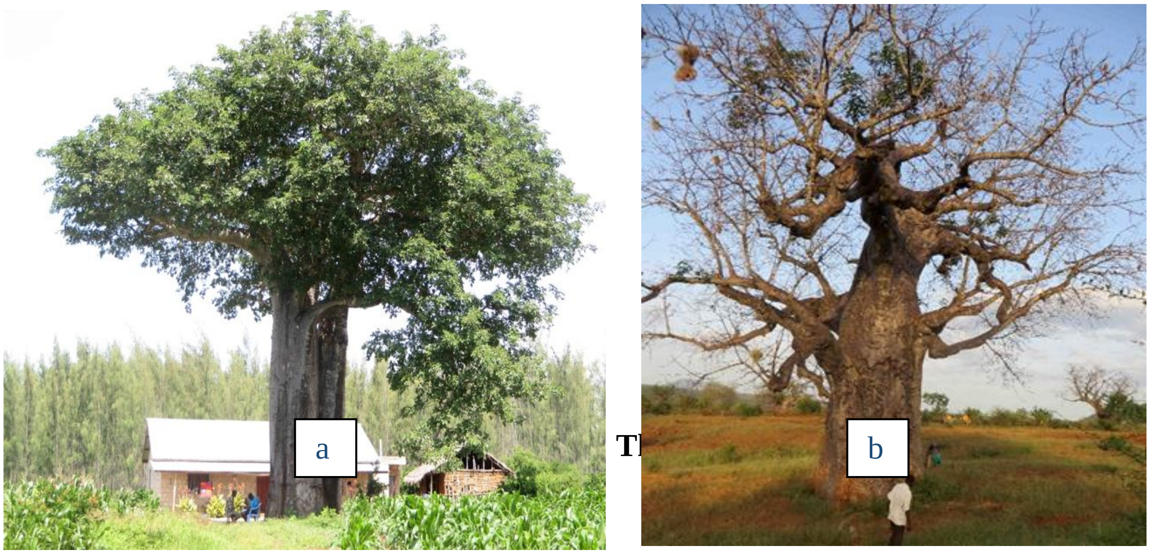


Figure 2-1: (a) Baobab tree with leaves (b) baobab tree during fruit season

2.4.1 Baobab leaves

Young baobab leaves contain about 13-15% protein with about 5 out of 8 essential amino acids, 60-70% carbohydrate, 4-10% fat, 11% fibre and varying energy ranging between 1180-1900 kJ/100g. Studies have also shown significant amounts of iron, calcium, magnesium and manganese minerals in the leaves. Iron plays a significant role in reducing the prevalence of iron deficiency anaemia, which is on the rise in savannah areas where the tree occurs. The leaves are also rich in linoleic acid (55 mg/g of dw) (Abdulkarim & Bamalli, 2014). Moreover, the leaves have appreciable amounts of vitamin B2 that is essential in body metabolism. For this reasons, baobab leaves have gained importance in various uses among households as staple foodstuff. In West Africa and among the San people of the Kalahari Desert, baobab is the most preferred food. In Zimbabwe, the leaves have been used as a substitute for fresh vegetables such as spinach, lettuce and kales. In Malawi the leaves are boiled as vegetable using potash while in Mali the leaves are used in sauces and meats especially fish as a tenderizer. The leaves have also been dried to produce powder used in thickening sauces and porridge (Sidibe *et al*., 2004).

2.4.2 Baobab fruits

The remarkably high content of vitamin C has, however, drawn special attention on baobab fruit pulp. Studies have shown that the vitamin C content is 10 times higher than in oranges. A study in Nigeria recorded 337 mg ascorbic acid/100g in baobab pulp (Braca *et al*., 2018). The pulp contains about 155mg/g dry weight basis of total lipid content with linoleic fatty acids occurring in significant amounts. The 0.8 amino acid score shows that leucine, valine and threonine are present in sufficient amounts. More recent studies have shown that the pulp has a variety of other minerals including calcium 295- 300 μg/100g, phosphorus varies 96-210 mg/100g; iron content was 7 mg/100g, magnesium 0.10 mg/100g, zinc 0.064 mg/100g and manganese 2.07 mg/100g (Braca *et al*., 2018).

The pulp has been widely used as a food and is the most preferred among most communities in Africa. It has been eaten fresh, used in cooking as a condiment, added in sugarcane juice to aid fermentation for beer making processes in Tanzania among the Hausa community, the fruit pulp emulsion has been mixed with milk to make an enriched drink (Bamalli, 2014). Baobab pulp has been widely used in the preparation of a number of food products at household level and for commercial purposes. These include gruels, beverages and sour dough (Kaboré *et al.*, 2011). 'Baobab milk' for instance is very common among many cattle owning communities in Nigeria, the Fulani and Hausa mix the fruit pulp emulsion in milk to make a drink (Sidibe *et al.*, 2004). The milk is a highly nutritious drink (Tsige & Michael, 2018). Baobab emulsions have been used to adjust the consistency of thick gruels to make thinner gruels. The pulp has also been widely used in making refreshing drinks with wine-gum like flavor (Bamalli, 2014).

Figure 2-2: (a) Whole baobab fruits, (b) baobab powder

2.4.3 Baobab seeds

Baobab seeds contain about 15% of fat, which makes them good for cooking and cosmetics. This has heightened the attention towards baobab seeds as a source of vegetable oil to curb the ever-increasing demand of vegetable oils (Kaboré *et al*., 2011). Baobab seeds have been used widely as a source of food despite the challenges faced in extorting the seeds from its hard shell. The seed powder has been used in thickening soups and as a substitute of coffee after roasting. Seeds have been eaten as a snack after roasting (Braca *et al*., 2018).

Table 2.1: Selected nutrient composition of baobab pulp, leaves and seed

Nutrients of interest	Baobab pulp	Baobab leaves	Baobab seeds
	Quantities in mg/100g expressed on the basis of dry weight		
Calcium	237-480	1132-4519	252
Magnesium	113-239	186-959	402
Iron	2.5-9.75	20.35 -71.5	5
Zinc	0.6-2.1	1.11-3.52	5
Vitamin C	38-478	-	-
Insoluble dietary fibre	14.7	-	56.5
Soluble dietary fibre	65.6	-	16.3

(Chadare et a.,l 2008, Magaia et al., 2013, Tsige & Michael, 2018)

2.5 Role of baobab in Food security

Most indigenous wild trees have been used as an emergency food especially during food shortages and periods before harvest. Despite their importance in food security some trees such as the baobab tree have remained underutilized and un-researched (Gebauer & Luedeling, 2013). Being a seasonal tree, its products are available throughout irrespective of seasons. In Kilifi and Kitui counties of Kenya, baobab occurs in alternating seasons and this is influenced by the agro-ecological zones.

Baobab plays a vital role in household food security in many areas in western and Southern Africa. In West Africa for instance, the fruit and leaves contribute significantly to the diet especially during times of food scarcity. Its products have a positive contribution towards nutrition and health for rural households particularly women and children who are the main consumers in most households. Nutrients in baobab are vital for growing children who are prone to malnutrition which will manifest into diseases and mortality in fatal cases. The leaves of the tree are mainly consumed in times of scarcity and famine. This gives an impression that the tree can be depended on during the `hard times`.

2.6 Role of baobab in household income

Most indigenous crops play a significant role in contributing to household income and so is baobab. In recent years the baobab fruit has been accepted as a novel food and ingredient by the EU and the US Food and Drug Administration (FDA) (Gebauer, *et al*., 2016). It has thus become an article of commerce in local, national and international market (FAO, 2002). A study in West Kordofan state in Sudan showed that wild fruits contribute 71% to household food income (Ali, & Ibrahim, 2011). In South Africa, baobab was reported to be the only non-timber forest product whose commercial value is 4 times its subsistence use. The study suggested that commercialization of baobab has far reaching benefits and that unlimited access to the tree and increased investments on the tree would further increases its value for many marginalized households in South Africa (Venter & Witkowski, 2013). Annual sales of baobab fruit alone in South Africa contributed to 38% of the total sales accrued form sale of non-timber forest products. Respondent reported that sale of baobab fruit was important since it helped alleviate poverty in arid areas (Venter & Witkowski, 2013). The implication of commercialization of baobab, however, has to be carefully considered. Due to the high local and international demand of baobab and its products, there has been intensified harvest which often leads to overexploitation of the natural tree a situation which call for domestication efforts (Whitney, *et al*., 2016)

2.7 **Ready-to-eat snack**

Snacks can be defined as a type of food as well as an eating occasion. Most snack labels usually have the tendency of drawing attention to the calorie, total fat, saturated and trans-fat content which most perceive as unhealthy ignoring important information on dietary fibre, minerals and vitamins listed at the bottom of the label. Therefore, most consumers don’t tend to select snacks with nutrient of importance to the human body just because they are paranoid to specific ingredients. Its thus important that different stakeholders provide a comprehensive dietary guidance on consumption of common snacks choices based on nutrient density (Hess *et al.*, 2017).

Cereals used in the production of ready-to-eat snacks have been shown to be important to human health. Some of the cereals play a significant role as a source of non-digestible carbohydrates that promote beneficial physiological effects including stimulating growth of lactobacillus and bifidobacteria in the colon. In addition, some of the cereals are an important prebiotics they also play a role in complementing limiting amino acids in legumes for human nutrition. This is because they are rich in sulphur containing essential amino acids such as methionine, tryptophan and cysteine while these are notably low in storage proteins of most legumes. In recent times food product developers have incorporated legumes into traditional cereal formulations. A combination of cereals and legumes produces a complementary nutrient diversified cereal formulation that would reduce the incidence of malnutrition among vulnerable groups (Usman & Okafor, 2016). Cowpea is a legume of valuable protein source that is vital in most diets particularly in developing countries (Phillips *et al*., 2003). They are a good source of minerals, vitamins and dietary fibre. Cowpea is rich in lysine essential amino acid as opposed to cereals. However, they are deficient in sulphur containing amino acids (Dlamini & Sciences, 2016).

Wheat, corn and rice cereals are the commonly used cereals in the preparation of ready-to-eat snacks. Sorghum is a staple food indigenous to Eastern African that is tolerant to drought and can thus be grown in arid and semi-arid areas. In Kenya, for instance, in the last 10 years, there has been an increase in production area and tonnage of sorghum due to demand mainly for use in the brewing industry and consumption at household level in the ASAL area. Besides the unique characteristic smell of sorghum, sorghum is also gluten free, and rich in dietary fibre, minerals and phenolic compounds. Apart from the macronutrient, sorghum is a good source of micronutrients (Phillips *et al*., 2003).

Sorghum complements well with leguminous protein sources to prepare nutritionally balanced composites of high biological value. Sorghum has been used in novel foods such as baked products. In addition, it has been used traditionally in many traditional foods products such as roti, porridges and dumplings. Popped sorghum is one ready-to-eat snack whose use has been limited. It has potential to develop value added products as a convenient ready to use food. Use of elevated temperatures during popping and baking results in the loss of the heat labile vitamins C in most snacks. The remarkably high content of vitamin C has, however, drawn special attention on the use of baobab fruit pulp in incorporating vitamin C in snack based food products. Studies have shown that the vitamin C content is 10 times higher than in oranges. A study in Nigeria recorded a total of recorded 337 mg ascorbic acid/100g pulp (Braca *et al*., 2018)

CHAPTER 3

FOOD SECURITY, FOOD CONSUMPTION AND NUTRITION STATUS OF HOUSEHOLDS RESIDING ALONG THE BAOBAB BELT IN KENYA

Abstract

The significant potential of the baobab tree (*Adansonia digitata*) as a means of improving household food and nutrition security by diversifying and complementing diets particularly during food insecure seasons and ability to improve household income has widely been tapped in other countries in Sub-saharan Africa where this tree occurs. This potential has, however, remained underutilized in Kenya. In Kenya, the baobab belt cuts across the semi-arid areas of Kitui and Kilifi, which are mostly areas of marginal agricultural potential. Despite the abundance of baobab trees, the populations along these areas are vulnerable to malnutrition, a chronic deficiency of vitamins and minerals and recurring episodes of food insecurity. A cross-sectional study among 216 caregiver/child pairs was designed to evaluate food security, food consumption and nutritional status of households residing along the baobab belt. Tablet-based semi-structured questions were used to obtain information on socio-demographic characteristics of children (6-13 years) and caregivers. Food insecurity status was assessed using the Households Food Insecurity Experience Scale (HFIES). Information on food consumption was obtained from qualitative 24hr recalls as a basis for calculating a Household Dietary Diversity Score (HDDS). Data was also obtained from a non-quantitative Food Frequency Questionnaire (FFQ). Anthropometric measurements of children`s and caregivers' height and weight were taken to assess their nutritional status. Data were analyzed using SPSS version 24 and WHO AnthroPlus 1.0.4. The majority (98.2%) of the households were food insecure despite 81.5% and 57.4% in Kitui and Kilifi counties owning baobab trees and all households having access to the tree. About 32.1% of the households had poor dietary diversity scores (< 4). The prevalence of stunting (28.6%), thinness (11.6%) and underweight (25%) rates among

children were high. A significant association was observed between the children stunting rates and household`s food security status ($p < 0.001$). Of the caregivers, 14.8% were underweight, 18.1% were overweight and 8.8% were obese. There was significant association between the nutrition status of the caregivers and the stunting rates of children ($p = 0.047$). Households residing along the baobab belt in Kilifi and Kitui counties of Kenya report high food insecurity, poor food consumption patterns and high malnutrition rates among children aged 6-13 years and their caregivers. The findings indicate a need for appropriate dietary improvements.
Keywords - Dietary diversity, malnutrition, baobab, nutrient intake, Kenya

3.1 Introduction

In 2017, Food insecurity affected an estimated 36.5% of the population in Kenya (FAO, 2018), of whom 2.6 million were reported to be severely food insecure. According to the Kenya Food Security Steering Group (KFSSG), 3.8 million people are in urgent need of assistance to meet their basic food need (KFSSG, 2012). About 31% of households in Kenya do not have enough food or enough money to buy food. These households also reported a mean Coping Strategy Index (CSI) of 18.9 (KDHS, 2014). The burden of food insecurity affects everyone. It, however, disproportionately affects children and women especially in developing countries (Madjdian & Bras, 2016). As a result, the estimated prevalence of stunting, wasting and underweight among children in Kenya stands at 26%, 4%, and 11%, respectively. In addition, about 9% of women aged 15-49 years were reported undernourished (BMI <18.5 kg/m^2) (KDHS, 2014). Malnutrition, which occurs early in life leads to poor cognitive, physical and mental development in children and, depression, poor health and anxiety among women who play a significant role in food security and nutritional status of household members (Pulok et al., 2016).

While much attention in combating food insecurity has focused on increasing production of staple crops (Mcmullin & Kehlenbeck, 2015), farming is able to provide only about one-third of the total food requirements of the country. This is partly because 80% of Kenya`s landmass has been classified as arid and semi-arid. These areas are characterized by poorly distributed rainfall, drought, flash floods and a chronic near total crop failure annually (WFP, 2016). As the country aims at covering the nutrient deficits with local resources, indigenous crops are getting increasing attention (Clover, 2003). One of those indigenous food sources is *Adansonia digitata L*., the baobab tree (Poole *et al*., 2016).

Kilifi, and Kitui counties are marginalized agricultural areas in Kenya characterized by the widespread growth of baobab trees. Baobab tree products (fruits, leaves and seeds) have been used to complement and diversify the typical staple-centred diets. They especially increase the nutritional quality of local diets through their micronutrients content (Gebauer, 2016; Adam, *et al*., 2016). As the trees are drought tolerant, their products are even available at times of food scarcity during the drought period. The tree may have great potential in supporting local communities in vulnerable dry land ecosystems in the face of drought and food shortages when staple crops fail (Mcmullin & Kehlenbeck, 2015). It may also have potential in increasing dietary diversity and quality of such households (Fischer, 2015). Dietary diversity of households is an indicator of food security, access to a variety of food groups and nutrient adequacy of an individual's diet within households (FAO, 2010; Tsige & Michael 2018). Most households in Sub Saharan Africa have been characterized by low dietary diversity, consumption of less than four food groups per day (FAO, 2010). A study in Lungo village in Tanzania reported 45.2% of households consuming daily from less than 3 food groups (Lumole, 2013) while in Kitui County a dietary diversity of < 4 (Kitui County Government, 2013) was reported. A nutrition survey in Kilifi County revealed a decline in dietary diversity between November 2015 and November 2016 (FEWS NET, 2017).

In addition to improving household dietary diversity, baobab fruit, being highly nutritious has the potential of increasing nutrient uptake, preventing nutrient deficiencies and contributing to human health and nutritional status of household members (Braca *et al*., 2018). Kitui and Kilifi counties in Kenya, where the tree occurs in abundance, however, have been reported to have an extremely high stunting prevalence of 46.8% and 39.1%, respectively. Among school going children, malnutrition has been associated with low school enrolment, absenteeism from school, poor performance and school dropout (Haile *et al*., 2016).

The burden of under nutrition among women makes them prone to increased risk of infections which further increases their nutrient need creating a perpetuating cycle of infection and malnutrition (Girard *et al*., 2012). Approximately, 32.6% of the women in Kitui and 19.0% in Kilifi counties are undernourished (KDHS, 2014). These risk factors result in poor quality childcare, low birth weight of the offspring and malnutrition of children and other households members (Sumarmi 2016; Silva Lopes *et al*., 2017).

In areas such as West Africa, where knowledge on the importance of the baobab is widespread, the availability of baobab tree has played a significant role in food security during food shortage and crop failure (Jensen *et al*., 2011; Tsige & Michael 2018; Fischer, 2015). Additionally, baobab seeds oil and fruit pulp have been exported from South Africa to markets in Europe and North America. Income generated from sales of baobab products has been shown to increase household income and support thousands of livelihoods in rural areas (Venter & Witkowski, 2011; Fischer 2015). In Zimbabwe and other parts of South Africa, for instance, sell of baobab fruit increased monthly income for rural households by 250% during baobab harvesting seasons (Gruenwald and Galizia, 2005).

Predicating on the fact that baobab may be important for food and nutrition security of households within its habitat, and that there is limited literature documented about populations living along the baobab belt in Kenya. The objective of this study was to determine the food security status, food consumption patterns and nutritional status of caregivers and children among selected households living along the baobab belt in Kilifi and Kitui counties.

3.2 Materials and methods

3.2.1 Study design

A cross-sectional study design was applied with a sample of 216 caregivers with children aged between 6 and 13 years interviewed between July and November 2017 during the lean food seasons.

3.2.2 Study Setting

The study was carried out in Kitui and Kilifi counties of Kenya (Figure 3-1). Kilifi County lies between latitude 2^{o} 20'and 4^{o} 0'South, and longitude 39^{o} 05' and 40^{0} 14' East along the coastal regions of Kenya while Kitui is located between 0°10'and 3°0' south and longitudes 37°50'and 39°0' East to the Eastern region of Kenya. Kilifi covers an area of 12,609.7Km^2 whereas Kitui covers an area of 30,496.4Km^2. Rainfall in Kilifi ranges between 300mm in the hinterland to 1300mm at the coastal belt with an average rainfall of 900-1100mm annually and that of Kitui ranges between 1800 to 2200mm annually. Annual temperatures in Kilifi County range between 30 ^{o} C to 34 ^{o} C in the hinterland and 21 ^{o} C to 30 ^{o} C along the coastal belt. Kitui County on the other hand experiences temperatures ranging between 14°C to 34°C.

The estimated population in Kilifi County is 1 million with 47.5% being males and 52.5% being female while in Kitui according to the census report of 2009 population in the County was approximately 1 million where 531427 were females while 481,282 were males. The main economic activities in Kilifi County are crop farming with an average of 52,519.4 ha and 47,681 ha of land for food crops and cash crops respectively. This represents 56% of land suitable for agriculture with 44% land that can be made useful through irrigation. Similarly, In Kitui County majority of the population depend on agriculture with 14,137km^2 arable land. Over 85% of the population here live in rural areas with an average land holding size estimated to be 12 ha per person males (Kilifi County Integrated plan, 2017; Kitui County Government, 2013).

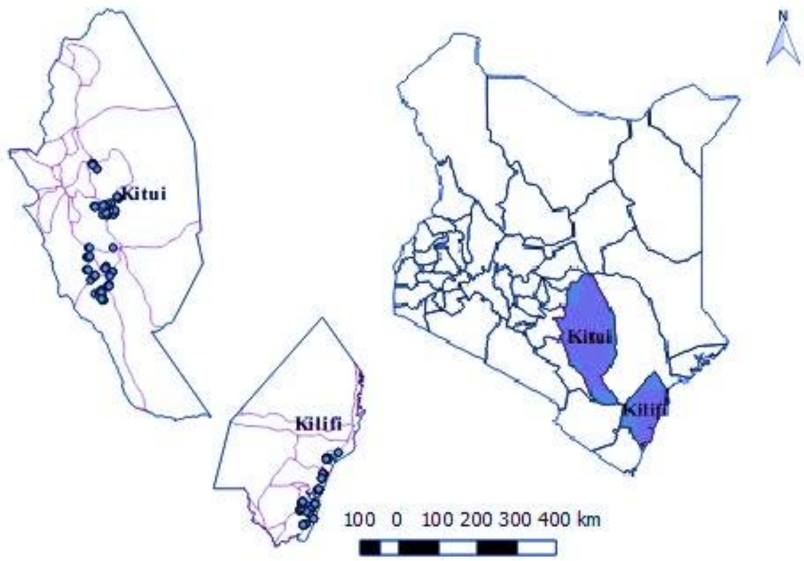


Figure 3-1: Map showing Kilifi and Kitui Counties of Kenya (Source; QGIS)

3.2.3 Site Selection

Kilifi and Kitui Counties were selected for this study because baobab occurs in abundance in the Coconut Cashew nut-Cassava agro-ecological zone in Kilifi County, which lies in Kilifi South and Kilifi North, and the lower midland agro-ecological zones in Kitui County where Kitui South and Kitui East lie. Secondly, these regions being marginalized agricultural areas experience recurrent episodes of hunger, high prevalence of malnutrition and food insecurity. This is due to the unpredictable erratic rainfall resulting in successive failed seasons in most parts of the regions (KFSSG, 2012). The inclusion criteria adopted in this survey was the presence of baobab trees in the villages where the study took place.

3.2.4 Study population

Children aged 6-13 years were selected. In households that had more than one child within this age bracket, the youngest child was selected to participate in the study. Children in this age group are likely to go looking for baobab in the wild. There is also limited information on the malnutrition status of this age group in comparison with the under fives. (Awel *et al*. 2016; Dorcas 2007; Jenkins *et al*. 2015). It is the caregivers of these children that were interviewed. Caregivers- in all the households being mothers - were interviewed because women have a direct influence on food security and nutrition status within the households.

