TYPOLOGIES, CHOICE OF PRODUCTS TO PROCESS AND PROFIT EFFICIENCY OF BAOBAB PROCESSING IN KENYA

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Typologies, choice of products to process and profit efficiency of baobab processing in Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

I would like to dedicate this work to my parents Festus and Winfred Muriungi and my siblings Walter, Karen, Seamus, and Cynthia, for their support during the entire study period.

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LIST OF ABBREVIATION AND ACRONYMS

ANOVA Analysis of Variance

ASAL Arid and Semi-Arid Land

CA Cluster Analysis

DEA Data Envelopment Analysis

GDP Gross Domestic Product

IFAD International Fund for Agricultural Development

IPGRI International Plant Genetic Resources Institute. International Plant Genetic Resource Institute

KAM Kenya Association of manufacturers

KNBS Kenya National Bureau of Statistics

MLM Multinomial logit Model

MPP Marginal Physical product

NGO Non-Governmental Organization

PCA Principal Component Analysis

SFA Stochastic Frontier Analysis

SPSS Statistical Package for Social Sciences

USA United States of America

ABSTRACT

Baobab (Adansonia digitata L.) is one of the underutilized fruit trees which have continued to provide more non-timber benefits to the people. These trees are mostly used traditionally for their oil, food and medicinal properties. Baobab is an iconic tree that is commonly utilized as a source of food and income generation due to its nutritive properties. Despite its importance, baobab processing in Kenya remains low and it is characterized by an undeveloped market system with few processed products being available in the market. Thus, the main questions that remains unanswered are, is baobab processing profitable? What are the factors that determine baobab processing in Kenya? Further, what are the factors that determine the choice of baobab product to process in Kenya? The above concerns remain undocumented and not well known. Thus, this study sought to characterize the baobab processors, determine the factors that influenced the choice of baobab product to process, and estimate the profit efficiency of baobab processing in Kenya. The study was conducted in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties. The research used purposive and snowball sampling techniques to select a sample of 304 baobab respondents. The study used a structured questionnaire to collect information from the respondents. Principal components analysis and cluster analysis were adopted to characterize the baobab processors. The logit regression model was used to determine the processor's choice of product to process, while stochastic frontier analysis was adopted to estimate the profit efficiency of the baobab processors and its determinants. The socio-economic characteristics results revealed that 92.5% of the respondents were female while the males were 7.5%. Baobab candy was the most processed product by over 90 % of the respondents, followed by ice cream at 4.6%, juice at 3.6%, and powder at 1%. Majority (76.2%) of the respondents had access to land while the level of credit access was low (35.7%) among the processors. The main (50.4%) target market was rural market and most (54.8%) processors reported varied processing patterns throughout the year. The processors depicted different education levels, experience, income from others sources, profit levels, baobab revenue processing cost and efficiency levels among the study counties. The cluster analysis findings indicated that the baobab processors in the study area would generally be grouped into three types namely: type 1 which is characterized by high quantity processors; type 2 which consists of average quantity processors and type 3 which is made up of low quantity processors. The Principal Component Analysis (PCA) results revealed that variations in baobab processing were due to income, output, input, and socio-demographic factors of the baobab processors. Baobab processors' clusters were shaped by training, experience, quantity of baobab processed, baobab processing cost, income from other sources, access to land, and baobab profit levels. The logit model results indicated that education level ($P<0.05$), number of baobab trees owned ($P<0.01$), and credit access ($P<0.05$) favored processing of other products (juice, ice cream, and powder) while marital status ($P<0.05$) and land size ($P<0.05$) positively influenced candy as the choice of baobab product to process. The stochastic frontier analysis results revealed that on average the profit efficiency of baobab was 60% which implies that the baobab processors would generally increase their profit efficiency by a further 40%

keeping all the other factors constant. The model indicated that the coefficient of sugar costs positively correlated with the normalized profit of baobab processing. The results of the inefficiency model showed that the level of non-processing income, marital status ($P<0.05$), gender ($P<0.1$), and number of baobab trees owned ($P<0.01$) influenced profit efficiency positively, while non-baobab processing occupation ($P < 0.1$) negatively influenced profit efficiency. The study concludes that, the processors in the study area were heterogeneous in nature. The baobab processors were moderately profit efficient with the women processors being generally less profit efficient compared to their male counterparts. The determinants of profit efficiency were incomes from other sources, number of trees owned, gender, marital status, and non-processing occupation. The study recommended that policy makers should put in place policies that will help increase processors' efficiency through training and adopting better processing technologies. Similarly, there was need to address the gender gap in baobab profit efficiency between male and the female processors. Further, investment in human capital, particularly informal education on baobab processing activities and encouraging harvesting and conservation of baobab trees will help spur baobab value addition. Lastly, there is need to streamline laws governing land access and ownership among the baobab processors so as to allow access to baobab and harvesting especially those that are in restricted areas such game reserves and parks. Providing processors with land ownership documents will enable them to access credit to use in baobab processing.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Baobab (*Adansonia digitata L.*) is one of the underutilized fruit trees that has potential provide to more non-timber benefits. It is a deciduous tree that belongs to the plant family *Bombacaceae* majorly found in the African savannas and India. The tree originated from Central Africa and spread to the other African tropical regions and some continents (Wickens & Lowe, 2008). The baobab tree is known for its therapeutic capability, which has increased its popularity in Africa and globally. Baobab seeds, bark, fruit pulp, roots and fruit shell are a source of food and components for processing (Kaboré *et al.*, 2011). The barks are used in manufacturing of clothes and ropes, while the fruits are consumed as food. The fruit is composed of pulp on the seed. Pulp on seed is the seed which is covered by powder. The powder is added to milk or porridge for fermentation, used to make wine, or mixed with water, and consumed. The magical tree contains several substances such as vitamin C which contain, antimicrobial, antiviral, antioxidant, and anti-inflammatory features that are used for the treatment of numerous diseases in African traditional medicine such as anemia, diarrhea, asthma, microbial infections, and fever among others (Kamatou *et al.*, 2011) . Young leaves are used as fodder and as a source of water by animals and human beings. The leaves can also be dried and processed into leaf powder (Chadare *et al.*, 2008).

Globally, baobab fruit has economic benefits to the farmers and different people involved in its trade and processing. There are over 300 uses of baobab in Africa (Buchmann *et al.,* 2010) . Besides, in 2013 there were over 300 baobab processed products in the European markets (Gebauer *et al*., 2016; Jackering *et al*., 2019; Kaimba *et al*., 2020). These trees have the potential to contribute to income generation, food security, environmental services, and nutritional benefits. Moreover, these trees can improve the livelihood of the poor and disadvantaged in developing countries by ensuring food security, as a source of income, maintaining nutritional balance, and meeting medicinal needs (Sanchez, 2010).

In Africa, the fruit is processed into various products which are consumed and sold to earn revenues for the processors. Overall, as a food source, the fruit pulp is probably the most essential processed product. It can be consumed fresh or dissolved in water or other drinks. In Tanzania, baobab pulp is used in beer manufacturing to aid in fermentation. In Benin, baobab milk is mixed with cereal flour to make an acidic food product that can last for a week. Baobab seeds are used as flavoring agents or can be roasted and eaten as snacks.

In Kenya, coated seeds are sold as candies mostly referred to as "mabuyu" in Swahili (Muchiri & Chikamai, 2003). The seeds are also used to make oil, but it is not widespread. Baobab is used to dilute groundnut oil in West Africa, and in Senegal, it is used for cooking (Wickens & Lowe, 2008). Baobab acts as a buffer to the people in the arid and semi-arid areas (ASALs), where it is mainly found, due to its ability to grow and produce fruits when other crops fail. It plays a vital role in improving the people's livelihoods in the areas where it is grown, processed, and traded (Mwema *et al.,* 2013).

Venter and Witkowski (2013) established that income from the sale of baobab fruits helps to reduce poverty. In Mali and Benin, cash from the sale of baobab dried leaves and fruits acts as a buffer to the household income (De Caluwe, 2011) . In Kenya, earnings from baobab processing and trade supplement household income (Kiprotich *et al*., 2019). Baobab is nutritionally rich and thrives well in areas where the production of other crops is constrained by climatic conditions (IPGRI, 2002). Baobab adapts well in areas where the common staple foods find it challenging to thrive. They can improve nutrition; for instance, most neglected species contain more vitamin C and pro-vitamin A than other staple crops (Muthai *et al*., 2017). Besides, these underutilized crops can improve the livelihood of the poor rural people where they are grown.

In Kenya, the baobab trees are grown in the eastern part of the country in two belts, namely the inland and coastal belt. The Inland belt originates from the Tanzania border, East of Mt. Kilimanjaro, and runs towards the North East around Kitui town. In coastal belt it is found in the whole coastal region (Gebauer *et al*., 2016). Baobab value addition in Kenya is done on a small scale, but few large-scale processors exist. The various baobab processed products include pulp, candy, juice, ice cream, ropes, bowls, rat traps, and ropes. Among the named products, candy is the main processed (Jackering *et al* ., 2019).

Baobab remains an important tree in the arid and Semi-arid lands (ASAL) areas of Kenya in particular, due to its adaptability to the environment. Its ability to improve the livelihood of the farmers and processors is undoubtedly great. The acceptance of baobab pulp as a food ingredient by the European Commission (European Commission, 2008) and Food and Drug Administration (Food and Drug Administration, 2009) and the rising international market signifies a brighter future for the baobab industry in Kenya (Kaimba *et al*., 2020). However, the secret of unlocking its potential is embodied in the value addition and commercialization of the products. Ultimately, processing of baobab becomes an important function of the value chain.

Despite its importance, the baobab remains neglected and underutilized and is often regarded as an orphan crop and less important compared to the common staple crops in terms of market value and global production. Baobab has not been given much attention by the commercial sector and remains less researched (Padulosi *et al*, 2013). Despite baobab's economic and health benefits, its full potential remains untapped (Mullin & Kehlenbeck, 2015). This may be attributed to various challenges such as the seasonality of the baobab fruit, inadequate information on processing, lack of enough markets, and poor access to training and credit facilities (Kaimba *et al*., 2020). Baobab value addition is majorly affected by insufficient markets for the processed products resulting from low information on baobab products (Gebauer *et al*., 2016).