3.2.5 Study size and sampling procedure

The required sample size was calculated according to Cochran, (1977) formula. An assumption that half p=0.5 of the households living along the baobab belt are food insecure was used to obtain the sample size. A minimum sample size of 196 households was estimated given a ±7% precision level, a 95% confidence interval and the proportion of target population living along the baobab belt.

Sample size was calculated using (Cochran, 1977).

Where:

$$n = z^2 * p * \frac{q}{e^2}$$

n= Desired sample size

z=Standard normal deviate

p=Proportion of target population estimated to have particular characteristics

q=1-p

e=the margin error/ sampling error

$$n = (1.96)^2 * \frac{(0.50)(0.50)}{(0.07)^2} = 195.97$$

Therefore, n is approximately 196

Probability proportional to the sample size (PPS) approach (WHO, 2008) was used to distribute the sample size (196 households) amongst participating counties (KNBS, 2015).

n=total population desired

n1=Sample size in Kitui County

n2=Sample size in Kilifi County

p_i =Proportion of households in Baobab growing areas in County i

n1= (23095/50317) *196=89

n2= (27222/50317) *196=106

A sample size of 89 in Kitui County and 106 households in Kilifi County was determined. A multistage sampling procedure was adopted. Four sub-counties (Kitui South and Kitui East sub-Counties in Kitui County and Kilifi North and Kilifi South in Kilifi County) were selected purposively because they lie within the baobab belt. From each sub-County, 3 wards giving a total of 12 wards- were also purposively selected due to the presence of baobab. A sampling frame consisting of 96 villages with baobab from each county was created. Systematic random sampling was used to select 12 villages from the sampling frame in each County by selecting a random starting point and a sampling interval of 8 villages (sampling frame (96)/desired sample size (12)). A total of 24 villages in Kitui and Kilifi County were selected. When households in these villages were approached a total of 216 households were achieved. This is 10.2% more of the total required sample size to compensate for non-responses and outliers. Due to lack of a comprehensive list of households in selected villages households were selected following a random procedure (start from the center of the village and select every second (Kilifi) and every next (Kitui) household in two opposite directions until a total of 9 households was achieved for each village. Due to a lower household density in Kitui, the selection differed from Kilifi.

3.2.6 Pre-testing

Questionnaires were drafted and coded into a tablet version. Open Data Kit (ODK) tool version 1.6.1 on Lenovo pad tablet model number TB3-710F Essential android tablet version 5.0 was used. They were pretested and revised during enumerator training with enumerator participation. Pretesting was done with a total of 21 households in Kilifi and Kitui. These villages (Muivu, Kanzanzu, Nzatani in Kitui County and Mere, Paziani and Mikondoni in Kilifi County) were not included in the study. Appropriate corrections were done on the questionnaire after the pretesting.

3.2.7 Data collection

Trained enumerators administered pretested, tablet-based questionnaire to the caregivers. The data collected included socio-demographic characteristics and nutritional status of caregivers and children and household food security status and food consumption patterns. Nutrition, food security status and food consumption patterns were the main outcome variables.

3.2.8 Socio-demographic characteristics

Socio-demographic characteristics collected included age, gender and education level among children, and age, education level and occupation among the caregivers. These characteristics are quite similar in the two counties. Therefore, the data from both areas have been combined and not analysed for differences.

3.2.9 Assessment of household food insecurity status

The Household Food Insecurity Experience scale (HFIES) was used to determine the severity of food insecurity. HFIES is a global scale for the measurement of food insecurity, which consists of 8 questions showing food-related behaviours reflecting increasing levels of food insecurity. The scale classifies respondents at different levels of severity: “food secure” (respondents who answer no to all questions) or “food Insecure” (respondents who experience a certain degree of food insecurity: mild, moderate and severe food insecurity) (FAO, 2016).

3.2.10 Assessment of nutritional status

The nutritional status of primary caregivers was assessed using body mass index (BMI). Mid Upper Arm Circumference (MUAC) was used for pregnant caregivers only. Weights, heights and circumferences were measured twice to the nearest 0.1 kg and 0.5 cm, respectively, using a SECA digital scale (A SECA GmbH and Co.KG Hamburg, Germany Model number: 8741321009) while the subjects were wearing light clothing without shoes. The height of the children was measured while in a standing position on a stadiometer (A SECA GmbH and Co.KG Hamburg, Germany Reference number: 213 1721009) with back, heels and head touching the upright ruler and feet placed together. The participant was asked to look straight ahead and the stadiometer header lowered to flatten hair. The BMI was calculated by dividing participants` weight in (kg) by height in meters squared (m^2). According to WHO a BMI of <18.5 kg/m^2 for non-pregnant caregivers and non-lactating women were categorized as underweight. Between 18.5-24.9 kg/m^2 indicates adequate nutrition whilst a BMI between 25-30 kg/m^2 is classified as overweight, while a BMI of over 30 kg/m^2 indicated obesity. Stunting, wasting/thinness and underweight among children were defined as height for age, BMI for age and weight for age Z-scores. Scores less than -2SD from the median were considered as indicative of malnutrition.

3.2.11 Food consumption patterns

3.2.11.1 Food intake of households

3.2.11.1.1 Food frequency questionnaire (FFQ)

A simple non-quantitative Food Frequency Questionnaire (FFQ) based on 10 local food items was used to assess the frequency of consumption of various food groups. The questionnaire only reported the frequency of consumption but not the quantities consumed. Each food item included 9 categories of the frequency of food intake such as times per day (either 1, 2 or 3), times per week (either 1 2, 3 4, or 5 6), times per month, or never. Respondents were asked to select a category of frequency in the last 1 month (Hodge, et al., 2000).

3.2.11.1.2 A quantitative 24-hour recall

The recall method used a paper and pencil approach employing standardized probes, pictorial portion sizes and coding as a way to prompt accurate recall. Information on the number of people who consumed a particular meal, where the meal was consumed, the source of raw ingredients and preparation methods were included in the 24-hour recall questionnaire. Interviewers also added footnotes regarding any unique context surrounding food intake. A 24-hour reference period was used since it is less subjective to recall errors (KNMS, 2011).

Data collected was converted into total energy and nutrient intakes using Nutri-survey 2007 software. The inbuilt Germany food composition database was supplemented by East Africa and Kenyan food databases and additional foods locally consumed in Kenya. Consumption patterns were recorded only for a typical day.

3.2.11.2 Dietary diversity of households

3.2.11.2.1 Household dietary diversity score

Food intake was determined using the 24-hour recall method. The information was then used to determine the Household Dietary Diversity Score (HDDS). Foods from the 24-hour recall were grouped into ten food groups as shown in table 3.1 to create this score (Swindale & Bilinsky 2006; INDDEX Project, 2018). Dietary diversity scores were calculated by summing the number of food groups consumed in a household over the 24-hour recall period. Households were classified as follows: <4-low dietary diversity score, 4 – 6-moderate diversity score and > 6-high dietary diversity score (FAO, 2010).

Table 3-1: Aggregation of food groups to create HDDS scores

	Food groups
1	Cereals
2	Tuber and roots
3	Vegetables
4	Fruits
5	Meats and meat products
6	Eggs
7	Legumes, nuts and seed
8	Milk and Milk products
9	Oils and fats
10	Spices, sweets, condiments and beverages

3.2.12 Ethical clearance

The Mount Kenya University Ethical Clearance Committee issued an Ethical clearance with Reference number MKU/ERC/0389 and the National Council of Science and Technology (NACOSTI) issued a research permit with serial number 13507 to approve the study procedures and protocols. Verbal informed consent and assent was sought from caregivers and children, respectively, after they were told the study purpose and design. The information obtained was kept confidential.

3.2.13 Statistical analysis

Data were analysed using the Statistical Package for Social Science (SPSS) (IBM Corp. (2016) IBM SPSS Statistics for Mac OS, Version 24.0. Armonk, NY: IBM Corp.) Software. Descriptive statistics such as frequencies (percentages) and means ± standard deviations were used in describing socio demographic characteristics, food insecurity status, food consumption patterns and nutritional status of households, caregivers and children. Dietary diversity scores were calculated by summing the number of food groups consumed in a household over the 24-hour recall period. Anthropometric indices of children were computed in WHO AnthroPlus 1.0.4 and the results classified according to WHO Reference (2007) for 5-19 years. Comparison between genders was performed using student *t*-test. Bivariate correlation tests were done to determine the association between socio-demographic variables and the main outcome variables and also to determine an association between the main outcome variables using p-values. For categorical variables, chi-squares and student *t*-tests were used to obtain p-values. A p-value of <0.05 was considered statistically significant in all analyses.

3.3 Results

3.3.1 Socio demographic characteristics

Table 3-2 summarizes the socio demographic characteristics of children, caregivers and households residing along the baobab belt in Kitui and Kilifi counties of Kenya. The majority (77.7%) of the households were male headed households and the mean household`s size was 7.99±2.98 (mean ± 2SD) members. The proportion of male children interviewed (52.3%) in this study population was slightly higher than that of female children (47.7%). Most of the children (63.4%) were aged between 6-8 years and about half (50.5%) attended lower primary school. Most caregivers had either attained primary school level of education (59.3%) or had no formal schooling (31%). Their major occupations were crop farming (32.2%) and casual labour (30%). The mean age of caregivers was 37.57±10.79 (mean±2SD) years.

Table 3-2: Socio-demographic characteristics of children, caregivers and their households

Socio-demographic Characteristic		n (%)
Children		
Gender	Male	113(52.3)
	Female	103(47.7)
Age	6-8 years	137(63.4)
	9-13 years	79(36.6)
	Mean	8.0±2.1
Education level	Pre-primary	66(30.8)
	Lower primary (1-3)	108(50.5)
	Upper primary (4-8)	40(18.7)
Caregivers		
Age	Less than 21 years	3(1.4)
	21-31	63(29.2)
	32-42	83(38.4)
	43-53	40(18.5)
	54-64	16(7.4)
	65 and Above	6(2.8)
	Mean	37.6±10.8
Level of Education	No formal schooling	67(31)
	Primary school	84(59.3)
	Secondary school	18(8.3)
	Tertiary	3(1.4)
Occupation	Crop farming	91(32.3)
	Salaried employee	14(4.9)
	Wages from piece	85(30)
	Business	43(15.2)
	Tourism	2(0.7)
	Mixed farming	42(14.8)
	Livestock keeping	6(2.1)
Household characteristics		
Household Size	2-4	13(6)
	5-7	97(44.9)
	8-10	73(33.8)
	More than 11	33(15.3)
	Mean	7.99±3
Household head	Male	167(77.7)
	Female	49(22.3)

Entries are of means ± standard deviation; n (%): sample size (percentages): n=216

3.3.2 Food security status

Of the 216 households interviewed, only 2.8% (n=6) were food secure. Food insecurity was reported by 97.2% (n=210): 8.8% (n=19) were mildly food insecure, 14.8% (n=32) were moderately food insecure while 73.6% (n=159) were severely food insecure.

3.3.3 Food consumption patterns

3.3.3.1 Food sources and frequency of food consumption

The majority of the households interviewed purchased food throughout the year irrespective of the seasons. During dry season for instance, 75.5 % depended entirely on food purchases while during rainy season about 27.8 % still purchased food. Only 18.1% (n=39) of the households in these two counties received food aid at an interval of once in 5 months. Majority of these households (32.90 %) received beans, 30 % received maize, 26.80 % received rice while only 11 % of the respondents received oil supplies. Majority (81.9 %) of the households usually consumed 3 meals per day, 15.7 % consumed 2 meals, 0.9 % consumed 4 meals while 0.9 % consumed only 1 meal per day. This, however, changes during food scarcity seasons where 61.1% of the households consumed 2 meals, 22.7 % consumed 1 meal and only 15.7 % were able to consume 3 meals per day. About two thirds (67 %) of the children interviewed attended schools with school feeding programme.

3.3.3.2 Food and nutrient intake

3.3.3.2.1 Food Frequency Questionnaire (FFQ)

About three quarters (74.5%) and a third (63%) of households interviewed consumed mainly cereals and vegetables, respectively, once or more than once a day. Legumes were the next highly consumed food group. The largest proportion of households (47.2%) consumed legumes 2-4 times a week. Fruits and meat and meat products were the least consumed food groups (Table 3-3).

Table 3-3: Frequency of consumption of various food groups within households

	Daily	5-6 times a week	2-4 times a week	Once per week	1-3 times a month	Never/less than 1 month
Fruits	6(2.8)	2(0.9)	29(13.4)	30(13.9)	50(23.1)	99(46)
Cereals	161(74.5)	38(18.1)	9(4.2)	7(2.3)	_	_
Vegetables	13663.0)	9(4.2)	49(22.7)	7(3.2)	9(4.2)	6(2.8)
Legumes	47(21.8)	9(4.2)	102(47.2)	33(15.3)	18(8.3)	7(3.2)
Milk and Milk products	77(35.7)	2(0.9)	24(11.1)	12(5.6)	21(9.7)	79(37.1)
Meat and meat products	_	1(0.5)	14(6.5)	15(6.9)	54(25)	132(61.1)
Fish and seafood	16(7.5)	8(3.7)	53(24.5)	18(8.3)	15(6.9)	106(49.1)
Nuts	21(9.7)	6(2.8)	32(14.8)	14(6.5)	36(16.7)	107(49.5)
Sugar	_	3(1.4)	1(0.5)	5(2.3)	56(25.9)	151(69.9)
Caffeine beverages	163(75.5)	7(3.2)	25(11.6)	7(3.2)	5(2.3)	9(4.2)

n (%); sample size (percentages) : n=216

3.3.3.2.1.1 Nutrient intake among caregivers from the 24 hour recall

As shown in Table 3.4, nutrient intake among caregivers for nearly all nutrients was low.

Table 3-4: Energy and nutrient intake among caregivers

Nutrient	19-50 Years				> 50 Years			
	RDA	AI	% Adequacy	n(%)	RDA	AI	% Adequacy	n(%)
Kcal	1816.4-2294		47.3	17(9.0)	1696.94-2174		58.4	3(10.7)
Protein	46		54.6	24(12.8)	46		59.0	4(14.3)
Carbohydrate	200-300		69.6	39(20.7)	200-300		85.1	9(32.1)
Dietary fibre		25	73.9	39(20.7)		25	92.6	8(28.6)
Vitamin B12	2.4		38.3	5(2.0)	2.4		26.3	3(1.2)
Folic Acid	400		43.5	17(9.0)	400		61.2	4(14.3)
Vitamin C	45		45.9	27(14.4)	45		60.5	7(25)
Calcium	1000		20.3	0(0.0)	1300		29.3	0(0.0)
Iron	18		62.1	3(1.6)	8		76.3	2(7.1)
Zinc	8		57.0	21(75.0)	8		243.1	21(75.0)

RDI: Recommended Daily allowance; AI=Adequate Intake; n=216

Nutrient Reference Values by National Health and Medical Research Council (2006); (FAO/WHO/UNU, 2005)

3.3.3.2.2 Nutrient intake among children

The prevalence of inadequate nutrient intake among children differed between age groups and gender. According to age groups, the prevalence of inadequate intake was higher among adolescents (≥9 years) compared to children (<9 years). In the latter age group, only less than half of the children were able to meet more than 80% of the nutrient requirements for most nutrients. Insufficient intakes in energy, vitamin A and C and calcium were observed with less than 20% of the children able to meet the requirements. Adolescents (≥9 years), on the other hand, had an insufficient nutrient intake for almost all nutrients except carbohydrates and iron. The prevalence of inadequate intake among boys and girls differed with no statistical difference observed. Adolescent boys had higher mean daily intake for most nutrients than adolescent girls. The proportion of adolescents who met the daily nutrient intake was low as shown in Table 3-5

Table 3-5: Energy and nutrient intake among children (4-8 years) and adolescents (9-13 years)

Nutrient	4-8 years				9-13 years							
	Children (n=137)				Boys (n=50)				Girls (n=29)			
	RDI	AI	%Adequacy	n (%)	RDI	AI	%Adequacy	n (%)	RDI	AI	%Adequacy	n (%)
Kcal	2172		38.1	2(1.5)	1810-2150		37.4	0	1550-1795		45.3	0
Protein	20		113.2	63(46.0)	40		51.7	23(46.0)	35		54.1	11(39.3)
Carbohydrate	130		116.4	64(46.7)	130		106.3	25(50.0)	130		106.8	12(41.4)
Dietary fibre		18	122.2	53(38.7)		24	67.5	17(34.0)		20	96.2	11(37.9)
Vitamin A	400		37.4	20(14.6)	600		24.5	4(8.0)	600		24.1	3(10.3)
Vitamin B1	0.6		115.2	57(41.6)	0.9		57.2	16(32.0)	0.9		69.0	11(37.9)
Vitamin B2	0.6		81.6	31(22.6)	0.9		42.4	8(16.0)	0.9		48.9	7(24.1)
Folic Acid	200		69.1	33(24.1)	300		45.6	10(20.0)	300		51.4	6(20.7)
Vitamin C	35		53.5	22(16.1)	40		54.9	9(18.0)	40		33.4	2(6.9)
Calcium	700		29.4	4(2.9)	1000-1300		15.3	1(2.0)	1000-1300		11.5	0(0.0)
Iron	10		80.7	45(32.8)	8		115.7	15(31.9)	8		100.7	9(33.3)
Zinc	4		114.7	62(45.3)	6		65.0	20(40.0)	6		62.7	12(41.4)

Nutrient Reference Values by National Health and Medical Research Council (2006); (FAO/WHO/UNU, 2005)

RDI: Recommended Daily Intake; AI: Adequate Intake; n (%) - sample size (percentages)

3.3.3.3 Dietary diversity of households

Findings from the 24-hour recall reported monotonous and recurring diets among households living within the same locality. Although a variety of food groups were mentioned during the 24-hour recall very few, including (cereals (17.30%), dark green vegetables (10.20%,), vegetables (10.10%), legumes (9.6%) oils (12.20%), condiments (14.4%) and sugars (12.2%)) accounted for the major part of household`s daily diets. Condiments, oils and sugars reflect the purchasing power of households but do not contribute to food intake and nutritional status within the household.

Table 3-6: Food groups consumed by households as reported by caregivers in the 24-hour recall in Kitui and Kilifi Counties of Kenya

Food Groups	n (%)	Percent of cases
Cereals	214(17.3)	99.07
Dark green leafy Vegetables	126(10.2)	58.33
Other vegetables	125(10.1)	57.87
Legumes	119(9.6)	55.09
Oils	151(12.2)	69.91
Condiments	178(14.4)	82.41
Milk and Milk products	86(6.9)	39.81
Sugars	151(12.2)	69.91
Organ meat	1(0.1)	0.46
Meat	9(0.8)	4.17
Fish and sea foods	38(3.1)	17.59
Eggs	1(0.1)	4.63
Nuts	13(1.1)	6.02
Orange fleshed vegetables	2(0.2)	0.9
White fleshed vegetables	7(0.6)	3.24
Orange fleshed fruits	4(0.3)	1.85
Baobab	11(0.9)	5.09
Fruits	2(0.2)	0.93

n (%); sample size (percentages); n=216

3.3.3.3.1 Household dietary diversity scores

For household's dietary diversity score about 32.1 % (n=69) of the households consumed food from less than 4 food groups daily. About 50.2 % (n=108) had a medium dietary diversity (4-6 food groups) and 17.7 % (n=38) had a high dietary diversity (> 6 food groups).

3.3.4 Nutritional status of children

Table 3-7 shows data on nutritional status of children. The prevalence of stunting, wasting and underweight among children was high at 28.6 %, 11.6 % and 25 %, respectively. A small proportion of the children were also reported overweight. Male children had higher rates of malnutrition than their female counterparts, though there was no significant difference observed between the genders.

Table 3-7: Nutritional Status of children in Kitui and Kilifi counties, Kenya

Nutritional status indicator	All	Males	Females	P value
Weight-for -age** (n=163) (% Underweight)	53(25.0)	30(27.7)	23(21.9)	0.79
Height for age (% Stunting)	61(28.6)	35(31.8)	26(25.2)	0.70
BMI for age (% Wasting/Thinness)	26(11.6)	17(13.5)	9(10.7)	0.52
Overweight (+1SD)	2(1.3)	1(1.3)	1(1.4)	0.92

Z score < −2SD from the median of WHO (2007) growth reference (5–19 years); p-values were determined using Student T test analysis; p-values are significant at p<0.05; n (%) - sample size (percentages); **) Weight-for-age reference data are not available beyond age 10 because this indicator does not distinguish between height and body mass in an age period where many children are experiencing the pubertal; n=216; T test analysis

3.3.5 Nutritional status of caregivers

More than half (57.3%) of the caregivers had a BMI within normal range. About 14.8% were underweight (BMI <18.5 kg/m^2) while 18.8% were overweight and 9.1% were obese. All pregnant caregivers (100%) were well nourished with MUAC greater than 21 cm as presented in Table 3-8.

Table 3-8: Nutrition status of caregivers in Kitui and Kilifi counties, Kenya

Nutritional status indicator of caregivers	N (%)
Mid Upper Arm Circumference	
> 22	8 (100)
Body Mass Index	
Underweight (< 18.5)	31 (14.8)
Overweight (25-29.9)	39 (18.8)
Obese (>30)	19 (9.1)

n (%)- sample size (percentages); n=216

3.3.6 Association between socio-demographic characteristics and food security, dietary diversity and nutritional status of households

The education level of caregivers was shown to have a statistical association with underweight ($p < 0.001$) and stunting ($p < 0.001$) rates of children (Table 3-9).

Table 3-9: Association between socio-demographic characteristics and food security, dietary diversity and nutritional status of households

Variables	Food Security Status	HDDS	WAZ	HAZ	BAZ
Children					
Gender	0.14 [a]	0.67 [b]	0.79 [b]	0.7 [b]	0.52 [b]
Age	0.15 [b]	0.35 [c]	0.027 [c]		0.99 [c]
Education Level	0.30 [b]	0.82 [c]	0.53 [c]	0.96 [c]	0.45 [c]
Caregivers					
Age	0.77 [b]	0.68 [c]	0.46 [c]	0.79 [c]	0.34 [c]
Education Level	0.12 [a]	0.23 [b]	0.001 [b]	0.001 [b]	0.23 [b]
Household size	0.52 [b]	0.14 [c]	0.93 [c]	0.83 [c]	0.97 [c]

Notes: p-values derived from [a] Chi- Square test; [b] Student t test; [c] Bivariate correlations; p-values are significant at $p < 0.05$; WAZ: weight for age Z scores; HAZ: height for age Z scores; BMI: body mass index; MUAC: mid upper arm circumference; HDDS: household dietary diversity scores; n=216

3.3.7 Association between food security status, dietary diversity of households and nutritional status of caregivers and children

A significant association was observed between the food security status of households and stunting rates of children ($P < 0.001$) (Table 3-10).