Various studies have been conducted on baobab such as Ometesho *et a*l. (2013) who revealed that negative cultural beliefs hinder the utilization of baobab in Nigeria. Kiprotich *et al*. (2019) document that product availability, packaging, labeling, and certification are key to baobab utilization in Kenya. Kaimba *et al*. (2020) conclude that building capacity around market development, education and research, institutional services and road networks are key to the creation of more profitable channels in pulp marketing in Kenya. While Jackering *et al*. (2019), conducted a value chain analysis of baobab products in Kenya, they gave less emphasis on processors' characteristics, choice of product to process, and profit efficiency of baobab processors. A review of the existing literature established little information on the characterization of baobab processors, determinants of the choice of products to process, and profit efficiency of baobab processing in Kenya. This calls for the study to characterize the processors, establish features and indicators of typologies, establish factors influencing the choice of products to process, and determine the profit efficiency of baobab processing for better policy development. The purpose of this study was thus to characterize the baobab processors by establishing the features and indicators of baobab typologies, investigate the factors influencing the choice of baobab products to process, and determine the profit efficiency of baobab processing and its determinants for better policy development. The study provides valuable insights on baobab processors characterization, determinants of baobab processing, and baobab profit efficiency levels and its determinants which are important to inform appropriate policies for the sector.

1.2 Problem Statement

Many people in the African rural areas derive numerous benefits from wild edible plants such as African baobab tree. Various parts of the tree such as the pulp and the leaves can be consumed directly or processed into other fine products. Besides baobab fruits offering immerse food-related benefits to the African people, it is also a source of income for the rural and marginalized communities. Baobab mainly grows in areas where crop production is low, thus supplementing income from crop or animal production. In addition, it offers income to traders and processors who benefit from baobab trading and processing. Despite the importance of baobab, the tree remains underutilized, especially in Kenya (Mullin & Kehlenbeck, 2015) . Baobab processing remains low, and the characteristics of the baobab processors remain not well documented or known. In Kenya, baobab processing is characterized by few products, which is contrary to other countries such as Benin, and Malawi where many processed products exist in the market (Darr et al., 2020). Additionally, the profit efficiency of baobab processing is not well known in the Kenyan context. A number of studies have been conducted on various aspects of baobab tree such as its nutritional properties (Chadare et al., 2009), the marketing of baobab among collectors (Kaimba et al., 2020), and consumer behavior towards baobab products (Kiprotich et al., 2019). However, there is scanty empirical evidence on characterization of baobab processors, choice of product to process and profit efficiency of baobab processing. Previous literature in Kenya has mainly focused on market channel choices of collectors (Kaimba et al., 2020) while Jackering et al. (2019) provided some information on the processors in their value chain analysis work, showing that processing increased the value of the processed baobab products. Measuring profit efficiency is key since the ability to make baobab farming an efficient venture does not lie on the farmers and traders only but also on processors who transform the fruit into different forms, offering consumers a wide range of baobab products to consume. The ability of baobab to thrive in the local and international markets will depend on the quality and processing skills used by the processors, which are determined by their efficiency. The purpose of this study is thus to investigate the typologies of baobab processors, choice of baobab products to process and profit efficiency of baobab processing in Kenya.

1.3 Objectives

1.3.1 General objective

The general objective of this study was to establish the baobab processor typologies, determine the choice of product to process, estimate profit efficiency, and the factors affecting the profit efficiency of baobab processing.

1.3.2 Specific objectives

The specific objectives of the study were:

i. To characterize baobab processors in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties of Kenya
ii. To assess the factors influencing the processor's choice of product to process in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties, and
iii. To estimate profit efficiency and determine factors influencing profit efficiency among the baobab processors in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties of Kenya.

1.4 Hypothesis

i. There are no variations in characteristics of the baobab processors in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties.
ii. Socio-economic factors of baobab processors have no significant influence on the processors' choice of products to process among baobab processors in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties.
iii. Baobab processors are not profit efficient and socio-economic characteristic do not have significant influence on processors' efficiency in Kitui, Mombasa, Nairobi, Kilifi, and Makueni Counties.

1.5 Justification

With the decline in crop and animal production and the unpredictable weather patterns in the ASAL areas, it is important to promote tropical underutilized tree species that are tolerant to this condition, and a special focus of this study is on African Baobab. Baobab, which thrives well in these regions, can be used to improve the livelihoods of the people. This can only be achieved through efficient and functional value addition. This tree has the ability to mitigate the effect of poverty by improving livelihoods through the provision of nutritious food products and income. Baobab processing is an essential activity in the chain, which transforms the raw fruits into different final products for consumption. It helps in adding value which gives the baobab products better characteristics and prolongs their shelf life (De Caluw´e, 2011) . In Kenya, baobab production is more predominant in Kitui, Makueni, Taita Taveta, and Kilifi. All the named locations have a poor rainfall distribution thus hampering crop production, which provides an opportunity to exploit baobab, which performs well in these regions. Characterizing baobab processors and establishing the determinants of the choice of baobab products to process offers policy insights of improving the sector in terms of quality of the processed products. Knowing the profiles of the processors helps to understand their needs thus becomes easy in crafting policies in relation to their requirement. Similarly understanding the factors that influence choice of product to process is a key aspect in promoting additional products while targeting the key determinants. Additionally, establishing the profit efficiency of baobab processors will help lower input costs through bulk purchasing of the inputs and use of right amounts of the ingredients, thus improving processing activities. Besides, it will promote the market development of baobab products. This research aims to characterize baobab processors, investigate determinants of the choice of products to process, and determine the profit efficiency of baobab processors in Kenya. The study area covers Kitui, Makueni, Kilifi, Mombasa, and Nairobi Counties.

1.6 The significance of the study

A study on baobab processing is significant, given the role that baobab is playing in improving the livelihood of poor rural people. Baobab is predominantly grown in semi-arid areas where the shortage of enough rainfall limits rain-fed cultivation. The study contributes knowledge on factors influencing choice of baobab product to process. This understanding contributes to development of more baobab products thus offering consumers wide range of products. Findings from the study will reveal the processing efficiency level of the processors. This will inform on the aspect that need to be improved to increase the efficiency. Furthermore, increasing efficiency is vital in the baobab industry because it will improve the quality of products for both the local and international markets. Development of more products and improvement of processing efficiency will in turn improve processors’ return from baobab value addition. Establishing the efficiency levels and their effect in the sector is one way that could help the stakeholders and planners to determine the current status, challenges, and possible solutions of improving the value addition of baobab.

1.7 Scope of the study

The study determined factors affecting the choice of products to process and the profit efficiency of baobab processing in Kenya between January and May 2019. The choice of the study was necessitated by increasing local and international demand for baobab processed products amid the rising processing costs. This study targeted baobab processors in Kitui, Mombasa, Kilifi, Makueni, and Nairobi Counties. In the named areas, the tree and its products are predominant.

1.8 Definition of terms

Candy-this is the sweetened and flavored pulp on seed. Commonly known as 'mabuyu' in Swahili.

Dendrogram- this is a diagram that displays hierarchical relationship between things. It is mostly produced as an output for from hierarchical clustering.

Pulp -powder from baobab fruit

Pulp on seed -combination of powder and seed found in baobab fruit.

Processor-An individual involved in baobab value addition.

1.9 Organization of the thesis

Chapter one covers; background information of the study, objectives, hypothesis, problem statement, justification and significance of the study. Chapter two discusses literature on characterization, choice of product and efficiency of baobab processing. It begins with explaining the overview of characterization, then conceptual framework and finally empirical literature of characterization. Similar steps are taken in explaining the choice of product to process and the efficiency analysis. Chapter three examines theoretical framework, research design and methods used in the study. It starts with description of the theoretical framework, econometric specification and estimation procedures for characterization. The same steps are taken for the choice of product to process and profit efficiency. Then, research design and study area are explained, and finally the techniques for data collection and analysis procedure are spelt out. In chapter four, descriptive and econometric results are presented. Descriptive results include the socio-economic and institutional characteristics of the processors, while econometric results involve cluster analysis, logit model and profit efficiency results. Finally, chapter five presents the summary, conclusion, and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section presents the literature on characterization, choice of product, and efficiency of baobab processing. In section 2.2, the overview, conceptual framework, and empirical literature of characterization are discussed. In section 2.3, the overview, conceptual framework, and empirical literature of choice are examined, while section 2.4 explains the overview, conceptual framework, and empirical literature on efficiency.

2.2 Baobab characterization

2.2.1 Overview of characterization of baobab processors

Understanding the underlying diversity of smallholder agricultural producers or processors is crucial to developing policies and interventions for the agriculture sector. Characterization offers a platform for learning and understanding different producers and processors. Characterizing the agriculture producers or processors refers to the process of profiling various classes of producers or processors based on their processing patterns, demographics, and economic attributes (Nyando *et al.*, 2019). These classes exhibit different features. Characterizing producers and processors will yield typologies or clusters.

Typologies provide a mechanism for analyzing agricultural production and processing issues while providing solutions to the need of every processor or producer. Typologies offer a platform for solving problems arising due to processor or producer heterogeneity. They help to reduce the complexity of agricultural systems. Characterization reduces the heterogeneous producers or processors to similar coherent groups used to deduce characteristics.

Smallholder processors exhibit dissimilarity within and between groups. Due to the uniqueness of each processor, the diversity of the processors deters the government or other stakeholders from implementing the various policies or interventions to improve the sector. Such challenges call for a deeper understanding of the characteristics of each processor or producer before implementing the relevant policy and interventions.

2.2.2 Conceptual framework of characterization

Any characterization of agricultural producers or processors has to consider different aspects of the processor or producers. The factors that influence the classification of the processors include their social-economic characteristics, the accessibility of services, markets, and population density, among others. The socioeconomic features and the agro-ecological factors shape different economic rationale and processing systems adopted by agro-based processors (Kawamura, 2010) . Every type of processor is an outcome of the unique combination of socioeconomic characteristics and specific resource endowments. Classifying processors in terms of operations looks at the processing activities that the processors carry out.

Under the type of operations, the baobab processors can be food and or non-food product processors. Baobab processed food products include candies, powder, yogurt and juice, among others (Kiprotich et al.2019). The non-food products include carving, bowls, and musical instruments, among other arts. In regards to processing capacity, baobab processors can be small-scale processors or large-scale processors. Large scale processors use more improved technologies in their processing activities and produce a high amount of output. On the other hand, small scale is characterized by using simple tools and low processed outputs (IFAD, 2013) . Smallholder processors do not have modern tools, but they use cheap and readily available tools in their operations.

Smallholder processors are assumed to be homogenous in their operations and output. However, this may not be true because the amount of yield varies for each processor. The baobab processing industry in Kenya is done chiefly on a small scale, with most concentrating on candies. However, this does not rule out the existence of some processors who are involved in other types of baobab products.

2.2.3 Empirical literature on agricultural characterization and typologies

There exist some studies that characterize the different typologies of various players. Goswami *et al*. (2015) carried out a study on the identification and characterization of farming systems in irrigated agriculture in West Bengal State in India. They adopted a multistage sampling technique to select a sample size of 120 farmers. Principal component analysis and cluster analysis were used to characterize farming systems. The authors identified four (4) different farm types, namely: vegetable and fruit growing farms, crop-based diversification with off-farm income farms, animal husbandry, fruits farms and food grains and jute growing farms. The study concluded that the methodological perspective used in the study may be used a decision support tool by extension agencies. It further recommended integration of holistic farm planning and extension into technology transfer.

Sarker et al. (2020) investigated farming system typology for the adoption of new technology in Bangladesh. A multistage sampling technique was used to select 92 farms in Dinajpur district, North-Western Bangladesh. Principal component analysis and cluster analysis were used to profile farm types. The study established four (4) farm types based on resource endowment and livelihood orientation. They are: well-resourced farmers, moderately resourced households, resource-constrained households, and severely resource constrained. The authors concluded that a multivariate statistical tool that involves principal component analysis and cluster analysis is ideal tool for establishing major socio-economic features of a typical farm. They recommended that, researchers and policy makers should give attention to key socio-economic characteristics when deciding on ways of increasing adoption of agricultural technology by farmers.

Kuivanen *et al*. (2016) explored the pattern of farming system diversity through characterization of 70 smallholder farm households in Northern Region of Ghana. The researchers used the multivariate statistical techniques of principal component analysis and cluster analysis to characterize farm households. The study identified six (6) farm types namely: type 1-well-resource endowed with large cattle herd, maize -based cropping with systems and non-farm activities. Type 2- well resource-endowed with larger farm areas, legume and maize-based cropping system, and market oriented. Type 3- resource-endowed with herd dominated by small ruminants, maize and legume oriented, and on-farm labor intensive. Type 4- moderate resource-endowed with farm income from sale of crop products, sufficient hired labor and herd dominated by small ruminants. Type 5- resource constrained with less non-farm income and maize-based cropping system. Type 6- Severely resource constrained, with income from non-farm activities and sale of livestock products and a small herd dominated by poultry. The study concluded that a more flexible approach to typology construction is necessary to provide more insight to causes, effects and negotiations of farm diversity. It recommended adoption of a more flexible approach by incorporating participatory and statistical methods in future typological studies.

Bidogeza *et al.* (2009) conducted a study to identify household farm typologies in Umutura Province in Rwanda. Stratified random sampling was used to select 96 households. The researchers adopted a multivariate analysis approach involving cluster analysis and principal component analysis to delineate farm typologies. The study identified five (5) distinct farm household types, namely: literate male-headed farms, large farms with livestock, tenant farms, illiterate household heads with no off-farm activities farms and female-headed farms. The study concluded that multivariate statistical technique such as principal component analysis and cluster analysis are suitable tools for establishing key socio-economic attributes that underscored the adoption of new technology. It further recommended extension messages and policies to be tailored towards specific groups.

Otieno (2020) investigated smallholder dairy farmers' typologies, collective action, and commercialization in Nakuru and Nyandarua Counties in Kenya. The author adopted a multistage sampling technique to select 380 dairy farmers. Principal component analysis and cluster analysis were used to determine smallholder dairy typologies. The study revealed three (3) different types of smallholder dairy farmers, namely: low resource endowed and low market-oriented; moderate resource endowed and moderate market-oriented and high resource endowed, and high market-oriented. Further, the study established that cost of production, labor engaged, land factors, household income, farming assets, experience in dairy farming, stock of dairy animals, dairy output, and consumption levels influenced smallholder dairy farmers' typologies. The study concluded that milk production was low among dairy farmers who had varied demographic and socio-economic attributes. It suggested revision of policies to boost financial resources, land accessibility, extension, technology innovations, feed availability, and physical infrastructure which are essential in boosting dairy production. Additionally, the study recommended that the policies should be accustomed to the needs of smallholder dairy farmer typologies.

Musafiri *et al.* (2020) conducted a study on farming systems' typologies analysis to inform agricultural greenhouse gas emissions potential from smallholder rain-fed farms in Tharaka Nithi County in Kenya. A multistage sampling procedure was used to select 300 farmers. PCA and CA were used to characterize the farming systems. The study established six (6) farm types: type 1 comprised of cash crop and hybrid cattle farmers; type 2 comprised of food crop farmers; type 3 composed of coffee-maize farmers; type 4 was made up of millet-livestock farmers; type 5 composed of highly diversified farmers and type 6 was made up of tobacco farmers. Household head education level, group membership, hired labor, access to extension services, and proportion of income from cropping activities were key factors that influenced farm typologies in the area. The study concluded that policies and intervention actions targeting climate smart agriculture at smallholder farm should not only consider farm-level soil fertility management technologies but also socio-economic attributes that affect adoption.

This review showed that majority of the studies focused on farmers or producers. Hence there is scarcity of information on characterization of processors especially in the baobab value chain in Kenya.

2.3 Choice of product to process

2.3.1 Overview of choice of product to process

Farm household systems are intricate, consisting of both consumption and production. The apportionment of productive resources and choice activities are outcomes of decisions made by household members (Upton, 1996). These decisions are either made individually or jointly with the other household members. Traditionally, the farmer carries two tags- producer and manager. As a producer, the farmer is involved in field operations which consist of taking care of the crops and livestock. As a manager, the farmer makes complex choices between alternatives. They decide what crops to plant or what livestock to rear. Similarly, the processor is faced by problem of what product to processor.

In making choices, the producer or the processor is guided by various objectives such as securing enough food supply, maximizing profits, avoiding risks, and survival in an uncertain environment. The processor needs not only to prioritize these objectives but also to balance them to avoid a clash. With these competing goals, the processor is forced to prioritize immediate short-term goals over long-term strategic goals. The challenge is meeting the immediate needs while working towards more sustainable and profit-focused farming.

Agricultural producers need to find solutions to production constraints and input supply, marketing, finance, and labor challenges. They need to answer the economic problem, which entails how to produce, for whom to produce, and what to produce. The ability to address the economic problem and make informed decisions is crucial for the producers and the processors in a dynamic environment.

2.3.2 Conceptual framework of choice of product to process

The processors' decision to choose the type of baobab products to process can be discussed under the theoretical framework termed as the science of choice. It is guided by the principles of rationality, which involves selecting the most cost-effective means to attain a certain goal without compromising its worthiness (Kadigi, 2013). The rational choice theory also known as rational action theory or choice theory is a theory for explaining and modelling social, economic as well as human behavior. It was popularized by Gary Becker who was the first to apply rational actor model more intensely. Proponents of the theory argue that when individuals are faced with several courses of action, they usually choose what they think will bring best outcome. Friedman (1953), simply put it as an individual's behavior of balancing the cost against benefits to attain action that maximizes personal advantage. Rational theory mostly referred to as the economic approach, has been widely used in social sciences. The view uses deductive reasoning to conclude and offers recommendations of what ought to represent the snapshot of the actual situation.

Proponents of the rational choice theory argue that it offers a unified framework for understanding human behavior, activities, and decision-making concerning their environment (Chai, 2001). However, critics have claimed that the theory fails to incorporate factors such as altruism and makes unrealistic assumptions about preferences (Herfeld, 2012). These limitations show that the snapshot of the complex world would only show few aspects of such complexity.

People's decisions and actions are guided by rational preferences and are limited by resource scarcity, quality of information, norms, and opportunity cost (Kadigi, 2013). The rational preferences are guided by key assumptions: convexity, non-satiation, and continuity, meaning that individuals will prefer more to less. Preferences are described by indifference curves, which represent the combination of outcomes that would offer the same level of satisfaction. Resource scarcity makes individuals to make choices that yield the highest effect.

2.3.3 Empirical literature on the choice of product to process in the agricultural sector

A number of studies exist in the literature that examines the choice of product to process in the agricultural sector. For example, Bardhan *et al.* (2012) investigated the factors that determined dairy farmers' choice of marketing channels and established to what extent their market choice influenced commercialization in Uttarakhand in India. The study employed a multinomial logit model (MLM) to identify major factors influencing producers' choice of marketing channels and a multivariate regression model to determine market participation level among 244 dairy farmers. Results revealed that, institutional incentives and market infrastructure increased milk production hence promoting commercialization. MLM analysis showed that high milk production would make farmers move away from cooperatives and settle to market at their point of sale.

Win *et al*. (2015) assessed the factors affecting marketing channel choice by paddy rice farmers in Myanmar. The survey used a two-stage random sampling procedure to select 200 farmers. The researchers used a multinomial logit model to analyze the factors influencing marketing channel choice. The study revealed that the probability of farmers offering their products for sale at the farm gate increased with an increase in market distance. The results further showed that access to better market information, transportation facilities, and large quantities of produce increased the chances of selling the produce directly to the mills. The study concluded that the ability of rice farmers to choose more remunerative direct channel shows their potential to increase their profit. The study proposed establishment of farmer groups, provision of marketing facilities, technical and organizational support to improve farmers bargaining power, access to credit, input, and markets to improve farmer's profit.

Thomas (2015) investigated the factors that influenced soybean farmers' choice of marketing channels in Saboba district northern of Ghana. The researchers used random sampling to select 240 soybeans farmers and 10 agents of the marketing channel. Logit model was adopted to establish the effects of economic and non- economic factors on producers' choice of marketing channels. The study found that age, mode of payment, the speed of payment, and price of soya beans influenced the farmers' decision to sell directly to the sedentary wholesalers. Cooperative membership of the farmers, marital status and the household size were found to have an influence on the farmers' decision to sedentary wholesalers relative to the direct sale to the NGOs. The study concluded that price of soyabean influenced the choice of marketing channel. The study recommended that the Ministry of Food and Agriculture and NGOs involved in agriculture should regularly provide current information on prices of soyabean to enable farmers make informed choices.