Table 3-10: Association between food security status, dietary diversity of households and nutritional status of caregivers and children

Variables	Children			Caregivers	
	WAZ	HAZ	BAZ	BMI	MUAC
Food security	0.09 [b]	0.0001[b]	0.93 [b]	0.23 [b]	0.61 [b]
HDDS	0.13 [c]	0.20 [c]	0.36 [c]	0.90 [c]	0.94 [c]
WAZ				0.76 [c]	0.98 [c]
HAZ				0.047 [c]	0.43 [c]
BAZ				0.57 [c]	0.44 [c]

Notes: p- values derived from [b] Student t test; [c] Bivariate correlation at $p<0.05$; p-values are significant at $p<0.05$; WAZ: weight for age Z scores; HAZ: height for age Z scores; BMI: body mass index; MUAC: mid upper arm circumference; HDDS: household dietary diversity scores; n=216

3.4 Discussion

3.4.1 Socio demographic characteristics

According to the Kenya National Bureau of Statistics (KNBS) 2009, the proportion of male children was higher compared to that of female children in Kilifi and Kitui Counties (Nandi County Government, 2013; Kilifi County Integrated plan, 2017). This is similar to results reported in the current study. The high school enrollment in the current study is in agreement with Kitui and Kilifi County Government reports which reported slightly higher (72.3%) school enrollment in Kitui County compared to the national statistics (70.5%) (Kitui County Government, 2013). Similarly, school enrollment in Kilifi has been rising from 288,650 since 2012 to 346,656 in 2017 (Kilifi County Integrated plan, 2017). This could be explained by the key action policies geared towards improving education system such as introduction of school feeding programs at County level. High illiteracy levels reported in the current study are in agreement with findings in Kilifi County Government report, which reported low literacy levels in Kilifi with 34.5% not able to read and write. On the contrarily, statistics by KNBS reported 62% of the population in Kitui County have primary education which is 10% above the national primary school attainment. It could be inferred that majority of literate people live in urban and peri-urban areas (Kitui County Government, 2013) yet the study was conducted in a rural setup in Kitui County.

Poor socio-economic status could be as a result of high poverty and unemployment rates in these counties. Kilifi County has also been ranked as one of the poorest County in Kenya with an absolute poverty level of 71.7% (KIHBS, 2005/2006). Moreover, Approximately 2.7% of the work force in Kitui are either unemployed or in the informal sector (Kitui County Government, 2013). Likewise, 30% of people in Kilifi County are unemployed while another 30.85% are self-employed. Large family size is a common trend in most rural areas. This implies that many persons in a household share a plate and that distribution of resources will be meagre for each individual. This translates to poor nutritional status among individual household members. It is estimated that an average caregiver in the rural area has 1 more child compared to their counter parts in the urban areas. Moreover, the fertility rate of women in Kilifi and Kitui counties is high (3.9 and 5.1) respectively (KDHS, 2004). Low level of contraception use (34%) among women in their reproductive age is also a major contributor to high population growth rate of 3.05% per annum (Kilifi County Integrated plan, 2017).

3.4.2 Food insecurity status

In the present study, a majority (98.2%) of the households interviewed experienced some form of food insecurity ranging from mild to severe. One explanation for this high rate of food insecurity could be the fact that households in the areas rely on subsistence cropping as their main source of livelihood despite the areas receiving unreliable rainfall (FEWS NET 2017). This has led to a decline in the harvest of the main staple foods, a decrease in household’s food stocks and an consequently an increase in food prices since 2011, therefore, heightening food insecurity (NDMA & WFP, 2017).

Secondly, the majority of the households were male headed. Household heads are the sole determinant of the household's ability to access adequate quantity and quality of food. In this study, similar to caregivers, the main occupation of the household head was either casual labourers or farmers. In a rural set up where most farmers are subsistence, these occupations command low incomes. Besides, men as household head, unlike women, have reported lower food expenditure (Shahraki *et al.,* 2016) thus the high degrees of food insecurity reported. The prevalence of food insecurity is higher compared to statistics reported by most Sub-Saharan countries. In selected towns along agro-ecological zones characterized by a declining potential of rain-fed agriculture in South Africa for instance, 64% of the households were reported to be food insecure (Chakona & Shackleton 2018).

3.4.3 Food consumption patterns

3.4.3.1 Food and nutrient intake

High intake of cereals, legumes, vegetables and hot beverages as found in the current study is similar to consumption patterns reported by children in South Africa (Chakona & Shackleton 2018). Overdependence on cereal-based foods could be due to the poor socio-economic status that forced most households to rely on a cheap source of food calories. A significantly low intake of more expensive food items such as meat among food-insecure households has also been reported among Iranian school going children (Alipour *et al*. 2016). Given the low intake of fruits, untapped potential of drought resistant indigenous baobab fruit could serve as a good supply of fresh, cheap and nutritious fruits during such seasons(Aluko *et al.,* 2016). High consumption of wild dark green vegetables particularly during the onset of short rains in Kilifi County indicates that there are potentially many useful wild traditional vegetables used in this community which are however not available during dry seasons. During such seasons, households excessively rely only on other vegetables such as cabbage and kales, which are substantially missing.

Relative to the RDAs, low nutrient intake was observed among children, adolescent and caregivers in the study area. This could be influenced by poor social economic status, low purchasing power, inadequate availability and access to supplies that pushes prices of various components particularly during famine. High nutrient intake among boys than girls is similar to findings by a study in the UK where the overall intake was high among boys than girls (Jenkins ,. *et al* 2015). However, whilst nutrient intake is generally higher among boys than girls the prevalence of wasting, stunting and underweight was still high among boys. Energy deficiency cut across all genders and ages. Diets consumed could barely meet the energy requirements for basal metabolic rates (BMR), which are 1215-1370 Kcal for boys between 6-13 years, and 1160-1280 Kcal for girls between 6-13 years. This could be as a result of reduced number of meals during famine and inability to acquire food that is adequate in quality and quantity due to poverty. Energy is crucial in maintaining basal metabolic rates and caring out physical activities.

Children between the ages of 5-10 years in developing countries are expected to lead a more active life since they have to walk long distances, undertake heavy physical activities. Their intakes are still low compared to their counterparts in developed countries as shown in the current study. Carbohydrate intake exceeded recommended dietary intake. Cereals and legumes which are the main carbohydrate source are cheaper and readily available thus their increased consumption. This findings are in agreement with results by Danquah which reported high carbohydrate intake due to readily available and cheap carbohydrate source (Danquah *et al* ,. 2013).

This study also reported high iron intake. This positive finding could be as a results of plant sources which form a major component of people`s diets. Plant sources are said to provide up to 2/3 of the total iron requirements in human diets. Iron deficiency is one of the commonest micronutrient deficiencies that lead to reduced physical and mental growth among children. High iron deficiencies reported among these children in the study region despite the high iron intake could be due to poor absorption and lack of bioavailability of the non-heme iron. Zinc deficiency was observed among adolescent boys and girls. This could be associated with the high stunting rates in this age group (Lopes *et al*., 2017). Low intake of dietary calcium is a worrying trend among all children irrespective of age and gender since it is crucial for attainment of peak bone mass density (Weaver, 2014). Results from this study also reported deficiency in Vitamin A, a crucial vitamin in enhancing the immune function of children and also preventing night blindness. Deficiency in thiamine and riboflavin, as expressed among adolescents, is greater than in younger children. This is of great concern given that these vitamins play a big role in energy metabolism and protection of children against diseases (Jacoby, 2012). Deficiencies can result in decreased growth, increased morbidity reduced muscle weakness and lack of coordination. It is therefore important that children receive adequate amount of these vitamins given their role (Danquah *et al*., 2013).

3.4.3.2 Dietary diversity score

In this survey population, dietary diversity of households was found to be poor. This observation is in conformity with a study in Kitui, Kenya, which reported a low dietary diversity score of 4.7 (Kitui Nutritional survey, 2012). Low dietary diversity is influenced by poor social economic status, low purchasing power, inadequate availability and access to supplies which increases prices of food in general and especially the high value food during famine (Rothman *et al.*, 2018). Cultural beliefs in adverse health and development effects can also limit dietary diversity (Kariuki *et al*. 2017). Diets in these areas can be potentially diversified through increased use of drought tolerant indigenous crops such as baobab, sorghum and millet (Shumetie & Alemayehu, 2018).

3.4.4 Nutrition status of children

Malnutrition among children still remains a major public concern in developing countries. The current study found a high prevalence of stunting, wasting and underweight among young school children residing in households along the baobab belt. The rate of stunting is similar to the national rate of 26% (KDHS, 2014). However, the rates of wasting and underweight are remarkably higher than the national average which is 4%, and 11%, respectively (KDHS, 2014). As wasting indicates acute malnutrition the counties have to deal with a higher degree of emergency.

Comparing to other areas along the baobab belt, the prevalence of malnutrition in Kitui and Kilifi are higher than those reported among pupils in Hohoe municipality in Ghana, West Africa (Agbozo *et al.*, 2017). There, the stunting rates are lower than those reported in Kitui (46.8%) and Kilifi (39.1%) county as a whole. This can be explained by recurring episodes of drought and food insecurity in these two Kenyan counties. Wasting and underweight could further be explained by the sudden food shortage due to the prolonged drought experienced in the country in 2017. The general nutritional status of girls was better than that of boys. Previato & Behrens, 2018 also reported a high prevalence of malnutrition among boys than girls. This could be due to the fact that boys at this age are more physically active and that they tend to lose more of their body fat reserves than their counterparts. A negative association existed between wasting and stunting of children. This means that children who were wasted were unlikely to be stunted. A positive association between stunting and underweight and wasting and underweight was observed showing a likelihood of underweight children becoming stunted or wasted.

3.4.5 Nutritional status of caregivers

Aside from identifying the nutritional status of children, nutritional status of women merits special attention because of their social vulnerability and that most parents rather starve themselves than let their child get malnourished. Here the prevalence of overweight (18.8%) and obesity (9.1%) among caregivers in the current study was higher than under nutrition (14.8%). The Tanzania Demographic survey has reported similar observations in rural Tanzania in 2010 where the prevalence of overweight and obesity was 15% while underweight was 13%. Kitui and Kilifi County are obviously affected by the double burden of malnutrition with the parallel occurrence of under nutrition and overweight.

Under nutrition among women could result from cultural norms and practices such as taboos that restrict consumption of certain foods among women. Moreover, given the high fertility rates among women in these counties (3.9 in Kitui and 5.1 in Kilifi) (KDHS, 2014), the increased energy and nutrient requirement during pregnancy and lactation may not be adequately compensated by dietary intake even after these physiological process (Kariuki *et al*., 2017). In addition, the high prevalence of under nutrition could result from heavy work demands by women in a rural setup. The poor nutritional status of caregivers could explain the high food insecurity status and high stunting rates among children reported in this study (Demos & Segal, 2016). This is because women directly influence food security and nutritional status within a household (Madjdian & Bras, 2016).

In the interpretation of the data, one major limitation needs to be considered. Generalization of the study findings to the general populations along the baobab belt is fairly limited due to the number of participants enrolled and the fact that only households with children between 6-13 years old were interviewed. There was no randomization, but this approach was justified by identifying the need for increasing dietary diversity using baobab products. The aim was not to do another general survey about food insecurity and malnutrition.

The findings of this study indicate a need for increasing dietary diversity as a more diverse diet can cover nutritional needs better than a monotonous diet on one hand and it can help to avoid a caloric overload, especially when fruits and vegetables are consumed which contain bioactive compounds in addition to nutrients and energy. As the survey has been performed in preparation of an assessment of the potential contribution of baobab to a diverse diet based on local indigenous food the findings justify this approach.

3.5 Conclusion

Despite the relative abundance of baobab trees and the potentials associated with it, a majority of the households interviewed were food insecure and reported medium to low dietary diversity scores. Malnutrition rates among children and caregivers were higher than the national statistics. Use of baobab could improve food security status, quality of diets and consequently nutrition status of individuals at household levels.

CHAPTER 4

ROLE OF BAOBAB IN HOUSEHOLD FOOD SECURITY IN KILIFI AND KITUI COUNTIES OF KENYA

Abstract

Baobab tree has in the recent past become of interest in improving households' food and nutrition security by serving to complement and diversify diets particularly during food insecure seasons and improving household income by selling it to local and export markets. These roles have, however, remained unexploited in Kitui and Kilifi counties yet the counties host a large population of baobab trees. A cross-sectional study among 216 households was designed to investigate the potential role of baobab in food security in these regions. More than three quarters (81.5%) of the households in Kitui County and more than half (57.4%) in Kilifi County owned baobab trees on their farm. Majority 80% in Kitui and 91.3% in Kilifi reported to have access to baobab tree trees from either neighbouring farms or trees that naturally occurred in forest areas. The proportion of households that used baobab in various forms was however limited. Households mainly consumed it in its fresh form with limited use in value-added products. Leaves were used by only 43.5% of the households' interviewed in Kilifi County mainly in softening other vegetables during cooking. Fruits and leaf harvesting patterns coincided with the hunger gap in both counties yet its use, as an emergency food or coping strategy during dire food insecure seasons was limited. About 51.6±85.5 Kgs in Kitui County and 37.7±83.0 Kgs in Kilifi County of baobab was harvested. Mean consumption of baobab pulp was statistically ($p<0.001$) higher in Kitui (30.6 ± 59.1) than in Kilifi County (5.3±20.1). The proportion of income from baobab contributed to only 2.05% of the total income in Kilifi and 0.8% in Kitui County. Baobab has remained underutilized as a source of food and a means of improving household income despite its relative abundance in the study area due to lack of knowledge and perceived health effects associated with its consumption. Creating awareness on baobab`s potential to contribute

to food security, nutrition and diversification of livelihoods is necessary in increasing its utilization.

4.1 Introduction

Africa is one of the continents with the fastest population growth and home to one of the poorest populations which heavily depend on agriculture as their main source of livelihood (GNP, 2017). Climate change has turned Africa into a key importer of food commodities threatening agricultural production. The largest proportion of undernourished people globally live in Africa (AU, 2012). An estimated 28% of Africa`s population suffers from chronic food insecurity while 38% suffer from acute food insecurity. Out of the 39 countries globally faced with food emergencies situations annually, 25 countries are found in Africa (Clover, 2003). In Kenya, approximately 1.6 million people are food insecure (KFSSG, 2012).

One of the potential ways to mitigate the impact of climate change on agriculture and ensure a food secure continent is by promoting the use of drought tolerant crops. Ironically, these are some of the least researched and used crops in Africa. One such crop is the baobab tree (*Adansonia digitata*). The baobab tree is a huge multipurpose tree that occurs naturally in arid and semi-arid lands (ASAL) of Sub-Saharan Africa (Gebauer, Adam, *et al*., 2016). It has been used extensively for subsistence and commercial purpose in countries in West Africa where its knowledge is widespread.

Baobab plays a significant role in food security during food shortages and crop failure (Gustad, Dhillion, & Sidibé, 2004; Chadare *et al*., 2010; Jensen *et al*., 2011). It`s edible parts have been used as a substitute in the main diet as well as a condiment to diversity diets (Tsige & Michael, 2018). Baobab`s subsistence use has been steered by its high nutritive value (Venter & Witkowski, 2013). The fruit pulp, for instance, exhibits high antioxidant properties with high Vitamin C content of between 169.74mg/100g and

231.57mg/100g (Aluko *et al*., 2016). This is 10 times higher than Vitamin C in oranges (Bamalli, 2014). The baobab leaves are rich in minerals such as calcium (307 to 2640 mg/100 g dw) and provide a good protein source with a chemical score of 0.81 (Chadare et al., 2008). The kernel and whole baobab seeds have a relatively high lipid content ranging between 18.9 to 34.7 g/100 g dw and 11.6 to 33.3 g/100 g dw respectively (Braca *et al*., 2018).

The economic potential of the baobab tree is of great significance among many local populations in Africa. Since the European Commission authorized baobab as a novel food, countries such as South Africa have exported their baobab to markets in Europe and North America. Income generated from sales of baobab products has been shown to support thousands of livelihoods in rural areas (Venter & Witkowski, 2011). In Zimbabwe and other parts of South Africa for instance, sale of baobab fruit has increased monthly income for rural households by 250% during baobab harvesting seasons (Gruenwald and Galizia 2005). Increase in household income consequentially increases household food security status.

While the tree has been widely exploited and used in West Africa (Christine, *et al*., 2010), its use in East Africa and particularly in Kenya is limited. Kitui and Kilifi counties located to the Eastern and Coastal region of Kenya respectively are marginalized agricultural areas that overwhelmingly depend on agriculture as their main source of livelihood. This is despite the area being characterized by unreliable rainfall, failed crop seasons and declining household food security (KFSSG, 2012). The counties, however, host a baobab population about which nothing is known in terms of population density, availability, use and harvesting patterns. Such information is crucial in evaluating baobab potential for future development and use in the areas. In addition, it`s subsistence and commercial importance at the household level remain unexploited. The main objective of this study was to investigate the untapped role of baobab in addressing household food security among rural households residing along the baobab belt in Kitui and Kilifi counties of Kenya.

4.2 Materials and Methods

See materials and methods in chapter 3.2.1 to 3.2.6 and 3.2.12

4.2.1 Data collection

A pretested, mobile-based questionnaire with structured and semi-structured questions was used to collect information on baobab availability, harvesting patterns, occurrence and uses. In addition, the untapped potential role in household's food security was assessed. Household face-to-face interviews were conducted solely with the caregiver by trained enumerators.

4.2.2 Statistical analysis

Data was analyzed using the Statistical Package for Social Science (SPSS) (IBM Corp. (2016) IBM SPSS Statistics for Mac OS, Version 24.0. Armonk, NY: IBM Corp.) Software. Descriptive analyses were performed to provide general information on the occurrence and the role of baobab in food security. Comparisons of variables between Kilifi and Kitui counties were done using student T-test. The average density of baobab trees was estimated as the number of baobab trees per hectare. A multiple linear regression model was used to quantify the association between baobab variables as the independent variables and household food security as the dependent variable while also accounting for other covariates potentially associated with the outcome variables of interest. Baobab variables explored were availability and accessibility of baobab, quantities of baobab harvested, consumed and sold, uses of baobab and factors influencing low consumption of baobab.

4.3 Results

4.3.1 Occurrence and ownership of baobab trees

Baobab density in rural Kitui County was 0.48 trees/Ha while that in Kilifi County was 0.87 trees/Ha as shown in Table 4-1.

Table 4-1: Baobab density in households in Kitui and Kilifi Counties of Kenya

	Land size owned (Ha)	N±SD	Baobab trees/Ha
Kilifi	4.6	4.0±6.4	0.87 trees/Ha
Kitui	9.5	4.6±4.0	0.48 trees/Ha

N±SD: Mean number of baobab trees on farm ± Standard deviation; Ha: hectare

4.3.2 Availability of baobab trees

More than three quarters (81.5%) of the households in Kitui County and more than half (57.4%) in Kilifi County had baobab trees growing on their farms (farms that they have a right of possession). For off-farms, (farms that they did not have a right of possession) 38.9% of these households in Kilifi and 17.6% in Kitui County reported to have access to baobab trees on such farms. A majority of the households, 80% (n=16) in Kitui and 91.3% (n=42) in Kilifi reported to obtain baobab from neighbouring farms, communally owned farms and forest.

4.3.3 Quantities of baobab fruits and leaves harvested per season

Generally, baobab fruit harvest was low among households in both counties. The average quantities harvested in Kitui County (51.6±85.5 Kgs) were higher than in Kilifi County (37.7±83.0 Kgs). There was, however, no significant difference between the harvests in the two counties. Baobab leaves were only harvested and used in Kilifi County by 43.5% (n=47) of household interviewed. The average harvest was negligible and could not be quantified.

4.3.4 Baobab consumption

Mean consumption of baobab fruits was statistically ($p < 0.001$) higher in Kitui County (30.6±59.1 Kgs) than in Kilifi County (5.3±20.1 Kgs). The frequency of consumption of baobab fruit was generally low. As shown in Table 4-2, 30.7 % of the households in

Kilifi County consumed baobab fruit either 1-3 times a month or 2-4 times a week. In Kitui, on the other hand, 42.4 % consumed baobab daily. Majority (61.7 %) of the households in Kilifi County consumed baobab leaves 1-3 times in a month.

Table 4-2: Frequency of consumption of baobab leaves and fruits among households in Kilifi and Kitui counties of Kenya

Frequency of consumption	Baobab leaves	Baobab fruits	
	Kilifi	Kilifi	Kitui
Never or less than once a month	7 (14.9)	11(10.9)	4(3.7)
1-3 times a month	29(61.7)	31(30.7)	11(10.2)
Once a week	3 (6.4)	15(14.9)	10(9.3)
2-4 times a week	8(17.0)	31(30.7)	18(16.7)
5-6 times a week	0(0.0)	8(7.4)	6(5.6)
Daily	0(0.0)	5(4.6)	46(42.4)

Entries are of n (%): sample size (percentages)

4.3.5 Baobab use

Baobab was underutilized among households interviewed. In total, only 10 food uses of the baobab tree were recorded as shown in Table 4-3. In addition, only a small proportion of households used baobab. The common uses were; eating the pulp fresh by cracking the hard shell and sucking the chalk powder off the seed and spitting the seed out, as a flavor in porridge, as a vegetable and as a juice. Other uses were distinct according to regions. In Kilifi County for instance, where sardine (kumbu) and fish were one of the main delicacies, the Giriama and Swahili used baobab in thickening soups (26.2%), making baobab flavoured ice bars (1%), fermenting coconut milk (12.3%) and making "Mabuyu" candy (10.3%). Among the Kamba community in Kitui County, baobab was used in the preparation of a special ugali called "Muswa" (6.5%). Preparation involved adding the fruit pulp into boiling water and slowly adding flour to make a thin kind of soft “Ugali” with a sweet and sour taste. Only 25% (n=54) of households interviewed used baobab for non-food uses mainly making ropes, as firewood and as rat traps as shown in Table 4-3. Small quantities of the leaves were used in softening vegetables (85.1%) such as cassava leaves during cooking. Another small proportion (6.4%) of households used baobab leaves as a vegetable substitute while (9.5%) used it as fodder for goats.

Table 4-3: Uses of baobab fruits among households in Kilifi and Kitui counties of Kenya

Uses of baobab fruits	Kilifi	Kitui
Eaten fresh	103(34.2)	100(36.1)
Soup thickener	79(26.2)	0(0.0)
Flavour in porridge	12(4.0)	60(21.7)
Vegetable	7(2.3)	35(12.6)
Dissolve in water	2.6(8.6)	63(22.7)
"Mabuyu" Candy	31(10.3)	0(0.0)
Fermentation of coconut milk	37(12.3)	0(0.0)
Frozen ice	3(1.0)	0(0.0)
Ugali "Muswa"	0(0.0)	18(6.5)
Jam	0(0.0)	1(0.4)

Entries are of means ± standard deviation; n (%): sample size (percentages)

Table 4-4: Non-food uses of the baobab tree among households in Kilifi and Kitui counties of Kenya

Baobab non-food uses	Kilifi	Kitui
Ropes	11(19.0)	11(64.7)
Rat traps	26(44.8)	2(11.8)
Mosquito repellent	1(1.7)	0(0.0)
Mushroom growth media	6(10.3)	0(0.0)
Firewood	8(19.0)	4(23.5)
Medicinal Value	3(5.2)	0(0.0)

Entries are of means ± standard deviation; n (%): sample size (percentages)

4.3.6 Factors contributing to low consumption of baobab

As shown in Table 4-4, low consumption of baobab fruits was mainly influenced by its astringent taste as reported by 54.9% and 30.2% of households in Kilifi and Kitui counties, respectively. On the other hand, households in Kilifi County reported sliminess (88.9%) and taboos (11.1%) as the main reasons that limited baobab leaves utilization.

Table 4-5: Factors associated with low baobab consumption in Kitui and Kilifi counties of Kenya

Reasons for not consuming baobab	Kilifi	Kitui
Stringent Bitter taste	28(54.9)	19(30.2)
Ethnic difference	1(2)	1(1.6)
Lack of knowledge on its importance	2(3.9)	4(6.3)
Tiredness	9(17.6)	6(9.5)
Tickling of feet	7(13.7)	3(4.8)
Dizziness	1(2)	0(0.0)
Gas and diarrhoea	1(2)	4(6.3)
Ulcers	1(2)	3(4.8)
Mouth sores	1(2)	0(0.0)
Skin dryness	0(0.0)	3(4.8)
Swollen body	0(0.0)	1(1.6)
Loss of weight	0(0.0)	3(4.8)
Lack of iron in the body	0(0.0)	6(9.5)
Causes thunder	0(0.0)	3(4.8)
No access to the baobab tree	0(0.0)	3(4.8)
Overuse of baobab fruits	0(0.0)	4(6.3)

Entries are of n (%): sample size (percentages)

4.3.7 Harvesting patterns

Harvesting pattern of baobab alternate between the two counties. In Kitui County, baobab harvesting begins in the month of February and gradually increases up till July. On the other hand, In Kilifi County harvest begins in June and gradually increases to November as shown in Figure 4-1. Households' harvested baobab leaves from both mature and young baobab trees. From mature trees, harvest begins in February and gradually increases to April during long rain season. Most harvesting occurs during these months since the leaves are still tender. After April, harvest starts declining till July when all leaves are shade-giving room for fruiting see Figure 4-2. Leaves from young baobab trees are mainly harvested between September and November mainly during short rains. During this season, other traditional vegetables sprout and are mixed with baobab leaves.

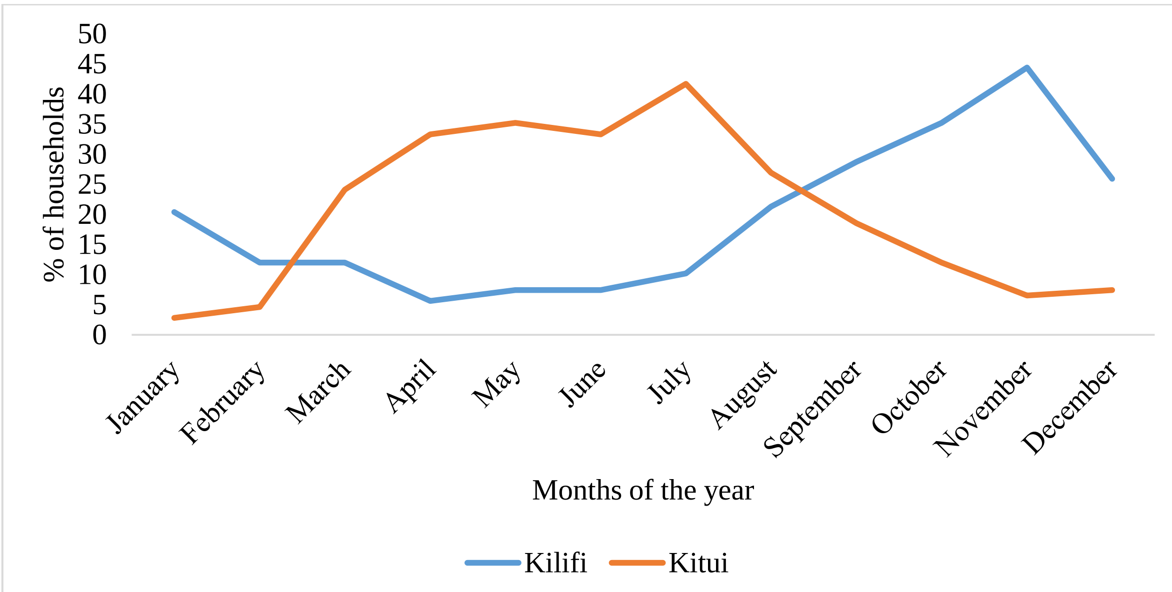


Figure 4-1: Percentage of households harvesting baobab during the specific months of the year in rural Kitui and Kilifi Counties

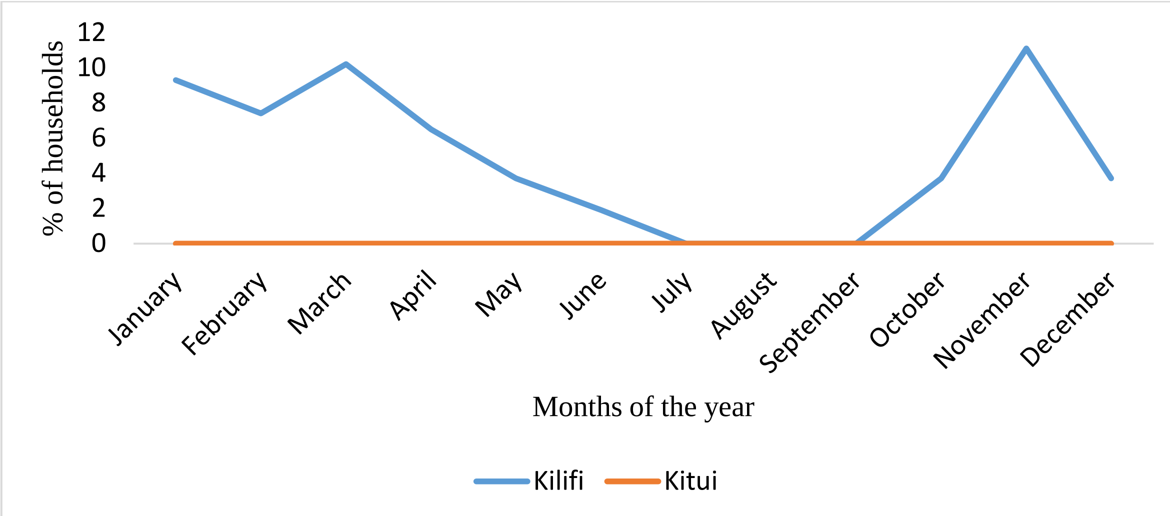


Figure 4-2: Percentage of households harvesting baobab leaves during the specific months of the year in rural Kitui and Kilifi Counties

4.3.8 Baobab sales

Households in Kilifi County (25.5±77.9 Kgs) sold significantly higher quantities ($p < 0.014$) of baobab than in those in Kitui County (15.0±36.7 Kgs). However, income from baobab sales contributed to only 2.05% of the total income within households in Kilifi County and 0.8% in Kitui County as shown in Table 4-5. The monetary value of baobab in both counties was generally low. A 90 Kgs bag of whole baobab fruits for instance retailed at about 575 Ksh in Kilifi County and 248. One Kg of cracked baobab fruits was sold at 51 Ksh in Kilifi County and 11 Ksh in Kitui County. Income from non-baobab food products was negligible.

Table 4-6: Proportion of total income per baobab season contributed by occupations of caregivers in Kitui and Kilifi counties

	Kilifi		Kitui	
Income stream	Total income in Ksh	Proportion of total income (%)	Total income in ksh	Proportion of total income (%)
Cash crops income	317400	10.9	1255145	26.8
Livestock income	2414400	83.2	3218155	68.8
Fishing income	25002	0.9	2588	0.1
Bee keeping income	10002	0.3	137360	2.9
Baobab food income	59527	2.1	37560	0.8
Salaried employees income	74583	2.6	30000	0.6

Ksh- Kenyan Shilling; Means, Percentages proportions(%); n=216

4.3.9 Role of baobab in food security

A logistic regression model was created to analyze the role of baobab in household food security. Independent variables entered into the model are shown in Table 4-7 along with the regression coefficients and p-values for each variable. Baobab variables in the model contributed to only 28% of the variability in food security status of the households. Consuming baobab pulp in it`s fresh ($p < 0.001$), using it as a thickener in preparation of soups ($p = 0.03$**)** and using it in fermenting coconut milk ($p < 0.0001$) were shown to significantly increase household food security. Factors influencing low baobab consumption such as lack of knowledge on the importance of baobab ($p = 0.01$) and perceived health problems such as tingling feet caused by its consumption ($p = 0.05$) significantly reduced utilization of baobab, hence increasing food insecurity among households.

Table 4-7: Logistic regression model of food insecurity status of households; β-coefficients significant at the < 0.05 level are bolded

Variables	National n = 216 Model R^2 = 0.2845 ($p < 0.0001$)	
	β-coefficient	p-value
(Intercept)	7.12	**<0.0001**
Availability of baobab trees (1 = yes, 0 = no)	-1.33	0.41
Number of baobab trees owned	0.02	0.76
Quantities of baobab harvested	-0.01	0.24
Quantities of baobab consumed	0.01	0.26
Quantities of baobab sold	0.01	0.41
Price per 90 Kg bag of baobab	0.00	0.83
Price per 1 Kg bag of baobab	0.04	0.28
Uses of baobab		
Eaten fresh (1 = yes, 0 = no)	3.71	**<0.001**
Soup thickener (1 = yes, 0 = no)	1.55	**0.03**
Porridge flavour (1 = yes, 0 = no)	0.17	0.81
Vegetable (1 = yes, 0 = no)	0.09	0.91
Fermenting coconut milk (1 = yes, 0 = no)	3.76	**<0.0001**
Ugali (mswa) (1 = yes, 0 = no)	0.86	0.43
Factors associated with low consumption		
Stringent taste (1 = yes, 0 = no)	-0.57	0.39
Lack of knowledge (1 = yes, 0 = no)	3.86	**0.01**
Tiredness (1 = yes, 0 = no)	0.24	0.84
Tickling feet (1 = yes, 0 = no)	2.50	**0.05**
Lack of access (1 = yes, 0 = no)	-3.97	0.13
Overuse (1 = yes, 0 = no)	-1.38	0.51
Cultures/taboos (1 = yes, 0 = no)	1.00	0.40

p-values are significant at < 0.05; Logistic regression; n=216

4.4 Discussion

4.4.1 Occurrence of baobab trees

The density of baobab trees in the study area was less than 1 baobab tree ha-1. These results are similar to the baobab density of 0.72 baobabs ha-1 reported in Kordofan, Sudan (Gebauer & Luedeling 2013). Higher baobab densities of between 1- 5 baobab trees per $Km^2$and 12.2 baobabs ha-1 depending on the agro-ecological have been reported by a study in Benin (Assogbadjo *et al*., 2017) and Southern Malawi (Cuni-Sanchez, 2011) respectively. This study also revealed a variation in baobab population densities with a higher density reported in Kilifi County (0.87 baobabs ha-1) than in Kitui County (0.48 baobabs ha-1). The different agro-ecological zones in which the counties lie can explain this variation. The baobab belt in Kitui County is located along the low midland agro ecological zone while Kilifi County is located along the Coconut cashew nut agro ecological zone (Kitui County Government, 2013; Kilifi County Integrated plan, 2017).

4.4.2 Access to baobab trees

The majority of the households living along the baobab belt had access to baobab trees either on their own farms or from elsewhere. These findings are in agreement with a study in Taita Taveta where majority of households (73%) owned baobab on on-farms and 77.27% had access to baobab trees elsewhere. (Fischer, 2015). Similar to the present study, the study in Taita Taveta confirmed that most baobab trees occurring on off-farms occurred at the periphery of their lands and its ownership was not clear (Fischer, 2015). A field guide in Kitui County, however, reported that with the increasing economic and subsistence potential of baobab, increasing number of households own it as a family asset.

4.4.2 Quantities of baobab harvested

Once mature, baobab trees continually provide seasonal fruit and leaf harvests with a high annual variability depending on the rainfall patterns (Venter & Witkowski, 2013).

Production of baobab trees in Benin for instance was reported to vary between 57.1 and 157.4 fruits while in South Africa it varied between 29.7 ± 6.6 and 81.7±18.1 fruits per tree, annually, between 2006 and 2009 (Venter & Witkowski, 2011). The average harvest of baobab fruits in the two counties was lower than the average production of one baobab tree. Leaf harvesting is a widespread practice among other countries where baobab occurs unlike in Kilifi County. In Dogaon village in Mali, for instance, baobab tree is largely managed for leaf production and harvest. Similarly in West Africa mass leaf harvesting and storage is done shortly after long rains (Leach *et al*., 2011). Harvesting techniques used could greatly explain the reduced harvest. Baobab fruit were mainly handpicked or pulled off the tree using a hook mounted on a long cane. Harvesting tender baobab leaves was difficult because of the tree heights. Most women break off the shoots off the tree to access the leaves. Such practice reduces the number of flower buds and can as well damage the tree. With such techniques, only easily accessible fruits could be reached leaving most of the fruit lying untouched thus the low harvest.

4.4.3 Utilization of baobab

The use of baobab is untapped in the study areas. Household interviewed were able to mention only 16 baobab uses. The uses reported were fewer than those reported by a study in Taita Taveta where 27 uses of baobab fruit were identified with most being food related (Fischer, 2015) and in rural West Africa in three countries, Benin, Mali and Senegal, where households recorded 300 different uses (Christine *et al*., 2010). In the study region, baobab is mainly used in its raw form mainly eaten fresh or dissolved in water. Non-food products from baobab are also only used at household level. This is unlike other areas in Africa where the baobab fruits and leaves have been widely used both in its raw and processed forms (Chadare *et al*., 2010; Hall, 2007; Ndabikunze *et al.*, 2011), Low consumption of baobab in the study area is also contrary to finding in Mali, Benin and Senegal which reported that rural households consumed baobab edible parts daily (Christine *et al*., 2010). Despite the baobab fruit being the most preferred and used edible part elsewhere, (Abdulkarim & Bamalli 2014; Kaboré *et al*., 2011; Fischer, 2015) households in Kilifi County did not consider it as a true food instead used it as a condiment or candy. In Southern Malawi unlike in Kilifi and Kitui counties, baobab leaves have been used as a vegetable substitute during dire food insecurity situations (Abdulkarim, 2014). Despite the relative abundance of baobab in the study areas, use of baobab presents lots of untapped potential in its raw forms and through value addition. Increasing its consumption especially when most subsistence crops fail could serve as a crucial nutrition source during food scarcity. Development of baobab products ensures its availability and accessibility even after the baobab fruit and leaf season. According to Fischer, (2015) and similar to the current study, limited use of baobab has been associated with myths and cultural beliefs. Several studies elsewhere have shown that misconception such as parents discouraging children from eating baobab since they believe it could cause a cough or the children could be choked by the seed (Fischer, 2015) limited baobab consumption. Elsewhere exaggerated consumption of the fruit pulp was thought to be a cause of hernia (Gustad *et al*. 2004). The undesirable slimy consistency of baobab leaves after cooking (Bamalli, 2014), lack of knowledge on their importance (Caluwe *et al*., 2009) and cultural believes associated with this leaves have also limited its use.

4.4.4 Harvesting patterns

Fruiting and leafing of baobab is seasonal in both counties. It corresponds to the hunger gap and food scarcity season. Fruits and leaf harvesting from mature fruits in Kitui and Kilifi County for instance correspond with long rains season when most households are food insecure since the long rains are unreliable and unpredictable (FEWS NET, 2017). Similarly, fruit harvesting in Kilifi County sets in before the onset of short rains when households are still food insecure. Harvesting of young baobab leaves on the other hand coincides with the short rains when other traditional vegetables are able to sprout. This enhances and diversifies the nutritional values of foods consumed within households. These findings are similar to a study in Benin where baobab fruiting coincides with the season of food shortage (Buchmann *et al*. 2010). This implies that baobab edible parts are readily available when households have limited food supplies. Harvest and consumption of baobab edible parts during food shortage seasons is, however, low in Kilifi and Kitui counties. This finding is contrary to a study in Mali, where consumption of baobab increases in times of food scarcity (Dhillion & Gustad 2004). Baobab has also been used as a coping strategy during food emergency seasons (Gebauer & Luedeling 2013; Kehlenbeck *et al*. 2013). Baobab, therefore, has a great potential to be used in diversifying diets in addition to being a potential source of income during the lean season. This is an opportunity that has not been adequately exploited in the study area.

4.4.5 Contribution of baobab to household income

The commercial significance of baobab in the study region is largely unexploited. This is different from Malawi which is the largest exporter of baobab pulp to Europe (Sanchez, 2011), and in rural Cinzana, Mali where baobab fruit and leaf powder are sold to urban centres (Gustad *et al*., 2004). In addition, the monetary value of baobab products in the market was very low compared to the average price of other food products. This is also different from other regions in Sub-Saharan Africa where baobab pulp was among the highest priced product. In rural Cinzana Mali, for instance, the cost of baobab fruit powder was 6-10 times more than millet while the cost of baobab leaf powder was 3 times higher than the price of millet. (Shackleton & Gumbo 2010). The proportion of income from baobab compared to the total household’s income in this study was low. This finding is contrary to a study in South Africa, where sell of baobab fruits alone contributed to 38% of the total income among most non-timber forest crops (Venter & Witkowski, 2013). With the increasing baobab market value, households could use baobab as an alternate source of income.

4.4.6 Role of baobab in food security

Despite its relative abundance, baobab does not play a significant role in food security since populations in this habitats lack awareness and knowledge on its nutritional and commercial potential. In addition, perceived nutritional health problems arising from baobab consumption reduces its utilization. Being marginalized agricultural areas, there is need to shift from overreliance of staple food to use of indigenous crops that are drought tolerant such as baobab. Increased utilization of baobab would improve household food security and consequently the nutritional status of household members since uses of baobab such as consuming it fresh, using it as a soup thickener and in fermenting coconut milk were shown to significantly increase food security status of households. There is a large potential of baobab use in diversified value added products that can significantly increase food security and household income.

4.5 Conclusion

In spite of Kitui and Kilifi counties of Kenya being endowed with baobab trees in abundance and the majority of the households having access to these trees, its subsistence use is low, and commercial use has remained largely unexploited. Use of baobab has further been limited by negative cultural beliefs and myths attached to this tree. The baobab, therefore, plays no significant role in food security. It is therefore necessary that communities living along the baobab belt be sensitized on the significant potential roles of the baobab tree so as to increase its use and tap on the benefits associated with the baobab tree.

CHAPTER 5

DEVELOPMENT, NUTRITIONAL AND SENSORY EVALUATION OF A BAOBAB FRUIT BASED READY-TO-EAT SORGHUM AND COWPEA BLEND SNACK BAR

Abstract

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.

5.1 Introduction

With the marked change in dietary patterns, the dietary concerns of today`s population who are defined by fast-paced lifestyles is facilitated by the availability of nutritious, affordable, palatable, and easily consumed convenience foods such as snacks (Mattes, 2018). Sale of snacks is estimated to exceed US$630 billion by 2020 globally. In the Mediterranean and Nordic countries, snacks contribute 14% and 29% of the total energy, respectively (Mattes, 2018). American children and adolescents get approximately a quarter of their daily energy from snacks (Hess *et al*., 2017). The growth of snack sales though smaller in developing countries in Africa, Latin America, Asian Pacific and Middle East compared to western nations, is steadily increasing. On the negative side, snacking has been associated with adiposity, high body mass index and poor diet quality because of high sugar, sodium and saturated fats. It poses greater concerns especially in environments where obesity and overweight are prevalent (Hess *et al*., 2017). However, snacking like any other dietary behaviours can be practised in a manner that is healthful.

With the increasing demand for energy and protein in supporting the rapidly increasing population, researchers have expanded their focus from the traditional staple foods and are exploring new and non-conventional sources of foods, particularly those that are tolerant to arid and semi-arid regions. These can be prepared as snacks, a form that is widely acceptable by most populations. Kilifi and Kitui counties of Kenya are arid and semi-arid regions characterized by a high prevalence of malnutrition and food insecurity. These counties, however, host a huge population of the baobab trees (Adam, *et al*., 2016). Households in the area also grow sorghum and cowpea (Kitui County Government, 2013). These are drought tolerant crops that have remained largely underutilized in these regions despite their nutritional and economic importance.

Sorghum is a gluten free cereal indigenous to Kenya (Kilambya & Witwer, 2013). It is rich in dietary fibre, minerals and phenolic compounds (Dlamini & Sciences, 2016). Its cultivation, demand and use have, however, been declining over time since there are no alternative uses. Sorghum grain is mainly consumed by households as ground flour used as a base in making ugali and porridge. In recent years the demand for sorghum has grown in the beer production industry (Kilambya & Witwer, 2013). A variety of ready-to-eat value added snacks have been mainly prepared from wheat, corn and rice. Use of sorghum in snacks is one area that has not been explored given that it is generally easier for most people to consume snack foods rather than other types of complementary foods.

Popping is one of the easy and economical processing methods that can be used in the preparation of ready-to-eat snacks from sorghum. It involves the use of high temperature short time (HTST) treatment. Popped products have a high keeping quality due to a significant decrease in moisture content. In addition to improving the shelf life of products, popping also serves in improving the nutritional quality of products particularly through making some nutrients bioavailable. During popping the bran is mainly retained giving rise to a crunchy snack item that is well aerated with desirable sensory qualities (Gundbboudi, 2006).

Sorghum complements well with leguminous protein sources to prepare nutritionally balanced composites of high biological value (Pradeep *et al*., 2014). Cowpea is a valuable protein source that is vital in most diets particularly in developing countries (Phillips *et al*., 2003). They are a good source of minerals, vitamins and dietary fiber. In addition, cow pea is rich in lysine essential amino acids though deficient in sulphur containing amino acids (Dlamini & Sciences, 2016). In recent times food product developers have incorporated legumes into traditional cereal formulations. This combination produces a complementary nutrient diversified cereal formulation that may reduce the incidence of protein energy malnutrition (PEM) among vulnerable groups (Usman & Okafor, 2016).