Jari and Fraser (2009) conducted research to establish the influence of technical and institutional factors on agricultural marketing amongst 86 smallholder farmers in Kat River valley, South Africa. The study used logit regression to identify the factors that affected the marketing choices of small-scale and new farmers in the study area. The study found that market information, expertise on grades and standards, contractual arrangement, social capital, market infrastructure, group participation, and traditions significantly influenced household marketing behavior. They concluded that farmers used informal marketing to sell their produce due challenges involved in formal marketing. The study suggested that the policy makers should craft policies that improve access to market information, increase farmers expertise on grades and standards, provide social capital and promote farmer groups formation.

Kirui *et al.* (2016) investigated the determinants of tea marketing channel choice and sales intensity among smallholder farmers in Kericho District, Kenya. The researchers adopted a multistage sampling technique to select 155 respondents. The researched employed Heckman two stage method to identify the factors that determined tea growers' choice of marketing channel and sales volume decision once sales were done. The study revealed that education, experience, age, second payment and gender significantly influenced growers' participation in marketing channel. Second payment, age, experience and tea production affected the intensity of participation in marketing channel. The researchers concluded that price was key factor that influenced tea marketing. They proposed provision of information on tea prices to enable farmers to participate in tea marketing.

This literature survey showed that, the majority of the studies focused on farmers or producers and particularly on the choice of marketing channels. Hence, there is shortage of information on how processors make choices of what to process and more so in baobab value addition.

2.4 Processing efficiency

2.4.1 Overview of efficiency

The main aim of every economic activity is to achieve maximum performance or efficiency. Efficiency is a concept used to compare two values: the optimal value and the expected value. The concept of efficiency occurs in a production process where inputs are used to produce the required outputs. Generally, efficiency is a term used to measure results achieved given a certain combination of raw materials. According to Fried *et al.* (2008), the difference in productivity is a function of variations in the level of operations, technology, operating efficiency and the business environment.

Improved yields or productivity can be achieved by improving technology such as through use of better machines and better seed varieties. Alternatively, productivity can be increased by introducing aspects that increase the firm's efficiency. Profit efficiency is the ability of a firm to earn the best possible profit given the inputs and the levels of fixed aspects (Chacha, 2013). Efficiency can be discussed in the following terms; economic, allocative and technical efficiency. Economic efficiency can be defined as the ability of the firm to produce a set quantity of output at a minimum cost given a certain level of technology (Bravo & Pinheiro, 1997). Economic efficiency comprises of allocative and technical efficiency. Technical efficiency is the ability of a firm to produce a given output given the resources, while allocative efficiency is about choosing the optimal ratio of inputs with the least cost in production.

2.4.2 Conceptual framework of efficiency

Farrel (1957) defined efficiency as the capability of the firm to achieve maximum yields or output from the given inputs. Technical efficiency is the ability of a firm to produce maximum output with a given set of inputs in an underlying production frontier or function. A production function depicts the relationship between the yields produced and the inputs using the existing set of technology. Technical efficiency can be expressed in two approaches: the input-oriented approach and the output-oriented approach.

On the other hand, allocative efficiency measures the capability of the firm to use the optimum amounts of inputs given the prices (Kadigi, 2013). Alternatively, it can be defined as the ratio between the total cost of producing a single unit of output in a technically efficient environment using the actual relative amount of inputs and the total cost of producing a single unit of output in a technically efficient environment using optimal relative amounts of inputs (Masaku *et al*., 2014).

Allocative efficiency determines the success of the firm in combining the appropriate inputs for production. Success is equated to profit maximization. Notably, for a firm to reach profit maximization in a perfectly competitive market, its marginal value product resulting from producing the extra unit must be equal to the unit cost. In each production frontier, the firm operating inside the function is deemed inefficient, while the firms operating on the frontier are said to be efficient. Those firms operating inside the frontier are considered inefficient because they are not able to employ all the resources in the production process. The profit production approach combines the aspect of technical and allocative efficiency in the profit relationship. Farrel (1957) explained the difference between allocative and technical efficiency using inputs X_1 and X_2, as shown in figure 2.1

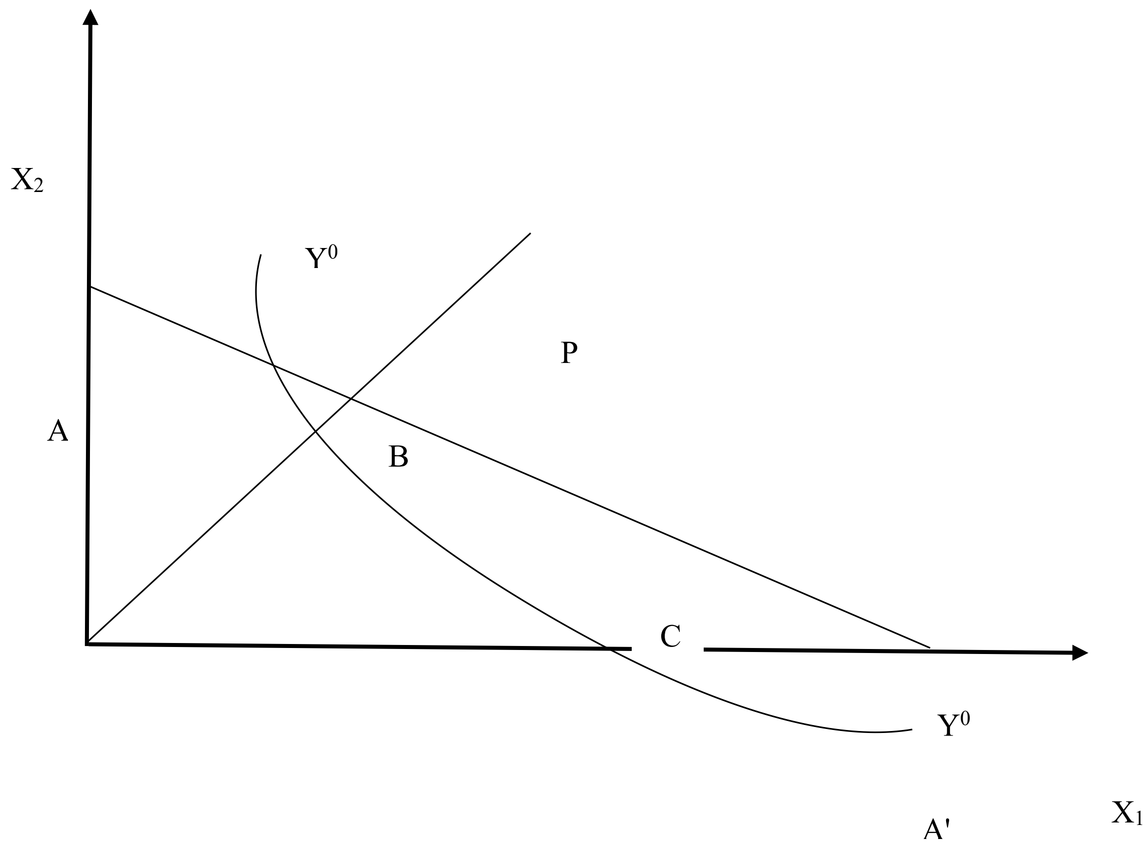

Figure 2.1: The relationship between technical and allocative efficiency

Source: Farrel, 1957

Isoquant Y_0 is the efficient production function that gives the combination of factors of input X_1 and X_2 that can produce a commodity. Point P is technically inefficient because it lies outside the isoquant Y_0. Point B is technically efficient because it lies on the isoquant Y_0. However, it is not allocative efficient since it does not lie on line AA', the iso-cost line. Point C, which lies at the tangent of the iso-cost line and isoquant, is deemed to be both technical and allocative efficient. At this point, the firm achieves economic efficiency (Elias *et al.*, 2017)

2.4.3 Empirical literature on the profit efficiency in the agricultural sector

There are a number of studies which have applied the concept of profit efficiency.

Ali & Finn (1989) estimated profit efficiency among Basmat rice producers in Pakistan Punjab. Random sampling technique was used to select 120 rice producers. The researchers used stochastic profit frontier model to estimate profit efficiency and factors influencing profit efficiency. The study revealed that rice producers experienced 28% profit inefficiency. The mean loss of profit was Rs1,222 per hectare. The factors that influenced profit efficiency were water constraint, late application of fertilizer, education, credit constraint and non-agricultural employment. The study concluded that farmers were inefficient in the use of their resources and there was potential to increase income without increasing resources. It suggested provision of credit facilities, extension services, promotion of modern production technologies and improvement of rural education to spur profit efficiency.

Ogunniyi (2011) estimated the profit efficiency of maize producers in Oyo state in Nigeria. The study randomly sampled 240 maize producers and employed a stochastic frontier profit function to measure the profit efficiency among maize producers. The results revealed that profit efficiencies of the farmers varied widely between 1% and 99.9%, with a mean score of 41.4%, suggesting that an estimated 58.6% of the profit was lost due to a combination of technical and allocative inefficiencies in maize production. In addition, the inefficiency model showed that education, experience, extension, and non-farm employment significantly influenced profit efficiency. The study concluded that farmers were inefficient in maize processing. It recommended improvement of education among farmers and extension agents to lower inefficiency in maize farming.

Mulie (2014) conducted a study on the determinants of profit efficiency of coffee producing and marketing cooperatives in Ethiopia using Sidama coffee farmers' union as a case study. The research adopted a stochastic profit frontier model to estimate the profit efficiency of the cooperatives. The results revealed that the area under coffee and the cost of hired labor positively impacted the profit levels, while the cost of family labor and capital negatively influenced profitability. The analysis further showed that firms were not operating on the profit frontier since the mean profit efficiency was 57%, implying that 43% of the profit was lost due to the organization's allocative and technical inefficiency. In addition, the study established the sources of inefficiencies to be limited access to credit, lack of storage after harvest, education level, and lack of extension services. The study concluded that famers' inefficiency in coffee farming was due inadequate to storage facilities, lack of formal education and low extension services. The researcher proposed that the government needed to train farmers on basic farming skills and promote farmers groups and cooperatives.