Preparation methods of most snacks such as popping and baking involve use of high temperatures that destroy heat labile vitamins such as vitamin C. The remarkably high content of vitamin C in baobab pulp (337 mg /100g pulp) shows it has good potential for use in incorporating in snack based food products after heat processing to enhance the vitamin C content. Besides Vitamin C, the baobab pulp is low in fat and high in fibre (about 50 g/100 g). The baobab pulp is low in protein but has a good amino acid profile and it is a good source of calcium 295-300µg/100g, phosphorus 96-210mg/100g, iron 7mg/100g, zinc 0.064mg/100g and manganese 2.07 mg/100g (Braca *et al*., 2018).

The use of these ingredients in developing a healthy ready-to-eat snack bar may increase their utilization and consequently improve household's food security, income and nutritional status. This study, therefore, aimed at formulating and analysing the physical, nutritional and sensory attributes of a baobab based ready-to-eat sorghum and cowpea blend snack bar.

5.2 Materials and methods

5.2.1 Preparation of raw materials

White low tannin sorghum (*Sorghum bicolour L. Moench*) was obtained from a farm in Jomo Kenyatta University of Agriculture and Technology (JKUAT). Cowpea (Vigna unguiculata) was procured from a farm in Thika town while honey was procured from a bee-keeping farm in Kitui. Baobab fruits were obtained from randomly selected households that were interviewed during the field survey. Sorghum grains were cleaned and boiled for 2 minutes. They were then tempered in cold water at room temperature for 3 hours and dried in the oven at 60° C for 30 minutes cooled and popped over high heat and stored in airtight containers. White cowpeas were cleaned and soaked for 12 hours. The grains were then cooked for 15 minutes and baked in an oven at 220° C for 30 minutes. They were then cooled and stored in airtight containers. Baobab pulp was prepared using the Ndabikunze *et al*., (2011) method with an additional step that involved scrubbing and cleaning the baobab shell before cracking open the fruit.

5.2.2 Formulation of the RTE snack bar

Popped sorghum, baked cowpeas and baobab pulp powder were blended in five different proportions as shown in Table 5-1 to produce RTE snack bars (see Figure 5-1). The baobab substitution levels were based on suggestions from other studies (Biosci *et al*., 2013; Koffi *et al*., 2013). However, the 25% substitution was not included because of the astringent nature of baobab that could result in a bitter undesirable taste in the snack. These substitutions also ensured that baobab could meet the daily requirement for vitamin C. Sorghum and cowpea composite was formulated in proportions that provided more than half of the total energy, carbohydrate and protein daily requirement for children and adolescents with the help of the USDA National Nutrition Database.

Figure 5-1: (a) Popped sorghum, (b) baked cowpea, (c) Ready to eat snack bars

Table 5-1: Formulation of the ready to eat snack bar

Sample ID	Sorghum pops (%)	Cowpeas (%)	Baobab (%)	Unit cost of input materials (Ksh)
RTEs1	45	55	0	20.10
RTEs2	50	45	5	21.15
RTEs3	55	35	10	22.20
RTEs4	60	25	15	27.45
RTEs5	65	15	20	24.30

5.2.3 Preparation of the RTE snack bar

The high-energy snack bar was prepared by mixing popped sorghum grain and baked cowpeas in the stated proportions in a bowl. Melted honey was poured into the mixture and stirred until the honey cooled. Baobab powder was then sprinkled and the mixture stirred again. The mix was then compacted in a pan lined with greased paper and allowed to take the shape of the pan. The bar was cut into desired shapes and sizes and packaged.

Mix popped sorghum and baked cow pea in given proportions

↓

Add 100g of melted honey and stir until cool

↓

Sprinkle baobab powder and stir again

↓

Compact the mix in a greased pan and leave to set and shape for 10 minutes

↓

Slice into desirable shapes and package

Figure 5-2: Preparation of the RTE snack

5.2.4 Sensory evaluation of the RTE snack bar

The cereal bar was assessed by 30 panelists between the age of 22 and 45 years. The panel consisted of undergraduate and graduate students from the Department of Food Science and Technology. A 9-point hedonic scale questionnaire (1= dislike extremely, 9 = like extremely) was used to evaluate the colour, flavour, taste, texture and overall acceptability. The products from different formulations were served dry. Portable water was provided for rinsing the mouth after tasting each sample to minimize error and masking of sensory attributes (Lim, 2011).

5.2.5 Physical and chemical characteristics of the RTE snack bar

The ready-to-eat snack was ground into flour of particle size less than 250 μm and analysed.

Color: The color measurement for the RTE cereal snack was determined using hunter lab color difference meter (Minolta, Chroma Metre CR-200; Minolta Camera Co., Ltd., Osaka, Japan). Standardization of the instrument was done prior to sample measurement of color by using a white and black ceramic plate. Color measurements were done in triplicate at different positions of the sample. The procedure was repeated to get six values that were averaged. The values for L*, a* and b* were recorded for each sample portion produced by taking the color for three section readings of the sample. Measurement of three sections of the sample was done by placing over 8 mm aperture of the sample measurement port of the colorimeter. Values displayed on the color meter screen as L* for lightness/darkness (100 perfect lightness, 0 for black), a* for chromaticity from red (+) to green (-) axis and b* for chromaticity from yellow (+) to blue axis (-) were used for calculating the Hue angle using the equation Hue angle = [tan-1(b*/a*)] (Ahmed, Ramaswamy, & Hiremath, 2005).

Instrumental texture analysis: The texture analyses of the different formulations were determined using the TA.TX2 type Texture Analyser (Stable Microsytems, Godalming, UK). The maximum compression force of extruded snacks was used to measure the hardness when cutting through a blade. A vertical force was applied to the snack diameter at a crosshead test speed of 500mm/min and distance of 0.50 mm. The maximum peak force was recorded. The higher the maximum peak forces the harder the snacks.

Bulk density: Bulk density of the samples was determined using the method described by Onwuka (2005). Each sample was filled into a l0ml measuring cylinder. The bottom of the cylinder was gently tapped on a laboratory bench until there was further diminution of the sample after filling to l0ml mark. Bulk density was estimated as mass per unit volume of the sample (g/ml).

Water activity: The water activity for the cereal snack was established using hygropalm-HP23-AW-A-portable water activity analyzer (Rotronic AG, Bassersdorf Switzerland). The samples with established moisture contents were sealed in a ziplock bag that ensured an airtight condition. About 5 grams of the sample was put into a sample cup. The water activity meter was set at AwQuick mode where sealed samples were kept at relatively constant temperature (22±3°C) for 5 minutes that allowed temperature conditions of the sample and the probe to be stabilized before the displayed a_w reading was recorded.

Moisture content: The moisture content was determined according to the methods of AOAC 2000. About 5 g of fresh sample was weighed and placed in a clean dry moisture dish and the weight of the sample and dish taken. These were placed in a moisture oven and the temperatures adjusted to 105^0C. The samples were dried for 3 hours and removed, cooled and weighed. The amount of moisture in the samples was calculated using the formula:

$$\%\, moisture = \frac{W1 - W2}{W3} * 100$$

W_1= weight before drying; W_2= weight after drying; W_3= sample weight

Ash content: The ash contents of the samples were determined using muffle furnace according to the method of AOAC (2000). About 5 g of fresh sample was weighed into a clean and weighed crucible, and charred by heating in a fume hood till smoking ceased. The charred samples were then transferred to a muffle furnace and temperature increased gradually to 550^oC. The samples were then allowed to ash for about 5 hours. The temperature was reduced, samples removed and cooled in a desiccator before weighing. The amount of ash was calculated using the formula:

$$\%ash = \frac{W1 - W2}{W3} * 100$$

W_1 = weight of crucible with ash; W_2 = weight of empty crucible; W_3 = sample weight

The total energy value of the three formulations was determined according to the method of Mahgoub (1999) using the formula as shown.

Total energy (kcal/100g) = [(%carbohydrates *4) + (% protein *4) + (% fat *9)]

Crude fibre content: About 2g of samples was weighed and put into 200ml of 1.25% of H_2SO_4 and boiled for 1hr. The solution and the content were then poured into Buchner funnel equipped with glass wool. This was allowed to cool then filtered. The residue was boiled in 200ml NaOH for 1 hr, and then transferred to the Buchner funnel and filtered. It was washed twice with alcohol and thrice with petroleum ether. The residue obtained was aired in a clean dry crucible and dried in the moisture extraction oven to a constant weight for 1 hour. The crucibles were removed, cooled and weighed. The crucibles were placed in a muffle furnace for 1hour, removed, cooled and weighed. The difference in weight (i.e. loss in ignition) was recorded as crucible fibre and expressed in percentage crude fibre.

$$\%\ \text{Crude fibre} = \frac{\text{W1} - \text{W2}}{\text{W3}} * 100/1$$

Where, W_1 = weight of sample before incinerate; W_2 = weight of sample after incineration; W_3 = weight of original sample.

Crude protein: Protein was determined using the semi micro Kjeldal method, (AOAC, 2000). Approximately 2 g of sample was weighed into a digestion flask together with a combined catalyst of 5 g potassium sulphate and 0.5 g of copper sulphate and 15 mL of sulphuric acid. The mixture was heated in a fume hood till the digest color turned blue. This signified the end of the digestion process. The digest was cooled, transferred to 100 mL volumetric flask and topped up to the mark with deionized water. A blank digestion with the catalyst was also made. About 10 mL of the diluted digest was transferred into the distilling flask and washed with distilled water. 15 mL of 40% NaOH was added and this also washed with distilled water. Distillation was done to a volume of about 60ml distillate. The distillate was titrated using 0.02 N HCl to orange color of the mixed indicator, which signified the end point.

$\%N = (V_1 - V_2) * N * F * 100 / (V * 100/S)$

Where: V_1 is the titre for sample in ml, V_2 is titre for blank in mL; N= normality of standard HCl (0.02); f= factor of std HCL solution; V= volume of diluted digest taken for distillation (10 mL); S= weight of sample taken for distillation (1 g);

% Protein= nitrogen* protein factor (6.25)

Minerals: Analyses of minerals were done by dry ashing and atomic absorption spectrophotometry (AAS), according to AOAC, (2000); Osborne and Voogt, (1978). Clean dry crucible was weighed and about 5 grams of sample weighed into it. The crucibles were placed on a hot plate under a fume hood and the temperature increased slowly until smoking cease and the samples were thoroughly charred. They were then put in muffle furnace and temperature increased gradually to 250^0 and heated for 1 hour. The temperature was increased to 550^0 and incinerated for about 5 hours. The temperature was then decreased to $300^{0,}$ the crucibles removed and cooled to room temperature. The ash was transferred quantitatively to 100 ml beaker using 20 mL of 1N HCl and filled to the mark using 1N HCl. Atomic Absorption Spectrophotometer (AAS) was used to read the absorbance of the solutions. The various mineral standards were also prepared to make the calibration curve.

Vitamin C: The determination of vitamin C was done by the method described by Vikram, Ramesh, & Prapulla, (2005) with minor modifications. About 2g of the dried cereal snack was extracted with 30ml 0.8% Metaphosphoric acid. The extract was centrifuged at 10, 000 rotations per minute for 10 minutes at $4^{O}C$ temperature. The supernatant was filtered through a Whatman filter paper no.4. About 1 ml of the solution was filtered into vials using 0.450 Millipore filter. About 20µl of the extract was injected into the HPLC.

5.2.6 Statistical analysis

The results were subjected to statistical analysis of variance (ANOVA), using R Studio statistical package 1.0.6. R Core Team (2013). The significant difference between means was determined by the Tukey test, at $p<0.05$. Descriptive statistics of means and standard deviations were also calculated. A graph showing the percentage RDIs that two servings of the snack could meet for children (6-8 years), adolescents boys and girls (9-13 years) and female and male adults was drawn using nutrient reference from FAO/WHO/UNU 2015 and the (National Health and Medical Research Council, Australian Government Department of Health and Ageing, & New Zealand Ministry of Health, 2006).

5.3 Results and discussion

5.3.1 Physical characteristic of the RTE snack bars

Table 5-2: Colour properties of the RTE snack bars

Sample ID	Colour				
	L*value	a*value	b*value	Hue Angle	Chroma
RTEs1	65.64±8.55	1.17±0.92	15.62±4.37	85.72±3.10	15.66±4.39
RTEs2	64.58±7.28	0.71±0.60	14.33±1.80	87.16±2.47	14.35±1.69
RTEs3	68.29±5.22	1.03±0.85	17.01±1.55	86.54±2.85	17.04±1.53
RTEs4	64.00±8.14	0.91±0.86	15.21±3.44	86.58±3.00	15.24±3.44
RTEs5	67.89±6.29	0.97±1.03	17.48±2.87	86.82±2.60	17.51±2.87
P values	0.56	0.89	0.29	0.98	0.08

Means values of triplicates with different superscripts in the same column indicate significant difference ($p<0.05$). ANOVA; Means separated by Tukey`s honest significant difference method; RTEs-Ready to Eat Snack

The snack bars L*values ranged between 64.00±8.14 and 67.89±6.29. Redness (a*) of the snack bars ranged from 0.71±0.6 to 1.17±0.92 while yellowness (b*) ranged from 14.33±1.8 to 17.48±2.87 as shown in Table 5-2. Creamy white sorghum variety (*Sorghum bicolour L. Moench*) was used in the formulation of the snacks (Gundbboudi, 2006). This could explain the lightness in the RTE snack bars. The dark speck in the snack bars has been associated with the cereal-legume composite. Cowpea is a legume with a good amino acid profile with notably high proportions of lysine. During boiling and baking, proteins undergo Maillard browning reaction characterized by a dark colour in cowpea and consequently the snack bars (Hallén et al., 2004). A hue angle of between 85.72 and 87.16 denotes the brown colour of the snack. This colour could be as a result of combining cowpea that had black specs with the light-greyish yellowish brown baobab powder. There was no significant difference in the intensity of the colour of the snack as denoted by the chroma values.

Table 5-3: Physical properties of the RTE snack bars

Sample ID	Water activity	Bulk density (g/ml)	Texture (Force N)
RTEs1	$0.48^{a}\pm0.00$	$0.27^{a}\pm0.02$	1.11±0.37
RTEs2	$0.49^{ab}\pm0.00$	$0.42^{b}\pm0.01$	1.47±0.55
RTEs3	$0.48^{a}\pm0.00$	$0.41^{b}\pm0.01$	1.15±0.12
RTEs4	$0.48^{a}\pm0.00$	$0.48^{ba}\pm0.01$	1.22±0.52
RTEs5	$0.47^{ba}\pm0.00$	$0.50^{ba}\pm0.03$	1.64±0.68
P values	<0.001	<0.001	0.64

Means values of triplicates with different superscripts in the same column indicate significant difference (p<0.05); ANOVA; Means separated by Tukey`s honest significant difference method; RTEs-Ready to Eat Snack

The physical properties of the snacks are as shown in Table 5-3. The water activity of the RTE snack bars was generally low. Its values ranged between 0.47±0.00 and 0.49±0.00. The low water activity was as a result of the conventional method of dry heat popping used in sorghum and baking used in cowpea. In both preparation methods, high temperatures that result in the loss of sufficient amounts of water from the snack were used. Removal of sufficient water from a food system is accompanied by a decrease in the equilibrium relative humidity (ERH). The shelf life of foods relies more on the ERH as a measure of the water content available for microorganisms hence provides an indicator for the biological activity of the product. Water activity is crucial in product keeping quality since below 0.65, bacteria, yeasts and mold growth are suppressed (Belessiotis & Delyannis, 2011). Additionally, water activity has been shown to influence physical-chemical alterations that occur during food processing (Ramos & Stringheta, 2014). The bulk density of the cereal bars ranged between 0.27±0.02g/ml to 0.5±0.003g/ml. Sorghum grain, one of the ingredients of the snack, has a low bulk density of between 0.77 and 0.83 g/ml (Gundbboudi, 2006). This density is further reduced during popping due to loss of moisture content. Low bulk density indicates the fluffy nature and the lightweight of a snack. A significant increase in bulk density was observed on addition of baobab. Texture values ranged from 1.11±0.37 N to 1.64±0.67 N. The low cutting force is an indication that the snack was not hard. This is in agreement with the sensory evaluation of the snack where the mean texture was between 55.7±01.51N and 6.33±1.58N. Expansion of sorghum during popping greatly influenced the crispiness and reduced the hardness of the snacks. The high protein in the snacks which was as a result of the addition of cowpea could expect the snack to be harder since high protein content hinders starch expansion (Dlamini & Sciences, 2016). This hardening was probably offset by the addition of fine particles of ground baobab pulp. In addition, the low fibre content (<2.76g/100g) in the snack could have reduced its hardness. The high fibre content in snacks has been shown to increase its hardness due to the disruption of its continuous structure that impend the elastic structure during expansion (Dlamini & Sciences, 2016).

5.3.2 Proximate composition of cereal snack bar

Table 5-4: Proximate composition of the formulation of the cereal snack bar

Sample ID	% Moisture	% Protein	% Ash	% Fat	% Crude Fibre	% Carbohydrate	Energy (KJ)
RTEs1	9.48±0.04	16.08^{a}±1.63	1.87^{a}±0.10	3.14±0.21	2.76^{a}±0.02	66.27^{a}±2.79	1502.71±43.70
RTEs2	9.49±0.01	21.35^{b}±0.89	2.26^{ab}±0.40	3.20±0.26	2.38^{ab}±0.32	61.1^{a}±3.32	1503.93±54.36
RTEs3	9.46±0.01	14.07^{ac}±0.45	1.52^{ac}±0.07	3.26±0.13	2.02^{bcd}±0.15	69.78^{ab}±1.28	1524.06±30.47
RTEs4	9.43±0.02	12.28^{cd}±0.50	1.36^{ac}±0.02	2.00±0.03	1.59^{c}±0.12	73.25^{b}±0.31	1507.88±1.88
RTEs5	9.49±0.02	11.38^{d}±0.35	1.33^{c}±0.03	2.52±0.19	2.36^{ad}±0.23	73.00^{b}±0.12	1505.79±0.78
P values	0.52	<0.001	<0.001	0.837	<0.001	<0.001	0.935

Means values of triplicates with different superscripts in the same column indicate significant difference ($p<0.05$). ANOVA; Means separated by Tukey`s honest significant difference method; RTEs - Ready to Eat Snack

The proximate composition of the cereal snacks is as shown in Table 5-4. There was no significant difference in the moisture content of all formulations. It ranged from 9.43±0.006% to 9.5±0.041%. The conventional method of popping sorghum and baking cowpeas involves high temperatures resulting in reduced moisture content in the end product. Low moisture content increases shelf-life stability of the snack making it microbiologically safe (Dlamini & Sciences, 2016). In addition, low moisture content gives the snacks a crunchy texture and a low bulk density (Pradeep *et al*., 2014).

Crude protein in the formulations was high. It`s content significantly varied between 11.38±0.35g/100g and 21.35±0.89 g/100g. The use of high protein legume, cowpea, enhances the protein quality of the RTE snack bar. A decrease in the proportion of cowpea in the formulation thus resulted in a decrease in the protein content of the snacks. Cowpeas are a vital component in many diets in developing countries in Africa located in the arid and semi-arid regions, particularly because of its high tolerance to harsh climates. They are a good source of lysine amino acids. They are, however, deficient in sulphur containing amino acids. Compositing cowpeas and sorghum improves its protein quality (Dlamini & Sciences, 2016). This is important in addressing issues of protein energy malnutrition (Pradeep *et al*., 2014).

Crude ash content of the five formulations was low. It significantly varied between 1.33±0.03g/100g and 2.26±0.40g/100g. Cowpeas have high ash content (3.2%) (USDA, 2014). A decrease in crude ash content with decreasing proportions of cowpea in the formulations was thus observed. The crude fat content of the snacks ranged between 2±0.03 g/100g and 3.26±0.13 g/100g. Sorghum (3.43%) has a higher fat content than cowpeas (1.26%) and baobab (0.47%) (USDA, 2014). Substituting sorghum with cowpeas and baobab reduced the proportion of sorghum used in the preparation of the snack. This consequently reduced the fat content of the snack. Low fat content in this snack is desirable especially with a health conscious population that tends to omit snacks that for a long time have been associated with foods that are high in saturated fats. The presence of linoleic fatty acids in significant amounts in baobab pulp used in this snack makes the snack healthy (Bamalli, 2014). Linoleic is a polyunsaturated n-3 fatty acid which is essential in diet and has potential effects in reducing the aetiology of chronic diseases (National Health and Medical Research Council *et al*., 2006). Fat is the major contributor to energy because one gram fat is equivalent to 37 kJ whereas one gram of carbohydrates or proteins is equivalent to only 17 kJ (FAO, 2003).

Crude fibre content ranged from 1.59±0.12 g/100g to 2.76±0.02g/100g. Sorghum (6.7%), cowpeas (10.6%) and baobab have high crude fibre content before being exposed to heat treatments. Popping and baking are high temperature process that has been shown to significantly reduce crude fibre content of this snack. Carbohydrates provide energy to the cells particularly the brain cells that require glucose for metabolism. Two serving of RTEs3 are able to meet the total RDI for children and adolescents and more than 50% in adult men and women as shown in figure 5-3. The energy content in the RTE bar was high. It ranged between 1502.71±43.7KJ and 1524.06±30.47KJ. Energy is crucial in maintaining the metabolic rate of the body, growth and synthesis of new tissues, muscular activity and physiological functions. The average daily energy intake and requirements for energy are based on physical activity, age, BMI, and BMR (FAO/ WHO/ UNU, 2007).

5.3.3 Mineral and Vitamin C composition of the RTE snack bars

Table 5-5: Mineral and Vitamin C content of the RTE snack bars

Sample ID	Vitamin C	Potassium	Iron	Magnesium	Zinc	Calcium
RTEs1	$9.77^{a}\pm0.10$	31.35±1.53	5.27±1.19	9.87±0.48	$2.76^{a}\pm0.14$	$6.04^{a}\pm0.33$
RTEs2	$13.74^{bc}\pm0.21$	32.42±0.93	5.09±1.48	10.10±0.45	$2.74^{a}\pm0.11$	$7.99^{ab}\pm0.53$
RTEs3	$21.16^{b}\pm2.03$	33.12±1.72	5.04±2.85	9.79±0.15	$2.47^{a}\pm0.50$	$8.59^{ba}\pm0.62$
RTEs4	$19.83^{b}\pm1.34$	28.64±2.94	5.76±1.78	9.74±0.76	$2.51^{a}\pm0.14$	$11.19^{b}\pm1.46$
RTEs5	$8.76^{b}\pm0.49$	27.87±1.47	4.34±1.80	9.23±0.75	$1.65^{b}\pm0.35$	$6.72^{a}\pm0.58$
P value	<0.001	0.021	0.925	0.47	0.005	<0.001

Means values of triplicates with different superscripts in the same column indicate significant difference (p<0.05). ANOVA; Means separated by Tukey`s honest significant difference method; RTEs-Ready to Eat Snack

The mineral and vitamin C composition of the RTE snack bars is as shown in table 5-5. A significant difference in vitamin C content in the five formulations was observed. The values ranged between 8.76±0.49g/100g and 21.16±2.03g/100g. Vitamin C increased with increasing baobab concentration. Preparation procedures of most snack foods involve the use of heat that results in the loss of vitamin C a heat labile vitamin. In the preparation of this snack, baobab pulp was added after all heating processes were completes. This ensured the retention of appreciable amounts of the vitamin which is vital in the human body (Braca *et al*., 2018). Vitamin C is an antioxidant with a significant role in the biochemical and molecular functions of the body. The vitamin interacts with other nutrients such as Iron and copper aiding its absorption. It has also been shown to prevent scurvy (National Health and Medical Research Council *et al*., 2006). A significant difference in potassium concentration was observed. The concentrations ranged between 27.87±1.47 g/100g and 33.12±1.72 g/100g.

Potassium is a key mineral in regulating cell water balance, construction of proteins and efficient use of carbohydrates in the body. In addition, it plays a key role in the activation of enzymes, membrane transport and muscle contraction. The Iron content of the snack ranged between 4.34±1.80g/100g and 5.76±1.78g/100g. Iron plays a significant role in the manufacture and functioning of haemoglobin. Iron also binds with myoglobin an essential protein in muscle oxygenation.

Iron deficiency results in anaemia, a condition that affects about 33% of women in their reproductive age and about one-quarter of children under five years globally (WFP-FAO, 2017). Magnesium content of the RTE snack bar ranged between 9.23±0.75g/100g and 10.1±0.45 g/100g. Magnesium is one of the most abundant minerals in the body. It plays a significant role in aerobic and anaerobic generation, in glycolysis as an enzyme activator and by the mitochondrion in carrying out oxidative phosphorylation, stimulating the immune system and relaxing the muscles. A deficiency in magnesium can cause high blood pressure, headaches and muscles problems such as contractures and cramps. Zinc concentration was statistically different in all the formulations of the snack bar. Its concentration ranged between 1.65±0.35g/100g and 2.76±0.14g/100g.

Zinc is important in maintaining the structural integrity of proteins and in regulating gene expression. It plays an important role in the development of the male sexual organ. A deficiency in Zinc will result in sterility among men (National Health and Medical Research Council, 2006). Calcium content varied significantly between the different formulations. Values ranged between 6.04±0.33 g/100g and 11.19±1.46 g/100g. Calcium plays a key role in the renewal of the skeleton, cardiac and muscular contractions, blood coagulation, and transmission of nerve impulse and in hormone release. A deficiency in calcium leads to osteoporosis, cardiovascular and joint problems.

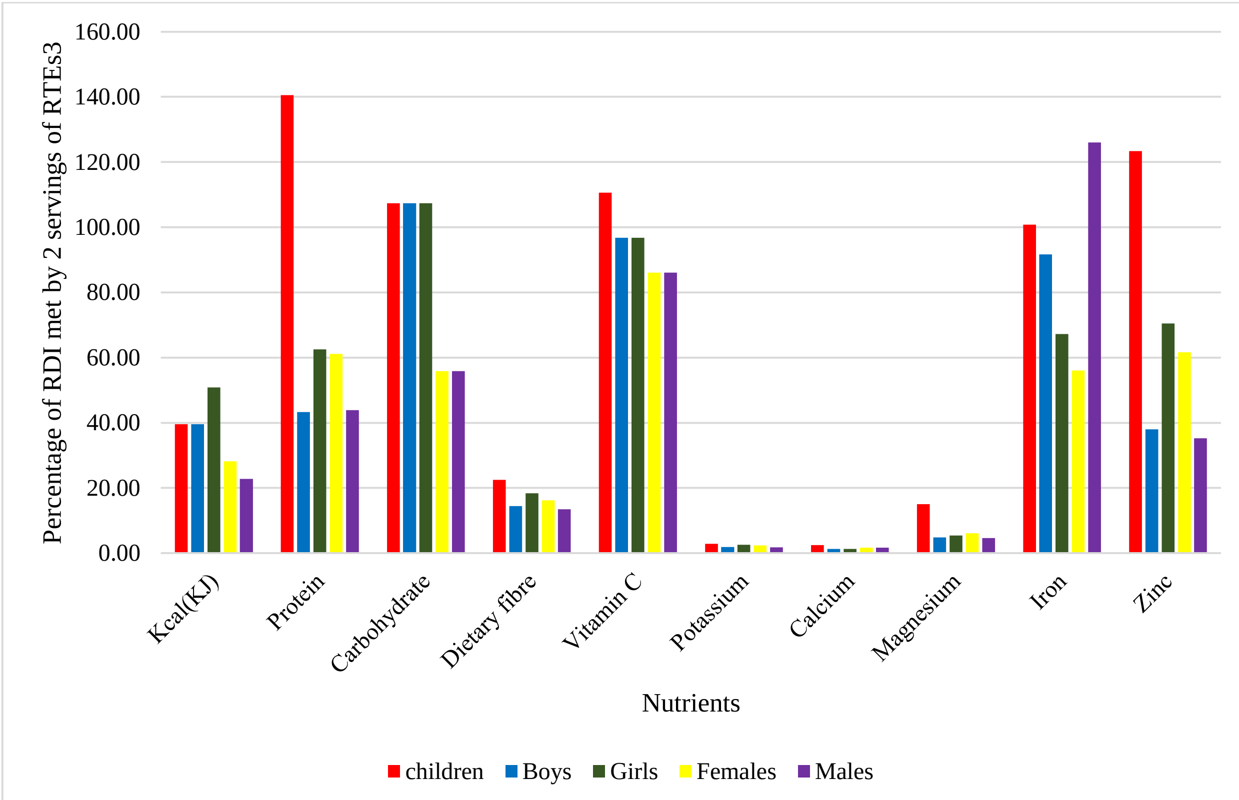


Figure 5-3: Percentage recommended daily intake that two serving of the RTE snack bar can meet

5.3.4 Sensory evaluation of the RTE snack bars

Table 5-6: Sensory evaluation of the RTE snack bar

Sample formulations	Appearance	Flavour	Taste	Texture	Overall Acceptability
RTEs1	6.57[a]±1.68	5.00±1.28	6.30±1.73	6.27±1.84	6.50±1.48
RTEs2	5.33[a]±1.45	5.00±1.47	6.03±1.40	6.07±1.84	5.93±1.67
RTEs3	6.17[b]±1.51	6.00±1.62	6.40±1.59	6.33±1.58	6.53±1.41
RTEs4	5.30[a]±1.39	5.00±1.46	6.40±1.04	6.03±1.61	6.17±1.18
RTEs5	5.03[ab]±1.73	5.00±0.00	5.93±1.28	5.70±01.51	5.90±1.39
P values	<0.001	0.47	0.6	0.63	0.26

Means ± SD; RTEs-Ready to Eat Snack

The hedonic scale approach was used to determine the sensory characteristic of the RTE snack bars. Consumer sensory testing of the snack bar is necessary for evaluating the level of liking of the snack bar. Such information is vital in evaluating and improving the snack bar that was the most liked. Results of the sensory evaluation of the snack are presented in table 5-6. There was no significant difference in all the attributes evaluated except in appearance where a significant difference was observed between RTEs1 and RTEs3 and RTEs5. Generally, snack bars with low baobab concentration were the most preferred. Formulation RTEs1 ranked best in terms of appearance. This did not contain baobab and was darker compared to other formulation. The difference in appearance could be attributed to the variation in baobab and cowpea concentrations in the different formulations.

Snack bars with high baobab quantities were lighter while snack bars with higher cowpea quantities were darker see figure 5-1. Another majority preferred RTEs3, which had 10% baobab powder. In terms of flavour, RTEs3 was the most preferred while

RTEs3 and RTEs4 were the most preferred in terms of taste. Popping imparts acceptable taste and desirable aroma in popped sorghum. Lower flavour and taste scores could be influenced by the beany flavour in cowpea after boiling and baking. This was also observed in the formulation of a sorghum cowpea complementary food for school aged children (Dlamini & Sciences, 2016). The snack without baobab (RTEs1) was the most preferred in terms of texture. The overall acceptability of all the formulations was greater than 5.5 giving an impression of a good quality product. The snack with 10% baobab (RTEs3) was the most preferred product while RTEs5 with the highest baobab concentration was the least preferred. The stringent taste in baobab has been shown to reduce it the consumption and acceptability of baobab based products.

Two serving of RTEs3 (snack with the highest sensory acceptability) snack are able to meet the total RDI for proteins among children less than 8 years, more than 50% among adolescent girls and women and more than 40% among adolescent boys and adult males. These are aslo able to meet about 40% RDI for carbohydrates for children and adolescent boys, more than 50% RDI for adolescent girls and between 22 % and 28 % for adult men and women. Two servings of RTEs3 are able to provide more than 80% of the total RDI for vitamin C required in the human body, less than 3% of the total RDI for potassium; the total RDI for Iron required by children, boys and men. Since the daily requirements for iron among girls and women are high, the snack is able to provide more than 50% of the total RDI; the total RDI of zinc among children less than 8 years, between 60% to 70% of the total RDI for female adolescents and adults and only 35% to 37% of total RDI among male adolescents and adults and between 1% and 3% of the total daily requirements for children and adults.

5.4 Conclusion

The drought tolerant crops such as sorghum and cow peas that are indigenous to Kilifi and Kitui counties and the multipurpose baobab fruit that occurs in abundance could serve to complement diets and increase the nutrient intake of households, particularly during food insecure periods when most staple foods fail and household's food stocks reduce. A ready to eat snack bar from sorghum, cowpea and baobab was accepted by most panellist. Popping and baking imparts acceptable taste and desirable flavour to sorghum and cowpea respectively. Complementing of cereals and legumes during processing of convenience food may contribute positively in addressing protein energy malnutrition in these regions. Use of baobab could increase it utilization and exploitation.

CHAPTER 6

GENERAL DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

6.1 General discussion

High rate of food insecurity in Kitui and Kilifi counties is partly as a result of overreliance on subsistence farming as the main source of livelihood among households despite the areas receiving unreliable rainfall which results in the decline of the harvest of the main staple foods, a decrease in household's food stocks and an increase in food prices (FEWS NET, 2017). The low dietary diversity of households and the high intake of readily available cereals accompanied by a legumes or vegetable and consequently low nutrient intake among children and caregivers would be influenced by poor social economic status, low purchasing power, inadequate availability and access to supplies which increases prices of food during famine (Rothman *et al*., 2018). This results in poor nutrition status among children and caregivers observed in the study region.

The present study presents to us the untapped role of the multipurpose baobab tree in the study region. The harvesting season for both leaves and fruits coincide with the food insecurity seasons in the two counties yet its use was still low. The market value in the counties was low contributing negligible income to households in the two counties. Lack of knowledge on the importance of baobab, the stringent taste and perceived health effects associated with the baobab tree greatly reduce its subsistence and commercial use leaving baobab largely unexploited a gap if well exploited could serve as a crucial nutrition source and improved food security status (Venter & Witkowski, 2013).

Formulation of RTE snack bars from a composite of unrefined sorghum cereal and cowpea and the addition of baobab gives rise to a readily acceptable product that is easy to consume and convenient for children, adolescents and even adults who are characterized by fast paced lifestyles. Complementing the snack improves its protein quality and increases its energy content. This serves to address the protein energy malnutrition, which is a global concern. In addition, the presence of vitamin C, zinc and Iron in the RTE snack bars, which are nutrients of concern among children and women, will reduce the deficiencies that arise from the lack of such nutrients. Desirable physical attributes such as colour, low water activity and low bulk density greatly influence the acceptability of snack by consumers.

6.2 General conclusion

Despite the relative abundance of the baobab tree and the majority of the households owning or having access to the tree, its subsistence and commercial use has remained largely neglected and unexploited. Households residing along the baobab belt in Kitui and Kilifi counties are thus characterized with high food insecurity, poor food consumption patterns and high prevalence of malnutrition among children and caregivers. Development of a ready-to-eat baobab based sorghum-cow peas snack would enhance the utilization of baobab tree products.

6.3 Recommendations

The high food insecurity and malnutrition status among children and caregivers call for nutrition intervention programmes. Stakeholders should create awareness and impart knowledge on the significant potential roles of the baobab tree in these communities. Processing and baobab value addition projects should be implemented. The baobab value chain should be developed and protected from unscrupulous people. Recipes that incorporate baobab products should be developed and households trained on how to incorporate them in their day-to-day diets. This study sets the stage for future research into whether household with access to baobab have better food security outcomes.

REFERENCES

Abdulkarim, S.M, Bamalli Z, G. M. . and K. R. (2014). Baobab Tree (Adansonia digitata L) Parts : Nutrition , Applications in Food and Uses in Ethno-medicine – A Review. *Austin Publishing Group*, *1*(3), 1–9. https://doi.org/10.13140/RG.2.1.1966.7602

Agbozo, F., Atitto, P., & Abubakari, A. (2017). Nutritional Status of Pupils Attending Public Schools with and without School Feeding Programme in Hohoe Municipality, Ghana. *Journal of Food and Nutrition Research*, *5*(7), 467–474. https://doi.org/10.12691/jfnr-5-7-3

Ahmed, J., Ramaswamy, H. S., & Hiremath, N. (2005). Original article The effect of high pressure treatment on rheological characteristics and colour of mango pulp. 885–895. https://doi.org/10.1111/j.1365-2621.2005.01026.x

Ali, S., Elmola, F., & Ibrahim, A. H. (2011). Contribution of Wild Fruits to Household Income and Food Security among Small Scale Farmers in West Kordofan State - Central-west of Sudan Sayed. 1–5.

Alipour, B., Farhangi, M. A., Asghari, S., Amirkhizi, F., Dahri, M., Abedimanesh, N., & Farsad-, A. (2016). Child-specific food insecurity and its sociodemographic and nutritional determinants among Iranian schoolchildren. 0244. https://doi.org/10.1080/03670244.2015.1129324

Aluko, A. E., Kinyuru, J., Chove, L. M., Kahenya, P., & Owino, W. (2016). Nutritional Quality and Functional Properties of Baobab (Adansonia digitata) Pulp from Tanzania. *Journal of Food Research*, *5*(5), 23. https://doi.org/10.5539/jfr.v5n5p23

Assogbadjo, A. E., Sinsin, B., Codjia, J. C., & Damme, P. V. A. N. (2017). Ecological diversity and pulp , seed and kernel production of the baobab (*adansonia digitata)* in Benin Author (s): Achille E . ASSOGBADJC , Brice SINSIN , Jean T . Claude CODJIA and Patrick VAN Source *: Belgian Journal of Botany , Vol . 138 , No . 1 (. 138*(1), 47–56.

AU. (2012). African union union africaine união africana. *Science And Technology*, *6*(April), 1–5.

Awel, A. A., Lema, T. B., & Hebo, H. J. (2016). Nutritional status and associated factors among primary school adolescents of pastoral and agro- pastoral communities , Mieso Woreda , Somali Region , Ethiopia : A comparative cross-sectional study. *Journal of Public Health and Epidemiology*, *8*(November), 297–310. https://doi.org/10.5897/JPHE2016.0824

Belessiotis, V., & Delyannis, E. (2011). Solar drying. *Solar Energy*, *85*(8), 1665–1691. https://doi.org/10.1016/j.solener.2009.10.001

Béné, C., & Heck, S. (2005). Fish and Food Security in Africa. *NAGA*, *WorldFish Center Quarterly*, *28*(3), 8–13.

Bickel, G., Nord, M., Price, C., Hamilton, W., & Cook, J. (2000). Guide to Measuring Household Food Security Revised 2000. *Agriculture*, 1–76. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Guide+to+Measuring+Household+Food+Security+Revised+2000#0

Biosci, I. J., V, N. K. P., Kouakou, B., Gildas, G. K., Thierry, A., & Dago, G. (2013). Quality characteristics of biscuits made from sorghum and defatted Macrotermes subhyalinus. *International Journal of Biosciences* |, *3*(1), 58–69.

Braca, A., Sinisgalli, C., De Leo, M., Muscatello, B., Cioni, P. L., Milella, L., … Sanogo, R. (2018). Phytochemical Profile, Antioxidant and Antidiabetic Activities of Adansonia digitata L. (Baobab) from Mali, as a Source of Health-Promoting Compounds. *Molecules, 23*(12), 3104. https://doi.org/10.3390/molecules23123104

Caluwe, E. De, Smedt, S. De, Assogbadjo, a E., Samson, R., Sinsin, B., & Damme, P. Van. (2009). Ethnic differences in use value and use patterns of baobab (*Adansonia digitata* L.) in northern Benin. . *African Journal of Ecology*, *47*(3), 433–440. https://doi.org/10.1111/j.1365-2028.2008.01023.x

Chadare, F. J., Gayet, D. P., Azokpota, P., Nout, M. J. R., Linnemann, A. R., & Boekel, M. A. J. S. Van. (2010). Three Traditional Fermented Baobab Foods from Benin , Mutchayan , Dikouanyouri , and Tayohounta : Preparation , Properties , and

Consumption. *0244*(December 2017). https://doi.org/10.1080/03670244.2010.491051

Chadare, F. J., Linnemann, a R., Hounhouigan, J. D., Nout, M. J. R., & Van Boekel, M. a J. S. (2008). Baobab food products: a review on their composition and nutritional value. *Critical Reviews in Food Science and Nutrition*, *49*(3), 254–274. https://doi.org/10.1080/10408390701856330

Chakona, G., & Shackleton, C. M. (2018). Household Food Insecurity along an Agro-Ecological Gradient Influences Children's Nutritional Status in South Africa. *Frontiers in Nutrition*, *4*(January). https://doi.org/10.3389/fnut.2017.00072

Christine, B., Prehsler, S., Hartl, A., & Vogl, C. R. (2010). The importance of baobab (Adansonia digitata l.) in rural west african subsistence-suggestion of a cautionary approach to international market export of baobab fruits. *Ecology of Food and Nutrition*, *49*(3), 145–172. https://doi.org/10.1080/03670241003766014

Clover, J. (2003). Food Security in Sub-Saharan Africa. *African Security Review*, *12*(1), 5–15. https://doi.org/10.1080/10246029.2003.9627566

da Silva Lopes, K., Ota, E., Shakya, P., Dagvadorj, A., Balogun, O. O., Peña-Rosas, J. P., … Mori, R. (2017). Effects of nutrition interventions during pregnancy on low birth weight: an overview of systematic reviews. *BMJ Global Health*, *2*(3), e000389. https://doi.org/10.1136/bmjgh-2017-000389

Danquah, A. O., Amoah, A. N., & Opare-obisaw, C. (2013). Nutritional status of upper primary school pupils in a rural setting in Ghana. *2*(6), 320–326. https://doi.org/10.11648/j.ijnfs.20130206.19

Demos, V., & Segal, M. T. (2016). Introduction to gender and food: from production to consumption and after. *Advances in Gender Research*, *22*, xiii–xxxiii. https://doi.org/10.1108/S1529-212620160000022009

Dlamini, N. P., & Sciences, A. (2016). Sensory and nutritional quality of an extruded sorghum and cowpea blend as a complementary food for school age children. (June).

Einstein, A. (2005). Measuring Mortality , Nutritional Status and Food Security in Crisis Situations : the smart protocol Version 1 Final Draft Make everything as simple as possible but not simpler . (Jan), 1–109.

FAO (Food and Agriculture Organization). (2010). Guidelines for measuring household and individual dietary diversity. In *Fao*.

Fao, J., & Consultation, U. N. U. E. (2005). Human energy requirements. Scientific background papers from the Joint FAO/WHO/UNU Expert Consultation. October 17-24, 2001. Rome, Italy. *Public Health Nutrition*, *8*(7A), 929–1228. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16277811

FEWS NET (Famine Early Warning Systems Network), K. (2017). Kenya Food Security Outlook February to September 2017 Atypical high food insecurity expected through September. (September).

Fiorentino, M., Landais, E., Bastard, G., Carriquiry, A., Wieringa, F. T., & Berger, J. (2016). Nutrient intake is insufficient among senegalese urban school children and adolescents: Results from two 24 h recalls in state primary schools in Dakar. *Nutrients*, *8*(10), 1–17. https://doi.org/10.3390/nu8100650

Fischer, S. (2015). The baobab (Adansonia digitata L .) in southern Kenya Table of Contents. (March).

Gebauer, J., & Luedeling, E. (2013). A note on baobab (Adansonia digitata L.) in Kordofan, Sudan. *Genetic Resources and Crop Evolution*, *60*(4), 1587–1596. https://doi.org/10.1007/s10722-013-9964-5

Gebauer, Jens, Adam, Y. O., Sanchez, A. C., Darr, D., Eltahir, M. E. S., Fadl, K. E. M., … Kehlenbeck, K. (2016). Africa???s wooden elephant: the baobab tree (Adansonia digitata L.) in Sudan and Kenya: a review. *Genetic Resources and Crop Evolution*, *63*(3), 377–399. https://doi.org/10.1007/s10722-015-0360-1

Gebauer, Jens, Whitney, C. W., & Tabuti, J. R. S. (2016). First record of baobab (Adansonia digitata L.) in Uganda. *Genetic Resources and Crop Evolution*, *63*(5), 755–762. https://doi.org/10.1007/s10722-016-0387-y

Girard, A. W., Self, J. L., McAuliffe, C., & Olude, O. (2012). The effects of household food production strategies on the health and nutrition outcomes of women and young children: A systematic review. *Paediatric and Perinatal Epidemiology*, *26*(SUPPL. 1), 205–222. https://doi.org/10.1111/j.1365-3016.2012.01282.x

GNP. (2017). *Global Nutrition Report 2017: Nourishing the SDGs*. 115. Retrieved from https://www.globalnutritionreport.org/files/2017/11/Report_2017.pdf

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., … Toulmin, C. (2012). The Challenge of Food Security. *Science*, *327*(February), 812. https://doi.org/10.4337/9780857939388

Gundbboudi, Z. A. (2006). Nutritional and processing qualities of pop sorghum cultivars and value addition. *Department of Food Science and Nutrition, M.S.*

Gustad, G., Dhillion, S. S., & Sidibé, D. (2004). Local Use and Cultural and Economic Value of Products from Trees in the Parklands of the Municipality of Cinzana, Mali. *Economic Botany*, *58*(4), 578–587. https://doi.org/10.1663/0013-0001(2004)058[0578:LUACAE]2.0.CO;2

Haile, D., Nigatu, D., Gashaw, K., & Demelash, H. (2016). Height for age z score and cognitive function are associated with academic performance among school children aged 8-11 years old. *Archives of Public Health*, *74*(1), 1–7. https://doi.org/10.1186/s13690-016-0129-9

Hall, M. (2007). Baobab fruit. *Forest Ecology and Management*, (April), 26–28.