Ng'ang'a *et al*. (2010) conducted a study on profit efficiency among 40 smallholder milk producers in Meru- South District, Kenya. The study adopted a stochastic profit frontier and inefficiency model to measure profit efficiency. The results showed a mean profit of 60% of the sampled farmers that varied between 26% and 73%, implying that an estimated 40% of the profit is lost in production due to a combination of both technical and allocative inefficiencies. The study further revealed that education level, experience, and farm size influenced profit efficiency positively while profit efficiency decreased with age. The researchers concluded that, farmers with high level of education, more experience, and large farms were more efficient. The study suggested that profit inefficiency among smallholder dairy milk producers in the study area could be reduced significantly by improving the farmers' education.

Mawa *et al.* (2014) estimated the profit efficiency of 122 smallholder dairy farmers in Rift Valley and the Central provinces of Kenya. The study used stochastic frontier analysis to estimate the profit efficiency and its determinants. The results established that farmers were fairly profit efficient with an average score of 68%. The cost of fodder produced on the farm was found to significantly improve profit efficiency among farmers. The study revealed that the size of the land under fodder positively influenced the profit efficiency of dairy farmers, while age and access to extension services negatively influenced the profit efficiency of dairy farmers. In addition, the application of modern technologies such as quality feeds improved the profit efficiency of dairy farmers. The study concluded that profit efficiency could be increased if fodder production was enhanced. It recommended introduction of institutional policies to improve the profitability and productivity of smallholder dairy farmers.

An observation made on the review of literature was that, most efficiency studies were based on farmers. There seems to be a shortage on efficiency studies in the agro-processing sector. Hence, this study determined the efficiency of baobab processors in Kenya.

2.5 Overview of the literature surveyed

A panoramic view of the literature surveyed, shows that, there exist a number of gaps in baobab processing. First, the characterization of baobab processors is not well known or documented. Second, there is scarcity of information on the choice of product to process. Third, there is knowledge gap on the efficiency of baobab processors. Thus, the study sought to fill the above gaps by characterizing baobab processors, establishing the factors that influence the choice of baobab product to process and estimating profit efficiency and its determinants among baobab processors in Kitui, Makueni, Kilifi, Mombasa, and Nairobi Counties of Kenya.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the theoretical framework, research design, and methods used in this study. It starts with section 3.2, which describes the theoretical framework, empirical specification, and estimation procedure for characterization. Section 3.3 explains the theoretical framework, econometric specification, and estimation procedure for choice of baobab product to process. In section 3.4, the theoretical framework, econometric specification, and estimation procedure for profit efficiency are described. Section 3.5 explains the research design, which involves the target population, sampling techniques, sample size, construction of research instruments, and pilot study. The section also describes the techniques for data collection and data analysis procedure.

3.2 Baobab characterization

3.2.1 Theoretical framework for characterization

Characterization in agricultural production and processing generally involves describing various classes of the processors. Producers with similar characteristics are grouped in the same class. This simplifies the study and understanding of the producers in the complex agricultural system. Various studies have characterized producers in the agricultural sector intending to establish producers' clusters. The purpose of characterization is to inform policy implementation for the various producers (Otieno, 2020).

Understanding the needs and requirements of the processors is necessitated by the heterogeneity among the processors. The variation in baobab processing is due to different resources endowment among the processors. Additionally, each processor is faced with a unique challenge. Baobab processors make decisions based on resource availability. Their processing revenues vary due to use of different quantities and qualities of inputs during the value addition process. Due to these variations, placing processors in their respective classes provides a suitable framework for providing intervention to each processor. Transforming baobab processing from an informal activity to a profitable venture lies in understanding the need and providing a solution to each challenge the processor faces.

3.2.2 Empirical specification of processor characterization

Two sequential multivariate statistical techniques, principal component analysis (PCA) and cluster analysis (CA), were used to characterize baobab processors. PCA was used to reduce information from original interdependent variables to a smaller set of independent variables, a case that also applies to baobab processors. The reduction thus shortens the dimensions while retaining the original information. PCA describes the difference between the correlated variables using smaller sets of uncorrelated variables (Chatterjee *et al*., 2015) . PCA is guided by the assumption of data interdependence normality, matrix factorability, and sampling adequacy. The data were subjected to Kaiser-Meyer-Olkin (KMO) and Bartlett Test of Sphericity (BTS) to uphold these assumptions. KMO and BTS were used to test for data adequacy and matrix factorability, respectively. Since the number of variables in the study was below 30, all factors with an eigenvalue above one were retained as per the Kaiser criterion (Field, 2005) . The retained factors were then subjected to orthogonal rotation.

The typical context for PCA involves a data set with observations on *p* numerical variable for each *n* individuals. These data values then define *p* *n*-dimensional vectors. Suppose *x* is a vector of random variable *n* and the transpose of x^T denotes the transpose of *X*. Thus

$x = [x_1, x_2, ..., x_t]^T$ .... (3.1)

The first step is to look for the linear function of $\alpha_1^T x$ of elements *x* with the highest variance, where $\alpha_1$is a vector of n constants $\alpha_{11}, \alpha_{12}, ..., \alpha_{1n}$ so that

$\alpha_1^T x = \alpha_{11}x_1 + \alpha_{12}x_2 + ... + \alpha_{1n}x_n = \sum_{j=1}^{n} \alpha_{1j}\, x_j$ .... (3.2)

Similarly, it is important to find the linear function of $\alpha_2^T x$ which is uncorrelated with $\alpha_1^T x$ and which has maximum variance and then, the linear function $\alpha_3^T x$ which is uncorrelated to $\alpha_2^T x$ and $\alpha_1^T x$ and so on up to n^{th} linear function such that k^{th} linear function is uncorrelated with $\alpha_1^T x, \alpha_2^T x ..., \alpha_{k-1}^T x$. The above transformation forms *n* new random variables called principal components (Jolliffe, 1986). Principal components are derived as described below.

The first principal component is defined by the linear combination of x variables having maximum variance. M denotes a covariance non-singular and positive semi-definite matrix of random variable *x* with n dimensions. Element (*i* ,*j*) of matrix M expresses the covariance between x_i and x_j where $j \neq i$.

The first step involves finding vectors of α_1 that maximize the variance of $\alpha_1^T x$, expressed as

Maximize $var[\alpha_1^T x] = \alpha_1^T \sum \alpha_1$………………………… (3.3)

A normalization constraint ($\alpha_1^T \alpha_1 = 1$) needs to be added for equation 3 to achieve maximum. That is $\alpha_1^T = \sum_{i=1}^{r} \alpha_{1i} x_i$ ……………………………………… (3.4)

To maximize the variance of $\alpha_1^T x$ subject to the constraint, the Lagrange multipliers technique is applied. Maximize $\alpha_1^T \sum \alpha_1 - \lambda(\alpha_1^T \alpha_1 - 1)$ ……………. (3.5)

Where λ is the Lagrange multiplier,

Differentiation with respect to α_1 produces

$\sum \alpha_1 - \lambda \alpha_1 = 0$ ……………………………………… (3.6)

Which can also be written as $(\Sigma - \lambda I_n)\alpha_1 = 0$ ……….. (3.7)

Where I_n stands for $(n \times n)$ identity matrix, hence α_1 is the eigenvector and λ the eigenvalue of Σ. The next step is to decide which eigenvectors produce the maximizing value for the first principal component. To achieve that, it is necessary to maximize,

$\alpha_1^T \sum \alpha_1 = \alpha_1^T \lambda \alpha_1 = \lambda \alpha_1^T \alpha_1 = \lambda$ ……………………… (3.8)

Thus λ must be the largest possible eigenvalue hence α_1 is the eigenvector that corresponds to the largest eigenvalue.

After deriving the first principal component, a similar process can be applied to others such that the k^{th} principal component of x is $\alpha_k^T x$ and its variance is λ_k. Thus, λ_k is the k^{th} biggest eigenvalue while α_k is the corresponding eigenvector of Σ, where *k* =1, 2…, *n* (Jolliffe, 1986).

The second PC describes the linear combination of the X variables accounting for the total remaining variation. The constraint to this component is that the correlation between the first and second components is equal to zero. The second component $\alpha_2^T x$ maximizes $\alpha_2^T \sum \alpha_2$.This can be expressed as,

$$cov(\alpha_1^T x, \alpha_2^T x) = \alpha_1^T \sum \alpha_2 = \alpha_2^T \sum \alpha_1 = \alpha_2^T \lambda_1 \alpha_1^T = \lambda_1 \alpha_2^T \alpha_1 = \lambda_1 \alpha_1^T \alpha_2 \text{ …. } (3.9)$$

Where cov (*x, y*) denotes covariance between variable *x* and *y.*

$\alpha_2^T \sum \alpha_2$ is maximized subject to these constraints: $\alpha_2^T \alpha_2 = 1$ and $\alpha_2^T \alpha_1 = 0$. To carry out the maximization process, the Lagrange multiplier method is employed, as shown below.

$$\alpha_2^T \sum \alpha_2 - \lambda(\alpha_2^T \alpha_2 - 1) - \phi \alpha_2^T \alpha_1 \text{ ………………………………………… } (3.10)$$

Where λ and ϕ are Lagrange multipliers. The next step is to differentiate with respect to α_2,

$$\sum \alpha_2 - \lambda \alpha_2 - \phi \alpha_1 = 0 \text{ …………………………………………………… } (3.11)$$

The equation is then simplified by multiplying the left side by α_1^T

$$\alpha_1^T \sum \alpha_2 - \lambda \alpha_1^T \alpha_2 - \phi \alpha_1^T \alpha_1 = 0 \text{ ………………………………….. } (3.12)$$

Given that $\alpha_1^T \sum \alpha_2 = 0$, $\alpha_1^T \alpha_2 = 0$ and $\alpha_1^T \alpha_1 = 1$, the equation reduces to $\phi = 0$.