Hallén, E., Ibanoğlu, Ş., & Ainsworth, P. (2004). Effect of fermented/germinated cowpea flour addition on the rheological and baking properties of wheat flour. *Journal of Food Engineering*, *63*(2), 177–184. https://doi.org/10.1016/S0260-8774(03)00298-X

Hess, J., Rao, G., & Slavin, J. (2017). The Nutrient Density of Snacks. *Global Pediatric Health*, *4*, 2333794X1769852. https://doi.org/10.1177/2333794X17698525

Hodge, A., Patterson, A. J., Brown, W. J., Ireland, P., & Giles, G. (2000). The Anti Cancer Council of Victoria FFQ: Relative validity of nutrient intakes compared with weighed food records in young to middle-aged women in a study of iron supplementation. *Australian and New Zealand Journal of Public Health*, *24*(6), 576–583. https://doi.org/10.1111/j.1467-842X.2000.tb00520.x

INDDEX Project. (2018). Data4Diets : Building Blocks for Food Consumption Score *(FCS)*. *1*(August), 1–4.

Jacoby, G. (2012). “ Make everything as simple as possible , but not simpler ” Albert Einstein. (April), 1–129.

Jenkins, K. T., Benton, D., Tapper, K., Murphy, S., & Moore, L. (2015). A cross-sectional observational study of the nutritional intake of UK primary school children from deprived and non-deprived backgrounds: implications for school breakfast schemes. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 1–10. https://doi.org/10.1186/s12966-015-0238-9

Jensen, J. S., Bayala, J., Sanou, H., Korbo, A., Ræbild, A., Kambou, S., … Parkouda, C. (2011). A research approach supporting domestication of Baobab (Adansonia digitata L.) in West Africa. *New Forests*, *41*(3), 317–335. https://doi.org/10.1007/s11056-011-9246-z

Kaboré, D., Sawadogo-Lingani, H., Diawara, B., Compaoré, C. S., Dicko, M. H., & Jakobsen, M. (2011). A review of baobab (Adansonia digitata) products: Effect of processing techniques, medicinal properties and uses. *African Journal of Food Science*, *5*(16), 833–844. https://doi.org/10.5897/AJFSX11.004

Kariuki, L. W., Lambert, C., Purwestri, R. C., Maundu, P., & Biesalski, H. K. (2017). Role of food taboos in energy, macro and micronutrient intake of pregnant women in western Kenya. *Nutrition and Food Science*, *47*(6), 795–807. https://doi.org/10.1108/NFS-09-2016-0146

KDHS [Kenya Demographic Health Survey]. (2014). *Kenya*.

KFSSG. (2012). Kenya Food Security Steering Group *(KFSSG)*. 1–20. Retrieved from http://www.kenyafoodsecurity.org/index.php?option=com_content&view=article&id=71&Itemid=58

Kilambya, D., & Witwer, M. (2013). *Analysis of incentives and disincentives for Sorghum in Kenya. Technical note series.* (February), 23–30.

Kilifi County Integrated plan. (2017). Republic of kenya kilifi county first county integrated *Table of Contents*. 2013–2017.

Kitui County Climate Information Services Strategic Plan. (2015). *Kitui County Climate Information Services Strategic Plan*. (January).

Kitui County Government. (2013). Republic of Kenya County Government of Nandi County Integrated. *County Intergrated Development Plan (2013-2017)*, (August 2013), 4–7.

Koffi, N., Gildas, G. K., Avit, B., Thierry, A., Anglade, M. K., & Dago, G. (2013). Nutritional and sensory qualities of wheat biscuits fortified with defatted Macrotermes subhyalinus. *International Journal of Chemical Science and Technology*, *3*(1), 25–32.

Leach, H. B., van der Stege, C., & Vogl, C. R. (2011). Baobab (Adansonia digitata L.) and Tamarind (Tamarindus indica L.) Management Strategies in the Midst of Conflict and Change: A Dogon Case Study from Mali. *Human Ecology*, *39*(5), 597–612. https://doi.org/10.1007/s10745-011-9415-x

Lim, J. (2011). Hedonic scaling: A review of methods and theory. *Food Quality and Preference*, *22*(8), 733–747. https://doi.org/10.1016/j.foodqual.2011.05.008

Lumole, Z. S. (2013). Household dietary diversity and nutritional status of children and women of reproductive age in Madizini township and its hinterland villages. https://doi.org/10.1017/CBO9781107415324.004

Madjdian, D. S., & Bras, H. A. J. (2016). Family, Gender, and Women's Nutritional Status: A Comparison Between Two Himalayan Communities in Nepal. *Economic History of Developing Regions*, *31*(1), 198–223. https://doi.org/10.1080/20780389.2015.1114416

Mattes, R. D. (2018). Snacking: A cause for concern. *Physiology and Behavior*, *193*(January), 279–283. https://doi.org/10.1016/j.physbeh.2018.02.010

MCMullin, S., & Kehlenbeck, K. (2015). *Untapped potential of baobab*. (June), 16–17.

Morgan, K. E. (2015). The Cognitive Effects of Chronic Malnutrition and Environment on Working Memory and Executive Function in Children The Cognitive Effects of Chronic Malnutrition and Environment on Working Memory and Executive

Function in Children.

Mwaniki, A. (2006). Achieving Food Security in Africa: Challenges and Issues. *Strategies*, 1–12. Retrieved from http://www.food-security.nl/sites/default/files/resource/achieving_food_security_in_africa.pdf

National Health and Medical Research Council, Australian Government Department of Health and Ageing, & New Zealand Ministry of Health. (2006). Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes. Retrieved from https://www.nhmrc.gov.au/_files_nhmrc/file/your_health/healthy/nutrition/17599_nhmrc_nrv_update-dietary_intakes_0.pdf

Ndabikunze, B. K., Masambu, B. N., & Tiisekwa, B. P. M. (2011). The production of jam from indigenous fruits using baobab (Adansonia digitata L .) powder as a substitute for commercial pectin. *African Journal of Food Science*, *5*(March), 168–175.

NDMA, & Word Food Programme. (2017). KENYA Food Security Outlook June 2017 to January 2018 Poor 2017 long rains mark second consecutive season of drought. (January), 1–16.

Poole, N., Audia, C., Kaboret, B., & Kent, R. (2016). Tree products, food security and livelihoods: A household study of Burkina Faso. *Environmental Conservation*, *43*(4), 359–367. https://doi.org/10.1017/S0376892916000175

Pradeep, P. M., Dharmaraj, U., Sathyendra Rao, B. V., Senthil, A., Vijayalakshmi, N. S., Malleshi, N. G., & Singh, V. (2014). Formulation and nutritional evaluation of multigrain ready-to-eat snack mix from minor cereals. *Journal of Food Science and Technology*, *51*(12), 3812–3820. https://doi.org/10.1007/s13197-013-0949-3

Previato, H. D. R. de A., & Behrens, J. H. (2018). Nutritional status and food pattern of adolescents. *Nutrition and Food Science*, *48*(5), 846–855. https://doi.org/10.1108/NFS-05-2018-0130

Pulok, M. H., Sabah, M. N. U., & Enemark, U. (2016). Socioeconomic inequalities of child malnutrition in Bangladesh. *International Journal of Social Economics*, *43*(12), 1439–1459. https://doi.org/10.1108/IJSE-03-2015-0065

Ramos, A. M., & Stringheta, P. (2014). Drying curves and water activity evaluation of dried banana 1 . *Departamento de Tecnologia de Alimentos - Universidade Federal de Viçosa , 36 . 571-000 , Viçosa , MG , Brasil ; email : miltonc9@hotmail.com*. (January 2014).

Rothman, M., Ranneileng, M., Nel, R., & Walsh, C. (2018). Nutritional status and food intake of women residing in rural and urban areas of Lesotho. *South African Journal of Clinical Nutrition*, *0658*, 1–7. https://doi.org/10.1080/16070658.2017.1415783

Sanchez, A. C. (2011). The status of baobab tree populations in southern malawi: Implications for further exploitation. *Forests Trees and Livelihoods*, *20*(2–3), 157–173. https://doi.org/10.1080/14728028.2011.9756704

Sasson, A. (2012). Food security for Africa: an urgent global challenge. *Agriculture & Food Security*, *1*(1), 2. https://doi.org/10.1186/2048-7010-1-2

Shahraki, S. H., Amirkhizi, F., Amirkhizi, B., & Hamedi, S. (2016). Household Food Insecurity Is Associated with Nutritional Status among Iranian Children. *Ecology of Food and Nutrition*, *55*(5), 473–490. https://doi.org/10.1080/03670244.2016.1212710

Shumetie, A., & Alemayehu Yismaw, M. (2018). Effect of climate variability on crop income and indigenous adaptation strategies of households. *International Journal of Climate Change Strategies and Management*, *10*(4), 580–595. https://doi.org/10.1108/IJCCSM-04-2016-0039

Sidibe, M., Williams, J. T., Hughes, A., Haq, N., & Smith, R. W. (2004). *Adansonia digitata BAOBAB L.*

Sumarmi, S. (2016). Maternal Short Stature and Neonatal Stunting : an Inter-Generational Cycle of Malnutrition. *International Conference on Health and Well-Being (ICHWB)*, 265–272.

Supply, F. (2006). Food Security and Agricultural Development in Sub- Saharan Africa Building a case for more public support Policy Brief No . *1*. (1), 1–7.

Swindale, A., & Bilinsky, P. (2006). Household Dietary Diversity Score (HDDS) for measurement of household food access: Indicator guide. *Food and Nutrition Technical Assistance …*, 11. https://doi.org/10.1017/CBO9781107415324.004

TY, H., & MB, K. (2018). Metaphysical Analysis of the Nutritional and Therapeutic Value of Baobab (Adansonia Digitata L.). *Journal of Nutrition and Health Sciences*, *5*(1), 1–9. https://doi.org/10.15744/2393-9060.5.101

UN FAO. (2006). Food security. *FAO*, (2), 1–60. https://doi.org/10.1016/j.jneb.2010.12.007

Usman, G. O., & Okafor, G. I. (2016). Organoleptic properties and perception of maize , African yam bean , and defatted coconut flour- based breakfast cereals served in conventional forms. (2014). https://doi.org/10.1002/fsn3.336

Venter, S. M., & Witkowski, E. T. F. (2011). Baobab (Adansonia digitata L.) fruit production in communal and conservation land-use types in Southern Africa. *Forest Ecology and Management*, *261*(3), 630–639. https://doi.org/10.1016/j.foreco.2010.11.017

Venter, S. M., & Witkowski, E. T. F. (2013). Fruits of our labour: Contribution of commercial baobab (Adansonia digitata L.) fruit harvesting to the livelihoods of marginalized people in northern Venda, South Africa. *Agroforestry Systems*, *87*(1), 159–172. https://doi.org/10.1007/s10457-012-9532-6

Vikram, V. B., Ramesh, M. N., & Prapulla, S. G. (2005). Thermal degradation kinetics of nutrients in orange juice heated by electromagnetic and conventional methods. *Journal of Food Engineering*, *69*(1), 31–40. https://doi.org/10.1016/j.jfoodeng.2004.07.013

Weaver, C. M. (2014). Calcium supplementation: is protecting against osteoporosis counter to protecting against cardiovascular disease? *Current Osteoporosis Reports*, *12*(2), 211–218. https://doi.org/10.1007/s11914-014-0208-1

WFP-FAO. (2017). The State of Food Security and nutrition in the world.

WFP. (2016). Comprehensive Food Security and Vulnerability Survey: Summary report Kenya 2016. 1–12.

WHO. (2008). Steps in applying Probability Proportional to Size (PPS) and calculating Basic Probability Weights. (c), 1–5.

Zahrau Bamalli, A. S. M. H. M. G. and R. K. (2014). Baobab Tree (Adansonia digitata L) Parts : Nutrition , Applications in Food and Uses in Ethno-medicine – A Review. *Austin Publishing Group*, *1*(3), 1–9. https://doi.org/10.13140/RG.2.1.1966.7602

APPENDICES

Appendix 1: Consent form for caregivers

Introduction to the study

I am Momanyi Dorah kwamboka, a masters' student in Jomo Kenyatta University of Agriculture and technology. As a research student I seek to answer questions regarding the role of baobab in food security in Kilifi and Kitui. My main objective is to access the contribution of baobab to household food security and income. This two counties experience recurrent food insecurity episodes yet Baobab a super fruit with high nutritional value naturally exists in relative abundance even during lean periods.

Role in the study

The research seeks to involve you as a participant by answering an interviewer-administered questionnaire for 60 minutes. This is because we feel that your experience and response about the subject matter will give better insight on the above subject. If you agree to be part of this study, you will be asked to answer questions regarding your social demographic characteristics, consumption patters and cultural practices associated with consumption of food and baobab.

Precautions

Some of the questions asked may be too personal or may place you in a position where by you are not willing to answer. In such a case please, know that you are under no obligation to respond to any of such questions.

Benefits

If you agree to be part of this study you will be able to enjoy the benefits of learning new knowledge on the super fruit-baobab. You will also get a chance to be part of those who will help in improving the nutritional status of people in Kitui County by encouraging everyone to incorporate baobab in their meals. We value your thoughts and opinions in contributing to the success of this study.

Confidentiality and anonymity

If you agree to take part in this interview, your responses will remain confidential. That means all the information you give me will not be disclosed to anyone including other household members who did not take part in this interview. In case of publication of the results its important to note that your identity cannot be linked with your personal responses.

Voluntary participation

Remember you do not have to talk about anything you are not comfortable about. Your participation is entirely voluntary and no penalties are involved in the refusal to participate.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Dorah Momanyi 0721966880 or Victoria Nyutu 0721275003. In case of any ethics concerns as regard the project please write to The Chairman, MKUERC, P.O Box 342-01000

Consent

I have read this form and I agree to take part in this study,

Signature of Participant ____________________ Date ____________________________

Appendix 2: Parental consent for participation of your child

Introduction to the study

I am Momanyi Dorah kwamboka, a masters' student in Jomo Kenyatta University of Agriculture and technology. As a research student I seek to answer questions regarding the role of baobab in food security in Kilifi and Kitui. My main objective is to access the contribution of baobab to household food security and income. This two counties experience recurrent food insecurity episodes yet Baobab a super fruit with high nutritional value naturally exists in relative abundance even during lean periods.

Role in the study

Your child`s participation in this study will involve taking measurements of height, weight and Mid Upper Arm Circumference. This will take only ten minutes of their time.

Precautions

There are no known risks associated with this kind of procedures. The procedure will be carried out by well trained personnel.

Benefits

Information on your child measurements will you understand better the nutritional status of your child. This information will also be helpful in updating national and county statistics.

Confidentiality and anonymity

All information regarding your child`s anthropometric measurements will be kept confidential. Your child`s identity will not be revealed in publication resulting from this study.

Voluntary participation

Remember your child`s participation is entirely voluntary and no penalties are involved in the refusal to participate.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Dorah Momanyi 0721966880 or Victoria Nyutu 0721275003

Consent

I have read this form and I agree that my child will be part of this study,

Signature of caregiver ____________________ Date _____________________________

Signature of Child ____________________

Appendix 3: Questionnaire

Date: ______________________

Time (start): ______________________ ID Enumerator |__|__|

B. **LAND OWNERSHIP**		
8. Do you own any land?	0= no 1= yes	LND
8a. If yes in 8 above, how many hectares of land do you own?	Record.............Hectares	LNDACR
8b. If yes in 8 above, what acreage is under cultivation	Record..........Hectares	HACCULT
8c. During which times of the year do you cultivate your land?	1=All seasons 2=Long rains seasons 3=Short rain seasons 4=Dry seasons 5=Never cultivate	SSNCULT

A. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF CHILDREN BETWEEN 6-13 YEARS' OLD			
Question	**Response**	**Codes**	
1.Do you have a child in the age group 6-13yrs	0= no 1= yes	**CHILD610**	
2.NAME OF THE CHILD……………………… **3.Household code**…………………………………**..**	Record the household code	**HHCODE**	
4. When was {NAME OF THE CHILD} born? ***If the child was born before 2007, thank the mother for her time and end interview. The child needs to be between 6 and 13 years***	*Record year of birth……………* *Record the age*………… 88= don't know	CHILDYOB	
5. Sex *(Observe the sex of the child. If the child is not present ask the mother)*	1=Male 2=Female	CHILDSEX	
6. What is the relationship of {NAME OF THE CHILD} to household head?	1=Son 2=Daughter 3=Male relative 4=Female relative 5=No relatives	CHILDRRHH	
7. What is the highest level of education of {NAME OF THE CHILD}?	1=No formal schooling 2=Lower primary (1-3) 3=Upper primary(4-8)	EDULEVL	

8d. If yes in 19 above, what is the ownership of your land?	1=Owned by self 2=Leased 3=Owned by family 4=Squatter 5=Communal land 88=Don't Know 99=Others specify.......................	LNDOWNR
C. **FOOD AVAILABILITY**		
9a. What is your staple food during dry /rainy seasons? ***(select multiple answers)*** ***Note a staple food is a food that makes up a dominant part of your diet***	1=Maize 2=Beans → Which type of beans 3=Cassava 4=Sorghum 5=Millet 6=Pigeon Peas 7=Sweet Potatoes 8=Bananas 9=Cow peas 10=Green grams 88=Don't Know 99=Others specify.......................	STPLFD
9b. How do you obtain your main staple food during dry seasons?	1=Own production gathering, hunting, fishing 2=Purchase 3=Food aid 4= Borrowed, bartered, exchanged for labour, gift from friends or relatives	SRCMAINFDDRY
9c. How do you obtain your main staple food during rainy seasons?	1=Own production gathering, hunting, fishing 2=Purchase 3=Food aid 4= Borrowed, bartered, exchanged for labour, gift from friends or relatives	SRCMAINFDRAIN
10a. What is your main source of fruit during Dry/Rainy seasons? ***(select multiple answers)***	1=Baobab 2=Mango 3=Treetomato 4=Pawpaw 5=Watermelon 6=Avacado 7=Castor Fruit 88=None	STPLFRUIT

	99=Others specify.......................	
10b. How do you obtain your main fruits during dry seasons?	1=Own production gathering, hunting, fishing 2=Purchase 3=Food aid 4= Borrowed, bartered, exchanged for labour, gift from friends or relatives	SRCSTPLFRUIT
FOOD CROPS		
In the next questions, I will only ask you about the food crops you grow in you farm later I will ask about cash crops ***Food crops are crops you grow for your own consumption*** **11a. What food crops do you grow in your farm during dry seasons? (*Multiple answers possible)***	1=Maize 2=Legumes 3=Cassava 4=Sorghum 5=Millet 6=pigeon peas 7=Green Bananas 8=Green grams 9=Cow peas 10=Sweet Potatoes 99=Others(specify)	FDCRPDRY
11b. How many bags do you harvest during the dry seasons?	1=Maize………….. bags 2=Legumes …………bags 3=Cassava …………… bags 4=Sorghum …………. bags . 5=Millet …………… bags 6=pigeon peas ……… bags 7=Green Bananas …………. bags . 8=Green grams………. bags 9=Cow peas **…………** bags 10=Sweet Potatoes 99=Others(specify)⋯..	FDCRPNBDRY

11c. What food crops do you grow in your farm during rainy seasons? (*Tick more than one)*	1=Maize 2=Legumes 3=Cassava 4=Sorghum 5=Millet 6=pigeon peas 7=Green Bananas 8=Green grams 9=Cow peas 10=Sweet Potatoes 99=Others(specify)	FDCRPRAIN
11d. How many bags do you harvest during the rainy seasons?	1=Maize ………… bags 2=Legumes ………… bags 3=Cassava …………. bags 4=Sorghum ………… bags 5=Millet …………….. bags 6=pigeon peas ………… bags 7=Green Bananas …………… bags 8=Green grams ………… bags 9=Cow peas **…………..** bags 10=Sweet Potatoes 99=Others(specify)	FDCRPNBRAIN
CASH CROP		
Now I will ask you about the cash crops you grow in your farm **Note cash crops are crops produced for commercial value rather than own consumption** **12. Do you grow any cash crops?**	0=No 1=Yes	GROWCASHCRP
12a If yes in 21 above, which cash crops do you grow during the dry seasons? (tick more than one)	1=Cotton 2=Tobacco 3=Sisal 4=Mangoes 5=Pineapple 99=Others (specify) ……………	CASHCROPDRY
12b.How much of the cash crops do you harvest during the dry seasons?	1=Cotton bags 2=Tobacco bags 3=Sisal ………..bags 4=Mangoes …..bags 5=Pineapple …bags 99=Others (specify)	CSHCRPNOBGDRY
12c. If yes in 21 above, which cash crops do you grow during the rainy seasons? (tick more than one)	1=Cotton 2=Tobacco 3=Sisal 4=Mangoes 5=Pineapple 99=Others (specify) ……………	CASHCROPRAIN

12d. How much of the cash crops do you harvest during the rainy seasons?	1=Cotton …………bags 2=Tobacco …………bags 3=Sisal …………bags 4=Mangoes…………bags 5=Pineapple…………bags 99=Others (specify) ……………	CSHCRPNOBGRAIN
12e. What is your approximate Monthly income from cash crop farming?	1=below 3000 (less than 1 dollar per day) 2=3001 to 6000 3=6001 to9000 8=>9001 88=Don't know 99=Refused	TTINCOME
13. Do you store your produce after harvest?	0=No 1=Yes	STRHARV
13a. If yes, Where do you store your harvest?	1=Granaries 2= Silos 3=Dwelling Houses 99=Others specify.......................	WHERESTRHARV
14. Do you face any post-harvest losses?	0=No 1=Yes	LOSSES
14a. In what ways do you loose your produce?	1=Spoilage by pests 2= Poor post harvest handling practices (transportation) 3=To animals 4=Contamination 99=Others specify.......................	WHATLOSSES
14b. How much of the produce do you loose after harvest?	1=All of the produce 2= 1/2 of the produce 3=3/4 of the produce 4= none 99=Others specify.......................	QUANTIFLOSSES
15. Do you irrigate your land?	0=No 1=Yes	IRRG2
16. What challenges do you face while farming?	1=Lack of rainfall 2=Lack of capital 3=Lack of farming tools 4= Lack of storage facilities 5=Lack of irrigation equipment	CHAL LENGES

LIVESTOCK FARMING			
17. Do you keep any Livestock?	0=No 1=Yes	LIVSTOCK	
17a. If yes in 17 above, which ones?	1=Cattle/Cow 2=Goats 3=Sheep 4=Camel 5=Chicken 6=Donkeys 99=Others specify...........................	WHICHLIVESTOCK	
17b. If yes in 17 above, why do you keep them?	1=Only for own consumption 2=Only for for sale 3=Consumption and for sale 3=Ploughing 99= Others specify...........................	WHYLIVESTOCK	
17c. How did you handle your animals during the previous dry season (Dec 2016 – April 2017).	1= sell them to the Government 2= sell them to the local market 3=Move to lands near water streams 4=Migrate 5=Slaughter them as food 6=Let them starve to death 99=Others specify....................................	HANDLELIVESTOCK	
17d. What is your approximate Monthly income from livestock keeping during the dry seasons?	1=below 3000 2=3001 to 6000 3=6001 to9000 8=>9001 88=Don’t know 99=Refused	TTINCOME	
17e. What is your approximate Monthly income from livestock keeping during the Rainy seasons?	1=below 3000 (Less than 1 dollar a day) 2=3001 to 6000 3=6001 to9000 8=>9001 88=Don’t know 99=Refused	TTINCOME	

	6=Pests and Diseases 99=Others specify....................	