Substituting ϕ with 0 in the equation will give

$$\sum \alpha_2 - \lambda \alpha_2 = 0 \text{ …………………………………………………… } (3.13)$$

Which can also be written as

$$(\Sigma - \lambda I_p)\alpha_2 = 0 \text{ …………………………………………………… } (3.14)$$

Where λ is an eigenvalue and α_κ is the corresponding eigenvector of $\sum$, since $\lambda = \alpha_2^T \sum \alpha_2$, λ will be as big as possible, assuming that $\lambda_1 \neq \lambda$ and does not violate correlation constraints. A similar procedure can be used to find the 3rd, 4th and pth PCs. The retained factors in PCA were used in CA to characterize baobab processors according to similarities or dissimilarities of their presented attributes. Individuals with similar characteristics were grouped in the same cluster.

3.2.3 Estimation procedure for processor characterization

In the first stage, 13 socioeconomic variables that described the attributes of baobab processors were used for PCA as shown in table 3.2. PCA condensed all the interrelated variables to a set of interdependent factors called the principal components. The factors were rotated using the varimax method, and highly correlated variables were put under each factor. All factors with an eigenvalue of above one were retained and explained. In this study, 4 components were retained.

In the second step, the retained factors in PCA were used in CA to characterize baobab processors according to similarities or dissimilarities of their presented attributes. Individuals with similar characteristics were grouped in the same cluster. A two-step clustering method was adopted, namely: hierarchical and partitioning clustering, to establish the number of clusters. The method was used due to its ability to automatically select clusters and create clusters based on categorical and continuous variables. In the hierarchical method, the k-cluster is formed by joining two clusters from the K+1 cluster, while the partitioning method separates observations in various numbers of clusters. A dendrogram was also used in determining the number of clusters. Further, a one-way Analysis of Variance (ANOVA) was used to identify the differences in variance between the clusters.

3.2.4 Baobab processors' characterization variables

Variable	Description	Variable type
Age	Age of processors (years)	continuous
Education level	Years of formal schooling of the processor	continuous
Other sources of income	Annual income (KShs)of the processor	continuous
Access to land	Yes =1, No =0	categorical
Land size	Processor's size of the land in acres	continuous
Access to baobab trees	Yes = 1, No = 0	categorical
Number of trees owned	The total number of baobab trees owned	continuous
Credit access	Yes = 1, No = 0	categorical
Total processing cost	Annual variable cost (KShs)	continuous
Processing revenue	Annual revenue (KShs)	continuous
Household size	Number of individuals in the processor's household	continuous
Experience	Years of baobab processing	continuous
Profit	Annual profit from baobab processing (KES)	continuous

Table 3.1: Key Processor Characterization variables

3.3 Choice of product to process

3.3.1 Theoretical framework of choice of product to process

This study is anchored on the random utility model which is based on the assumption that a person will make a decision that yields maximum utility (Mcfadden, 1979). We can assume that a processor i chooses from a set of mutually exclusive baobab products to process =1, 2...n. The processor achieves a certain given level of utility (U_{ij}) from each product chosen. The principle behind the processor's choice or decision is that he or she makes the decision that maximizes the utility. Subsequently, the processor makes a profit based on the utility achieved by processing a particular type of baobab product.

It is not possible to observe the processor's utility, but instead, some characteristics of alternative choices he or she has made can be observed. Therefore, a processor with specific characteristics associates a given utility level with each alternative baobab product choice. The processor's characteristics may be socio-demographics, institutional or technical factors. The i^{th} processor is faced with discrete choices between 1 candy (mabuyu), and 0 other baobab products given various attributes contained in each set. The utility is divided into two different parts: the deterministic (v_{ij}) and the random components (e_{ij}) as shown in equation (3.15)

$$U_{ij} = V_{ij} + \varepsilon_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.15)$$

Since the random component (ε_{ij}) is not observed, the processor's choice of products cannot be predicted clearly. Instead, the probability of choosing any particular product is derived. The utilities cannot be observed directly, but the choice made by the processor shows his or her highest utility. Therefore, a processor will select a product to process j=1 if; $U_{ik}>U_{ij}$, where U_{ik} represents a random utility associated with baobab product j=k.

3.3.2 Empirical specification of logit regression model.

In most of the studies that have adopted the logit or probit models for analysis, the choice to adopt or not adopt is viewed as an outcome of a binary choice model (Pivotal et al., 2019). Therefore, in this study, the choice of baobab product to process is modelled as a binary variable, which takes 1 if an individual chooses to process Mabuyu (candies) and 0 if he or she chooses to process the other commodities. According to Carrer *et al*. (2017), utility maximization influences producers to adopt an agricultural innovation. This occurs when the expected utility of adoption exceeds the utility of non-adoption. This study assumes that the baobab processor will process candies when the expected utility from candies exceeds the utility of processing other products. However, the vice versa is also correct.

Random utility framework enables a person to decide between alternatives, selecting the highest utility alternative. Such that, U_{1i} is the utility an individual i realizes if 1 is selected and U_{01} is the utility that the person gets if option 0 is selected. The decision on the choice made is affected by various factors, as expressed in equation (3.16)

$Y_I^{*}=X_I^{'}\beta_k + \varepsilon_i$……………………… ………………………….. (3.16)

Where X_i represents the vector of the independent variables, β is a vector of the parameter, and ε is the error term. The probability that a processor chooses baobab candies is expressed as:

$P[Y_i = 1] = P(e >- X_i\beta)$

$= 1 - F(- X_i\beta) = (FX_i\beta) = \frac{1}{1+e^{-(X_i\beta)}}$ ……… (3.17)

Where F is the cumulative distribution function, and β parameters are computed using maximum likelihood procedures. Logit model was adopted to estimate the likelihood of processing baobab candies. This can be expressed as follows

$P_i = P[y_i = 1] = \frac{e^{Xi\beta}}{1+e^{-(Xi\beta)}}$ ………………………………… (3.18)

3.3.3 Estimation procedure for choice of product to process

Logistic regression analysis is a model used to predict the relationship between a categorical dependent variable and a set of explanatory variables (Green, 2002). This means that the dependent variable has to take values such as 1 and 0. In logistic regression analysis, the categorical dependent variable is regressed on a set of independent variables. The logistic regression model was adopted because it is a multivariate method that estimates the probability that either event occurs or does not occur. Logistic analysis can calculate the probability of an event occurring and that of not occurring. For instance, it can compute the probability of a firm adopting a certain technology in production and not adopting it. In this case, a processor adopting the technology will be 1, and not adopting will be 0. Logit model uses maximum likelihood, which maximizes the chances of getting observed results, given the fitted regression coefficients.

The logistic regression model does not work with an assumption of a linear relationship between the dependent and independent variables but requires that the independent variables be linearly related to the logit of dependent variables (Gujarati, 1992). It is assumed that processors select a product that maximizes their utility subject to resource scarcity and socioeconomic constraints. If the cost of processing a particular baobab product exceeds its benefits, then the processors will not proceed to process the commodity. Instead, they will process a product in which benefits will surpass the cost

Table 3.2 shows the variables for the choice of product process and their hypothesized sign.

Variables	Variable explanation	Expected sign
Age	Year attained by the processor	+-
Years of schooling	Number of years in spent school by the processor	-
Marital status	1=married, 0=single ,2=divorced, 3=widowed,4=separated	+
Household size	Number members in the processor's household	+-
Land size	Size of land in acres owned by the processor	+-
Total awareness score	Number of baobab products the processor is aware of.	-
Access to baobab trees	1=Yes, 0=No	-
Number of trees owned	Number of baobab tree owned by the processor	-
Years of processing	Number of years spent in baobab processing	+-
Access to training	1=Yes, 0=No	-
Credit access	1=Yes, 0=No	+-
Nonprecessing income	Processor's mount of income from other sources in KES	
Processing pattern	1=similar 0=not similar	+-
Awareness score	The number of baobab processed products that a processor know	-

Table 3.2: Socio-economic variables for choice of product to process

3.4 Profit efficiency

3.4.1 Theoretical framework of profit efficiency

Production theory is a study content in the microeconomic theory that deals with producing an output given proportions of inputs. Production frontier is used to depict this relationship. The firm's objective is to maximize profits, which can be done by increasing the output produced or reducing the output cost (Efrance *et al*., 2016). Thus, the production frontier shows the maximum output produced using a given level of capital, labor, and raw materials. The output is also referred to as the total physical product (TPP). The marginal physical product of an output (MPP) is the additional good or commodity produced by using an extra unit of input while holding all other production variables constant.

Returns to scale are used to describe the firm's behavior with respect to an increase in the use of inputs. Return to scale can either be increasing, decreasing, or constant return to scale. The production function can be expressed in the following forms; linear function, polynomial function, and Cobb-Douglas function. Cobb-Douglas can further be modified to trans-log and transcendental functional forms. The production function represents a fixed state of technology. Once the technology changes, the production function will also change. According to Farell (1957), a positive technological change moves the production function towards the origin thus, the output is produced using lesser inputs while a negative technological change moves it away from the origin.

In measuring profit efficiency, three approaches are used i.e., parametric (stochastic production frontier), non-parametric (Data Envelopment Analysis), and productivity indices which is based on index theory principle and growth accounting (Coeli *et al*., 1988). The most used methods are stochastic frontier analysis (SFA) and Data Envelopment Analysis (DEA). The two methods estimate cost, profit, and technical efficiency. DEA applies linear programming to develop a pairwise frontier that envelops the firm's observation, while the stochastic frontier model requires that a functional firm be specified for frontier production function. DEA has an advantage over SFA in that multiple inputs and outputs can be considered simultaneously, thus inputs and outputs can be quantified using different units of measurements. However, SFA has an advantage over DEA since it considers the measurement error that may occur while dealing with the agro-based industry. In this study, stochastic frontier analysis was used to evaluate the profit efficiency of baobab processors.

3.4.2 Empirical specification of profit efficiency of baobab processing

Profit efficiency is defined as the profit earned by operating on the profit frontier while considering input prices and other factors (Kolawole, 2006). Stochastic frontier profit function was used in this study, similar to the studies conducted by Chacha (2013), and Nmadu & Garba (2013) who used the same model to postulate a profit function consistent with the stochastic concept. Processors' profit was measured using gross margin analysis model, which was computed by subtracting total variable cost from to total revenue as shown below;

$$\pi = \sum (TR - TVC) = \sum (PQ - WX_i) \ldots\ldots\ldots\ldots \text{(3.19)}$$

The profits are normalized by dividing the equation by the P the output price,

$$\frac{\pi\,(p,z)}{p} = \sum\left(\frac{PQ - WXi}{P}\right) = Q - \frac{WXi}{p} = f(X_i\ Z) - \sum P_i X_i \ldots\ldots \text{(3.20)}$$

Where TR represents total revenue, TVC is the total variable cost, Q is the quantity of input used, Z is the price of fixed input, P is the price of the output(Q), P_i=w/p which is the price of input X_i and f (X_i Z) represent production function.