18. Do you own any of the following assets (*Observe ownership of the following assets*)?	
Farm equipment	
Permanent house	
Piped water	
Others (specify)	

BAOBAb AVAILABILITY AND CONSUMPTION PATTERNS

Baobab Availability.

1. Do you know Baobab tree?	0= no 1= Yes	KNOWBB	
2. Do you have baobab tree in your farm?	0= No 1= Yes	BBTREEFARM	
2a. If yes, how many baobab trees do you have in your farm?	*Record number of baobab trees on farmland* …………….	NOBBIN	
Are there other trees close to your houses, that are not located on your farmland but belong to the household? If yes, how many, if no write 0	*Record number of baobab trees outside your farmland* …………….	NOBBOUT	
3. Do you harvest Baobab tree parts?	0= No 1= Yes	HARVESTBBPDTS	
3a. If yes in 3 above, which parts do you harvest during dry seasons?	1=leaves 2=fruit 3=seed	HARVDRY	
3b. How much of the baobab parts do you harvest per tree during dry seasons for own consumption?	1=leaves ………………bags 2=fruit …………………. bags 3=seed ………………. bags	QUANTITYBBDRY	
3c. How often do you harvest BB tree products during this season	1=Throughout the season seasons 2=Only when fruits are ripe 3=Only when the leaves are young 4=Unripe fruits 5=Mature leaves 99= Others (specify).....................	FREQBBHARVDRY	

3d. If yes in 3 above, which parts do you harvest during rainy seasons?	1=leaves 2=fruit 3=seed	HARVRAIN	
3e. If yes, how much of the baobab parts do you harvest per tree during rainy seasons for own consumption?	1=leaves ………………bags 2=fruit …………………. bags 3=seed ………………. bags	QUANTITYBBRAIN	
3f. How often do you harvest BB tree products during this season	1=Throughout the season seasons 2=Only when fruits are ripe 3=Only when the leaves are young 4=Unripe fruits 5=Mature leaves 99= Others (specify).....................	FREQBBHARVRAIN	
4. Do you store BB parts and BB products after harvesting and processing?	0= No 1= Yes	STOREBB	
4a.If no in 4 above, Why don't you store them?	1=Financial constraints 2=Lack of storage facilities 3=Increased labour demands 4=Too little harvest to store 5=I harvest only if a purchaser is expected to come soon 6= I only harvest the amount that is consumed the same day 99= Others (specify).	NOTSTORE	
4b. If yes, by which means do you store them?	1=Sun drying (uncracked fruits) 2=Air Tight containers 3=Using chemical preservatives 4=Freezing 5=Grinding them finely 99= Others (specify)..................	HOWSTORE	
4c. When do you use the stored BB parts and products?	1=After the seasons are over 2=When demand rises in the markets 3=During food shortage seasons 4=When prices of other foods are high 99= Others (specify)..................	WHENUSEBBSORED	
BAOBAB ACCESSIBILITY			
5. If you do not own BB in your farm in 2 above do you access it at all?	0= No 1= Yes	NOACCESS	
5a. If yes, how do you access the baobab that you use?	1=Neighbourhood trees 2=Community tree	HOWACCESS	

	3=Purchase it from the market 4=Receive as Gifts from visiting friends 99= Others (specify).....................		

BAOBAB USE			
6. Do you use baobab parts?	0= no 1= Yes	USEBB	
6a. If yes in 5 above how do you use BB?	1=Food 2=Non-food 3=Both	FREQUSEBB	
6b. If for food in 6a above, which part of baobab do you use during the dry seasons?	1=Leaves 2=Fruit 3=Seed 4=All parts	BBPARTS	
6c. How often do you use baobab tree products as food during the dry season? ***note that food shortage is defined by the inability to buy basic staple foods***	1=All seasons 2=During food shortage seasons 3=In religious celebrations 99= Others (specify)..................	FREQUSEBBDRY	
6d. If for food in 6a above, which part of baobab do you use during the rainy seasons?	1=Leaves 2=Fruit 3=Seed 4=Bark 5=All parts	BBPARTS	
6e. How often do you use baobab tree products as food during the rainy seasons? ***note that food shortage is defined by the inability to buy basic staple foods***	1=All seasons 2=During food shortage seasons 3=In religious celebrations 99= Others (specify)..................	FREQUSEBBRAIN	
7. If you use Fruits, describe how you use the fruit after harvesting.	1=for local beer production 2=jam production 3=add powder into porridge 4=freeze into a sweetened ice 5=dissolve in water or milk 6=Process into Mabuyu sweet 7=Production of wine 8=Production of a drink with wine gum flavour 99=others(specify)…………….	FRUITUSE	
7a. If you don’t use fruits, Please explain why you do not	1=Bitter	FRUITNOUSE	

use them	2=Hard to crack 3=stringent taste 4= considered as poor men food 5= food taboos 99=others(specify)…………….		
8. If you use leaves, describe how you use the leaves after harvesting.	1=salad 2=vegetable substitute 3=Cooking coarse vegetables 4= Livestock fodder 5= Spice 99=others(specify)…………….	LEAFUSE	
8a. If you don't use Leaves, Please explain why you do not use them	1=Bitter 2=Tough to cook and eat 3= considered as poor men food 4= food taboos 99=others(specify)…………….	LEAFNOUSE	
9. If you use seeds, describe how you use the seeds after harvesting.	1=cooking oil 2=cosmetic uses 3=thickening soups 4=Substitute for coffee 5=Flavouring agent 6=Ferment 7=Roast 99=others(specify)…………….	SEEDUSE	
9a. If you don't use seeds, Please explain why you do not use them	1=Hard to crack 2=Tough to cook and eat 3= considered as poor men food 4= food taboos 99=others(specify)…………….	SEEDNOUSE	
10. Do all family members use baobab parts and its products after you prepare them?	0= No 1= Yes	ALLPPLEUSE	
10a. If no, who does not use the parts and products prepared	1=Men 2=Women 3=Children	PPLENOUSE	
11. If for non food in 6a above, Describe how you use BB	1=Medicinal purposes 2= Commercial use 3=Traditional uses 4=Livestock feed and fodder	NONFDUSE	

	5=Ethno-veterinary uses 99=others(specify)…………….		

Cultural Perceptions			
12. Are you able to access BB tree freely	0= No 1= Yes	ACCESS	
12a. If no, who then is able to access BB freely without any restrictions	1=Men 2=Women 3=Children 4= Religious Leaders	FREEACCESS	
12b. What kind of restrictions do you face?	1=Forestry laws and restrictions 2= Restrictions by village elders and chiefs 3=Restriction for lack of family ties 4=Spiritual restrictions 5=Cultural and social customs 99= Others (specify).................	RESTRICTIONS	
13. Are there any cultural or religious reasons that promote the use of baobab parts?	0= No 1= Yes 2= don't know	CULTRELIGYES	
13a. If yes, *state them*	……………….	REASONSYES	
14. Are there any cultural or religious reasons that prevent you from using baobab parts?	0= no 1=yes	CULTRELIGNO	
14a. 1f yes, *state them*	……………	REASONSNO	

CONTRIBUTION TO HOUSEHOLD INCOME			
15. Do you sell BB parts and Processed products?	0= No 1= Yes	SELLBB	
15a. If yes in 15 above, which BB parts and BB processed products do you sell?	1=Leaves 2=Fruit 3=Seed 4= Beer/ wine 5=Jam 6=Powder added into porridge 7=frozen sweetened ice 8=Leaf salad 9=vegetable	WHICHBBPATSPRDCT	

	10=cooking oil 11=cosmetic Products 12= Coffee Substitute 13=Flavouring agents 99= Others (specify)		
15b. What is your approximate Monthly income from BB during dry seasons?	1=below 3000 (less than 1 dollar per day) 2=3001 to 6000 3=6001 to9000 4=>9001 88=Don't know 99=Refused	BBINCOMEDRY	
15b. What is your approximate Monthly income from BB during rainy seasons?	1=below 3000 (less than 1 dollar per day) 2=3001 to 6000 3=6001 to9000 4=>9001 88=Don't know 99=Refused	BBINCOMERAIN	
17. Do you sell BB non-food products?	0= No 1= Yes	SELLNONBBPDCT	
17a. If yes in 17 above, which BB non-food products do you sell? (multiple answers possible?)	1=Fibre 2=Dye 3=Hard shell 4=Woven baskets 5= robe 99= Others (specify)	WHICHNONFDPDCT	
17b. How much income do you get from the BB non-food products during dry seasons?	1=below 3000 (less than 1 dollar per day) 2=3001 to 6000 3=6001 to9000 4=>9001 88=Don't know 99=Refused	NONFDINCOMEDRY	
17b. How much income do you get from the BB non-food products during rainy seasons?	1=below 3000 (less than 1 dollar per day) 2=3001 to 6000 3=6001 to9000 4=>9001 88=Don't know 99=Refused	NONFDINCOMERAIN	
18. Who do you sell BB products to?	1=International Market	WHOSELLTO	

	2=Domestic markets 3=Sell to neighbours 4=fruit retailers 5=Fruit wholesalers 99= Others (specify).....................		
20. When do the prices of BB parts, processed products and non-food products vary most?	1=dry seasons 2=Long rainy seasons 3=Short rainy seasons	PRICEVARY	
21. Who sell the products in the market?	1=Father 2=Mother 3=Children 99= Others (specify).....................	SELLER	
19. **Majorly, how do you spend income obtained from BB sales?**	1= Food 2= Health 3= Education 99=Others specify...	BBINCOMEEXPE	
20. What challenges do you face in BB farming?	1= herders that were cutting huge amounts of branches towards the end of the dry season 2=Wild animals that destroy BB 99= Others (specify).....................	CHALLENGESBB	

A. SOCIODEMOGRAPHIC CHARACTERISTICS OF CAREGIVERS WITH CHILDREN AGED 6-10 YEARS **Name of the caregiver**…………………………………**.** **Household code**…………………………………**..**			
1.Sex (Observe and record)	1=Male 2=Female	**SEX**	
2.What is your year of birth	*Record year of birth……………* *Record age …………* 88= don’t know	YOB	
3.What is your marital status?	1=Married monogamous 2=Married polygamous 3=Single 4=Separated 5=Divorced 6=Widowed	MRS	

4.What is your religion?	1=Protestant 2=Catholic 3=Muslim 4=Others(Specify)	RELIGION	
5.Who is the Household Head?	1=Wife → Q7 2=Husband 3=Grandfather 4=Grandmother 5=Brother 6=Brother-in law 7=Sister 8=Sister in law	HH	
6.What is your relationship to household head?	1=Wife 2=Husband 3=Son 4=Daughter 5=Male relative 6=Female relative 99=No relative	RSHH	
7 What are the main (3 primary) sources of income of your household throughout the year?	1=Crop farming 2=Salaried employee 3=Wages from piece works 4=Business 5=Tourism 6=Mixed farming 7=Livestock keeping 8=Bee keeping 9=Fishing 10=Mining and Manufacturing 11=Baobab Farming 99=Others (specify)................	PRIOCC	
9. What is your highest level of education?	1=No formal schooling 2=Primary (1-8) 3=Secondary 4=Tertiary	EDUCLEV	
10. What is the highest level of education of the household head?	1=No formal schooling 2=Lower primary (1-3) 3=Upper primary(4-8) 4=Secondary 5=Tertiary	EDUCLEVHH	

11. How many members are permanently living in this household?(*permanent resident is defined by those who have lived in the household for more than 3 months)*	*Record number* ……………….	HHNO	

Appendix 4: Food frequency questionnaire

Food/Frequency	Daily	2-4times a week	5-6 times a week	Once a day	2-3times a day	4-5times a day	6+ times a day
Baobab Leaves							
Fruits							
Vegetables							
Legumes							
Milk and milk products							
Meat and meat products							
Fish and seafood							
Nuts							
Sugar							
Caffeine beverages							

Appendix 5: Household food insecurity access scale (HFIAS)

NO	QUESTION	RESPONSE OPTIONS	**CODE**
1	In the past four weeks, did you worry that your household would not have enough food?	0 = No (skip to Q2) 1=Yes	**HFIAS1**
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	**HFIAS2**
2.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS2a**
3	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0 = No (skip to Q3) 1=Yes	**HFIAS3**
3.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS3a**
4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0 = No (skip to Q3) 1=Yes	**HFIAS4**
4.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS4a**
5	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0 = No (skip to Q3) 1=Yes	**HFIAS5**
5.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS5a**

6	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0 = No (skip to Q3) 1=Yes	**HFIAS6**
6.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS6a**
7	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0 = No (skip to Q3) 1=Yes	**HFIAS7**
7.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS7a**
8	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0 = No (skip to Q3) 1=Yes	**HFIAS8**
8.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS8a**
9	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0 = No (skip to Q3) 1=Yes	**HFIAS9**
9.a	How often did this happen?	1 = Rarely 2 = Sometimes 3 = Often	**HFIAS9a**

Appendix 6: The 24-hour recall

Name of Caregiver/ Code of the household: ____________________________

Name of Child/ Code of the household: ____________________________

Date: __ __ / __ __ / __ __

Dietary Recall from YESTERDAY (24hr-recall)

Now I would like to ask you about everything (including snacks) that you and your child ate yesterday during the day or night, whether at home or outside of the home. I will further inquire what other meals you ate outside your household. Start the 24h-recall with the questions: "What was the first food your child ate after waking up" and continue you with "anything else?". *Continue through the day,* ***until respondent indicates child went to sleep****. If respondent mentions a mixed dish like a porridge, relish or stew, ask about all ingredients that went into the dish, including added oil, sugar or condiments.* ***Probe for drinks & fruits.***

1	Which day of the week does this record represent? **A**		⊔			
2	Child is present during the 24h-recall	0= no 1= yes	⊔			

		Please list all the food eaten the day before the interview: Mother	Child

3	4	5	6	7	8				9	11	12
Main Dish	**Total Quantity prepared** (grams or photo book)	**Unit -B**	How was the **dish** prepared-**C**	**Ingredients**	**Quantity eaten by mother** (grams or photo book)	**Other food eaten by mother outside the household** (grams	**Quantity eaten by child** (grams or photo book)	**Other food eaten by mother outside the household**	**Unit -B**	No. of People eaten from Main Dish	Where was the food consumed? - **E**

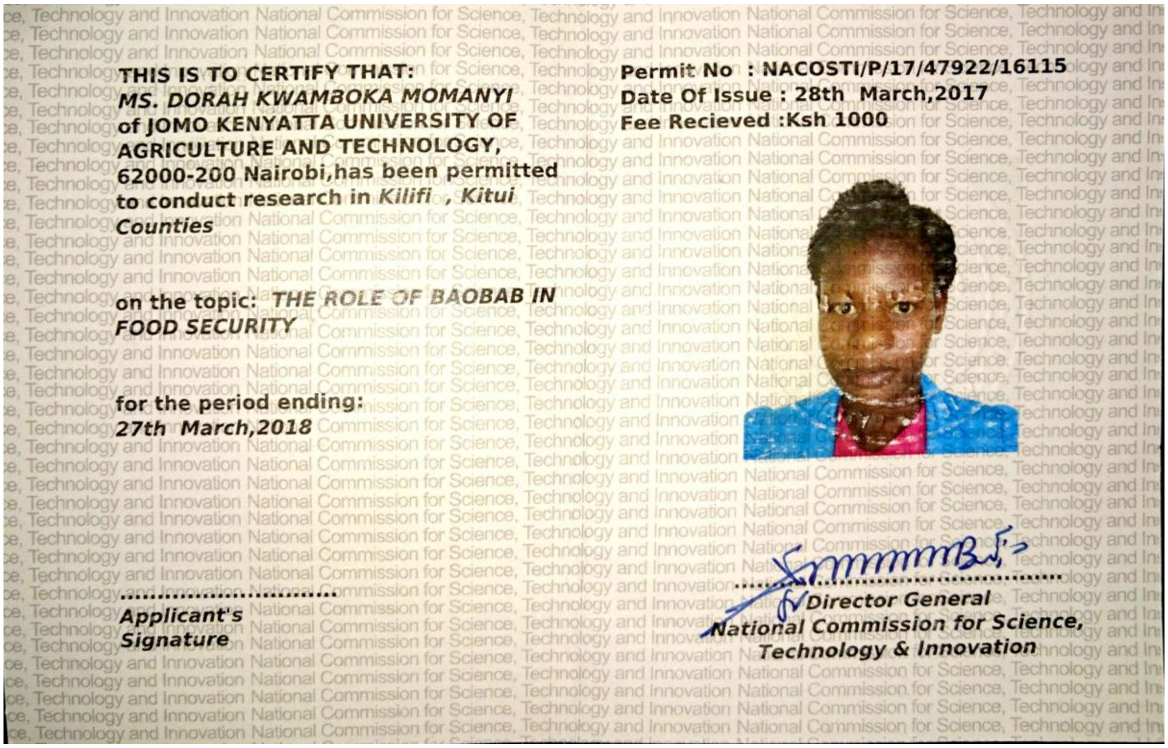
						or photo book)		(grams or photo book)			
		First food eaten after waking up									

Code A				**Code B**		**Code C**				**Code E**	
1	Monday	5	Friday	1	Own preparation	1	Raw	5	Stewed	1	Home
2	Tuesday	6	Saturday	2	Purchased	2	Dried	6	Fried	2	Hotel
3	Wednesday	7	Sunday	3	Gift	3	Boiled/ Cooked	7	Roasted	3	Friend
4	Thursday			**99**	**Other, Specify**	4	Steamed#	**99**	**Other, specify**	4	School
										99	Others

Food Groups	**required detailed information**	**CODE**
Meat	Kind of meat; description of cut, raw or cooked weight, method of cooking, lean or lean plus fat, bone in or not (waste factor)	
Fish and seafood	Kind of fish or seafood; raw or cooked weight; method of cooking; amount of bones, skin, or shell (waste factor)	
Poultry	Kind of poultry; parts or pieces eaten (e.g., breast, thigh), raw or cooked weight, method of cooking, white or dark meat, meat plus skin or meat only, bones (waste factor)	
Fats	Kind of fat, brand name (if possible)	
Milk products	Kind of dairy product, brand name (if commercial product), percentage fat (as butter fat or milk fat), liquid vs. powdered milk	
Bread, rolls	Type of grain (rye, whole wheat, etc.), homemade or bought, size: standard or unusual, toasted or not, topping and condiments, brand name (if commercial product)	

Baked goods	Type of product, whether iced or not, homemade or commercial, type of lling	
Cereal, pasta, or rice	Type of grain, whole or re ned, milled or polished (for rice), brand name, raw or cooked weight, enriched or not, cereal plus milk (if dry quantity unknown), method of cooking	
Vegetables	Fresh, frozen, or canned; peeled or unpeeled; method of cooking; topping (butter, etc.)	
Fruits	Fresh, stewed, frozen, or canned; peeled or unpeeled; type of liquid (heavy, light): sweetened or unsweetened; waste factor (e.g., peel, stone)	
Beverages, soup	Fresh or frozen; canned or bottled; fruit juice: sweetened or unsweetened; added vitamins or minerals (e.g., vitamin C); coffee: brewed, instant, decaffeinated, regular; soups: homemade or canned, dilutant (milk or water), proportion of dilutant : concentrate (e.g., 1:1), recipe; brand name (if commercial product)	
Street foods from vendors	Food (e.g., French fries and chips, maandazi, samosa), brand name (if commercial product), condiments added, method of cooking, vendor’s name/location	
Mixed dishes	Product name, homemade or commercial, recipe ingredients, cooking method	
Herbs, spices	Name; fresh or dried	

Appendix 7: Research permit



THIS IS TO CERTIFY THAT:
MS. DORAH KWAMBOKA MOMANYI
of JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, 62000-200 Nairobi,has been permitted to conduct research in *Kilifi , Kitui Counties*

on the topic: *THE ROLE OF BAOBAB IN FOOD SECURITY*

for the period ending:
27th March,2018

Permit No : NACOSTI/P/17/47922/16115
Date Of Issue : 28th March,2017
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix 8: Ethical clearance

Mount Kenya University

JUNE 13, 2017

Ref. No. MKU/ERC/0389

CERTIFICATE OF ETHICAL CLEARANCE

This is to certify that the proposal titled **"THE ROLE OF BAOBAB IN FOOD SECURITY IN KITUI AND KILIFI COUNTIES IN KENYA"**, whose Principal Investigator is Ms Dorah Kwamboka Momanyi has been reviewed by Mount Kenya University Ethics Review Committee (ERC), and found to adequately address all ethical concerns.

Mr Francis W. Makokha
Secretary, Mount Kenya University ERC

Sign: Makokha **Date:** 13.06.2017

Prof. Francis W. Muregi
Chairman, Mount Kenya University ERC

Sign: ________ **Date:** 13.06.2017

The Chairman
Mount Kenya University
Ethics Review Committee
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Nutrition & Food Science

Gaps in food security, food consumption and malnutrition in households residing along the baobab belt in Kenya

Dorah Kwamboka Momanyi, Willis O. Owino, Anselimo Makokha, Esther Evang, Habte Tsige, Michael Krawinkel,

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Gaps in food security, food consumption and malnutrition in households residing along the baobab belt in Kenya

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Received [illegible]
Revised [illegible]
[illegible]
Accepted [illegible]

Abstract

Purpose – This paper aims to describe food insecurity status, food consumption patterns of households and nutritional status of families residing along the baobab belt in Kitui and Kilifi counties of Kenya. It also explores associations between these and household sociodemographic characteristics.

Design/methodology/approach – A cross-sectional study design was performed with a sample of 516