The model begins with considering a stochastic function with a multiplicative disturbance term in the following form (Chacha, 2013):

$$\pi = f(Pi, Zik\beta i)ei(Ei) \ldots\ldots\ldots\ldots \text{(3.21)}$$

Where π is the normalized profits computed by subtracting variable cost from gross revenue and dividing the outcome by the output price, P_i is the normalized price of variable input by the processor divided by the output price, Z_i is the level of the k^{th} factor on the processing firm, β_i is the vectors of the parameters, e_i is the stochastic disturbance term consisting of two independent elements v and u

While $E_i = V_i + U_i$

$V_i^{'}$ is assumed to be independent and identically distributed random errors having normal $N(0,\delta^2)$ distribution independent of U_i while U_i is the one-sided disturbance representing profit inefficiency and is assumed to be non-negative.

The stochastic frontier model can determine both the individual profit efficiency and the determinants of profit efficiency. The frontier of the processing firm is given by;

$$\pi = \left(P_{i,} Z_i K, \beta\right) e^{(u+v)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.22)}$$

Profit efficiency of a processor is described as the ratio of predicted actual profit to the predicted maximum profit. Profit efficiency of the processor is expressed in equation (3.23)

$$\frac{\Pi}{\pi^{Max}} = \exp\frac{\exp\,[\pi(p,z)]\,\exp\,(\ln v)\,\exp\,(\ln U)\theta}{\exp\,[\pi(P,z)]\,\exp\,(Lnv)\theta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.23)}$$

where π is the predicted actual profit and π^{Max} is the predicted profit.

The profit function can be estimated using the maximum likelihood technique given the density function u_i and v_i. Profit efficiency will take values between 0 and 1. When U_i =

0, meaning that it is lying on the frontier, the processor has potential maximum profit given the processor's price and the level of fixed factors. On the other hand, if $U_i > 0$, the processor is inefficient and operates on low profits due to inefficiency (Nmadu & Garba, 2013).

The stochastic frontier function and behavioral inefficiency were used to estimate all parameters using one step likelihood estimation technique. The explicit Cobb – Douglas functional form for baobab processors was expressed as shown in equation 3.24.

$$ln\pi_{=} \beta_0 + \beta_1 \, lnX_{1i} + \beta_2 \, lnX_{2i} + \beta_3 \, lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_5 + V_i - U_i \text{ .... (3.24)}$$

Where π is normalized profit function, estimated by subtracting variable cost from total revenue.

X_1 is the normalized price of labor per person-day

X_2 is the normalized price of baobab pulp on seed per kg,

X_3 is the normalized price of sugar per kg,

X_4 is the normalized price of food color per Kg,

X_5 is the normalized price of heating (cost of cooking during the processing). The source of heat could be charcoal, firewood, kerosene, or electricity).

X_6 is the normalized price of flavor per litre

X_7 is the normalized price of packaging per packet.

β_0 is the intercept and

β_0-β_{15} are the parameters to be estimated,

U_i is the non-negative random, which affects the profit efficiency of the processor. U_i represents the inefficiency of the processor as it is assumed to be independent of V_i. The following equation defines U_i

$$U_i = \propto_0 + \propto_1 G_{1i} + \propto_2 G_{2i} + \propto_3 G_{3i} + \propto_4 G_{4i} + \cdots \propto_{15} G_{15i} \text{ ....} (3.25)$$

Where α_0 is the intercept

α_1 -α_{15} are the unknown parameters

G_1 is the Education of the processor (years)

G_2 is the gender of the processor

G_3 is the access to land

G_4 is the access to baobab trees,

G_5 is the number of baobab trees owned,

G_6 is the experience (years in processing,

G_7 is the income from other sources

G_8 is access to credit

G_9 is the access to training

G_{10} is the age of the processor

G_{11} is the marital status of the processor

G_{12} is the access to information

G_{13} is the involvement in the non-processing occupation

3.4.3 Estimation procedure for profit efficiency

Profit efficiency refers to the ability of the processors to achieve the highest possible gain given the prices of inputs and outputs. Profit efficiency is hinged on the production theory, where a processor is assumed to combine variable inputs and outputs that yield the highest profits. A processor involved in production makes two major decisions: the decision on the production methods to use and the decision on the most profitable quantities to produce. While making these decisions, the firm ensures that its costs are minimized. This means that the firm endeavors to produce quality products as cheap as possible. To achieve this, the firms choose the best combination of inputs that will produce the required amount of outputs using the least cost (Mulie, 2014). This is better explained by a production function which is the representation of the quantitative relationship between the outputs and inputs used in the production process. A processor producing an output- candy from several inputs such as sugar, color, and baobab input, among others purchased at a given input price and operating at a profit frontier, will be deemed profit efficient. However, if the processor uses the combination of inputs and outputs and fails to operate on the profit frontier will be deemed inefficient. Profit efficiency is a key performance tool that estimates the firm's efficiency and the potential profit if it was utterly efficient. Table 3.4 shows variables used in the frontier profit function, inefficiency models and their expected signs

Table 3. 3: Description of variables in the frontier profit function and inefficiency models.

Variable name	Description of variable	Expected sign
Variables in the profit function		
Ln profit	Normalized profit of baobab processors	
ln Labor	Normalized cost of labor	+-
ln Baobab	Normalized cost of baobab input (fruit, pulp on seed, pulp)	-
ln Sugar	Normalized cost of sugar	-
ln Fuel	Normalized cost of fuel (mode of heating)	-
ln Color	Normalized cost of food color	-
ln Flavor	Normalized cost of flavor	-
ln Packaging	Normalized cost of packaging	-
Inefficiency model variables		
Years of schooling	Processor's number of years spent in school	-
Gender	1= male, 0= female	+
Access to land	1=Yes, 0=No	-
Access to baobab trees	1=Yes, 0=N0	-
No. of baobab tree owned	Number of trees owned the processor	-
Experience	Processor's years of processing	-
Income from other sources	Processor's Amount of income from other sources in KES	-
Access to credit	Amount of credit accessed by the processor in KES	-
Access to training	1=Yes, 0=No	-
Age	Years attained by the processor	+-
Marital status	1=married, 0=single	-
Non-processing occupation	1=Yes, 0=N0	+
Access to information	1=Yes, 0=No	-

3.5 Data sources and collection

3.5.1 Study area

The study was conducted in Nairobi, Mombasa, and Kitui counties. Kitui, Makueni and Kilifi counties represent the rural processors. In all the above-named counties there is high prevalence of baobab production and processing. Kitui lies between latitudes $0^{0}3.7'$

and 3°00' south, and longitudes $37^0$45' and $39^0$00'. It is characterized by a rapidly growing population of 1,136,187 with falling food production and falling resilience to climate change (KNBS,2019), with 60 % of the population living below the poverty line.

Nairobi County has the highest urban population in Kenya and is characterized by a rapidly increasing population. This means that it is a future potential market for baobab products. This market can only be satisfied if the valued addition and baobab processing is improved. Thus, raising the profit efficiency of the baobab processors. In Nairobi, data was collected in Eastleigh, Jamia Mall, Pumwani, and Kibra. In Mombasa, the study was conducted in Kongoea, Marikiti, Likoni, and Mwembe Tayari. The main economic activities in Mombasa are, fishing, trading and tourism.

Makueni County is found on the lower side of eastern region with vast part of the county being semi-arid. The economic activities in the area are: crop farming and livestock rearing. Fruit growing is a common practice in the area with main fruits being mangoes, and oranges. Other wild fruits such as baobab are also found in the region. In Makueni County, the survey was done in Makindu, Kibwezi and Mtito Andei.

Kilifi County lies between latitude $2^0$20" and $4^0$0" south, and between longitude $39^0$05" and $40^0$14" East. It covers an area of 12,370.8km^2 and a home to 1,453,787 people. The main economic activities in Kilifi include: crop farming, livestock production, fishing, and apiculture. More than half of the land is arable for crop production (County Government of Kilifi, 2018). The county has a large population of baobab trees. The study was conducted in Malindi, Ngomeni, Takaungu, Mtwapa, Mnarani, Tezo, and Sokoni township areas. Figure 3.1 shows the location of study areas in Kenya.

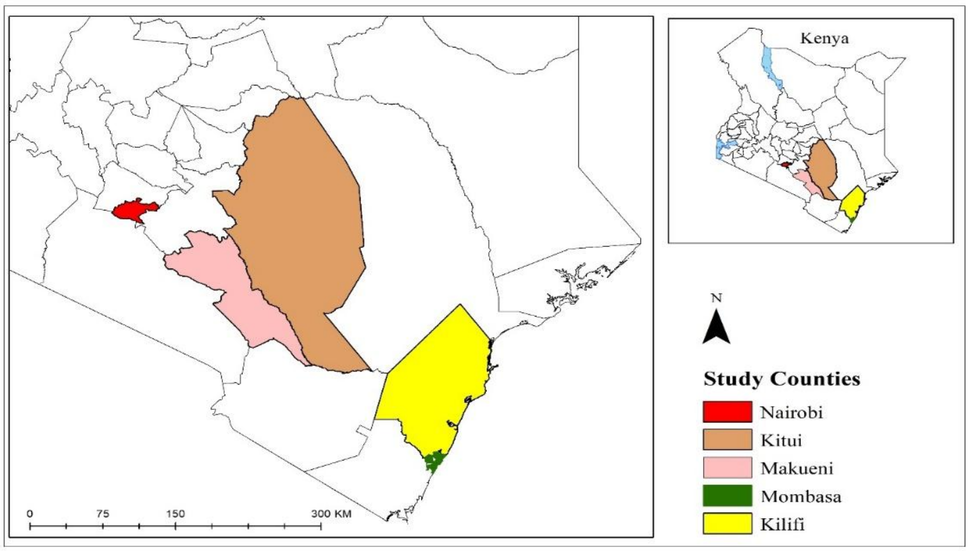

Figure 3. 1: Map of Kenya

3.5.2 Research design

The study adopted a cross-sectional survey. This design allows data to be collected in a single time for a sample to represent a big population. The design is preferable because it allows the researcher to collect data within a short period of time. In addition, it allows the researcher to accommodate a large sample size while maintaining the confidentiality of the data. Moreover, the design gives accurate responses to the questions asked.

3.5.3 Sampling

The target population was both the urban and rural townships processors of the baobab products. A multistage sampling technique involving purposive and snowball sampling were used to select respondents in Kitui, Makueni, Nairobi, Mombasa, Kilifi, and Kitui. A sample size of 304 respondents was selected. Using the Cochran (1977) formula, the sample size was determined as

$$n = \frac{Z^2 * P(1-P)}{e^2}$$

$$n = \frac{1.96^2 * 0.5(1-0.5)}{0.5^2}$$

Where, n = Target sample size, p = proportion of the population containing the major interest (0.5), z = confidence level (1.96). e = marginal error (0.05). n = 304.

3.5.4 Data collection tools

The research used primary data, where data was collected through the administration of questionnaires. The questionnaire was structured to capture questions on the processor demographics, institutional aspects, knowledge level, and awareness of processed baobab products. A pilot study was conducted to establish the viability of the tool.

3.5.5 Data analysis and presentation

The study used descriptive statistics and regression analysis to present the relationship between various variables. Descriptive statistics involved the use of mean, percentage, and frequency tables. Different econometric models were run using STATA and Frontier 4.1 programs. Descriptive statistics and cluster analysis were used to characterize the baobab processors. Logit model was used to establish the factors influencing the processor's choice of product to process, while stochastic frontier analysis was used to estimate the efficiency and determine factors influencing profit efficiency of baobab processing.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents both the descriptive and econometric results. Descriptive results include the socioeconomic and institutional characteristics of the processors. While the econometric results include the cluster analysis, logit model, and profit efficiency results. Section 4.2 presents socio-economic results of the processors. PCA results are presented in section 4.3 while 4.4 presents CA findings. Section 4.5 shows logistic model results and 4.6 explains the efficiency findings.

4.2 Summary of socio-economic statistics of processors across study sites

Table 4.1 presents the socioeconomic characteristics of the baobab processors. The results reveal a high level of involvement of women in baobab processing across study sites. The high involvement of women in baobab processing may be attributed to the fact that major source of income for women in the rural area is from gathering and selling of non-timber forest products (Nemarundwe et al., 2019).

Table 4.1: Socioeconomic characteristics of baobab processors.

Characteristic	Category	Kitui	Makueni	Kilifi	Mombasa	Nairobi	Overall
Gender	Female	90.5	91.7	99.1	79.5	96.9	92.4
Education of processor	None	9.5	25	15	21.9	7.8	14.8
	Primary	61.9	33.3	57.5	53.5	54.7	55.6
	Secondary	21.5	25	20.4	20.5	34.4	23.7
	Tertiary	7.1	16.7	5.3	2.7	3.1	4.9
	University	0.0	0.0	1.8	1.4	0.0	1.0
Other source of income	Full employment	7.1	16.7	7.1	4.1	0.0	5.3
	Business/trading	71.4	75	80.5	61.6	67.2	71.7
	Crop production	2.4	0	4.4	6.8	6.3	4.9
	Casual employment	7.2	0	2.7	4.1	18.8	6.9
	Part time job	0.0	0	0.0	1.5	3.0	1
	None	11.9	8.3	5.3	21.9	4.7	10.2
Access to land	Yes	76.2	66.7	66.4	57.5	37.5	59.5
Access to credit	Yes	35.7	25	46.9	43.8	67.2	48

Source: Author's computation based on 2019 survey data.

The results indicate that Mombasa County had the highest percentage of male processors with 20.5% only, while the share of male processors was even less in the other counties with the smallest share found in Kilifi at not even 1%. The findings show that the majority (55.6%) of the processors had primary education or secondary education level (23.7%). Nearly 6% of the processors had the post-secondary qualification, with tertiary at 4.9% and University at 1%. The respondents with no formal qualification were 14.8%. The majority (61.9%) of the respondent in Kitui had primary school education, followed by Kilifi (57.5%), Nairobi (54.7%), Mombasa (53.5%), and Makueni (33.3%). Further, the majority (89.8%) of the respondents were involved in other non-baobab processing activities, with only 10.2% recording that they did not have other sources of income. The results show that most processors were involved in business or trade activities (71.7%) as an additional source of income. This is followed by casual employment (6.9%), full employment (5.3%), crop production (4.9%), and holding a part-time job (1%), respectively.

Mombasa County had the maximum number of processors who had no other source of income except baobab value addition at (21.9%), followed by Kitui (11.9%), Makueni (8.3%), Kilifi (5.3%), and Nairobi (4.7%). More than half (59.5%) of the respondents had access to land. Kitui had the highest (76.2%) proportion of respondents with access to land, followed by Makueni (66.7%), Kilifi (66.4), Mombasa (57.5%), and Nairobi (37.5%).

Overall, 48% of the respondents had access to credit. Nairobi county had the highest number of processors (67.2%) who had access to credit. On the other hand, Makueni processors had the least access to credit, represented by 25%, Kilifi County (46.9%) was second, followed by Mombasa (43.8%), and Kitui (35.7%).

Table 4.2 presents the findings on household characteristics, baobab business decision-making, and on the operations of baobab processing. The results show candy to be the main (90.8%) processed product, while powder was the least (1%) processed. Ice cream (4.6%) and juice (3.6%) were second and third in terms of baobab processed products. This finding may be attributed to consumer preference for candy. Similarly, it can also be attributed to lack of processor diversification in baobab processing. Another reason may be low cost of processing candy compared to other products such ice cream and juice which require more equipment such fridge which may be expensive to acquire for some processors.

Table 4.2: Processor characteristics, decision making, and operations on baobab processing

Characteristic	Category	Kitui (%)	Makueni (%)	Kilifi (%)	Mombasa (%)	Nairobi (%)	Overall (%)
Processed product	Candies	100	100	92.4	95.9	75	90.8
	Powder	0	0	1.8	0	1.6	1
	Juice	0	0	4.4	1.4	7.8	3.6
	Ice cream	0	0	1.8	2.7	15.6	4.6
The decision maker	Husband	7.1	0	7.1	16.4	6.3	8.9
	Wife	83.3	58.4	77.8	61.7	62.5	70.8
	Wife & husband	2.4	8.3	1.8	2.7	6.2	3.3
	Children	0	0	0.9	1.4	0	0.7
	Male processor	0	8.3	0	6.8	0	2
	Female processor	7.2	25	12.4	11	25	14.3
Processing pattern (similar)	Yes	54.8	50	32.7	28.8	57.8	40.8
Access to baobab tree	Yes	23.8	16.7	47	27.4	10.9	28.3
Target market	Rural Market	35.7	33.3	45.1	1.3	0	23.4
	Rural town Market	61.7	58.3	36.3	5.5	6.2	27
	Urban market	2.6	8.4	18.6	93.2	93.8	49.6
Business registration	Yes	9.5	0	5.3	5.5	4.7	4.5

Source: Author's computation based on 2019 survey data.

In Kitui and Makueni counties, candy was the only product that was processed. Married women were the main (70.8%) decision-makers on whether to venture into the baobab processing business. The findings indicate that only 28.3% of the processors had access to baobab trees the source of baobab input. Only 40.8% of the respondents reported that their processing patterns were not similar throughout the year. Processors in Nairobi (57.8%) and Kitui (54.8%) reported that their processing patterns were similar throughout the year. While low numbers of processors in Kilifi (32.7%) and Mombasa (28.8%) had similar processing patterns.

In terms of decision making, Women were the main (85.1%) decision makers in baobab processing activities. Only 4.5% of the processors had registered their baobab processing businesses, with 95.5% of baobab businesses being unregistered. Similarly, a few (28%) of the processors had access to baobab tree, the source of baobab processing input. The findings also reveal that the processors' main (50.4%) target markets were rural markets, closely followed by the urban markets (49.6%).

Table 4.3 presents the processor's trading activities. The findings revealed that pulp on seed was the main input used in baobab processing in all the counties at 93.6%.

Table 4.3: Processors' trading activities.

Characteristic	Category	Kitui	Makueni	Kilifi	Mombasa	Nairobi	Overall
Purchased baobab input	Baobab fruit	0	0	4.5	0	0	1.7
	Pulp on seed	95.2	100	89.2	98.6	84.1	93.6
	Pulp	4.8	0	0.9	1.4	15.9	4.7
Point of sale	From processing point	31	41.7	54.9	57.5	58.3	52.3
	Take to the buyer	69	58.3	45.1	42.5	41.7	47.7
Mode of sale	Directly to market	50	66.7	56.6	63.4	68.3	60.1
	On order	14.3	25	9.7	11.3	18.3	13.1
	Both	35.7	8.3	33.6	25.4	13.4	26.8
Day of sale	Market day	38	66.7	8	8.3	6.6	13.7
	Any other day	31	16.	58.4	69.4	88.4	62.2
	Both	31	17.3	33.6	22.3	5	24.1
Storage place for inputs and processed products	Own room	78	81.8	93.6	80.6	96.7	88.4
	Different room	12.2	0	22.7	12.5	0	5.8
	Special room	9.8	18.2	3.6	6.9	3.3	5.8

Source: Author's computation based on 2019 survey data.

In terms of point of sale, the results showed that selling processed products at the processing point was common among the processors, with 52.3% of the respondents selling their processed products at their processing point, while 42.7% delivered the products to their customers. On the selling mode, the majority of the processors (60.1%) preferred selling their products directly to the market. 13.1 % sold their products on order, and 26.8% adopted both modes of sale. Further, the results revealed that most (62.2%) processors traded their baobab products on any other day. 13.7% chose to sell their processed products on markets days, and 24.1% adopted both markets and other days. The majority of the processors did not have a store for their processed and unprocessed products, with 5.8% of the processors storing their products in different unique rooms while 94.2% storing them in the rooms they occupied.

Table 4.4 presents the ANOVA results used to identify differences between various household characteristics in the five study counties. The findings indicate that the mean age of baobab processors was 39 years. Processors in Makueni were significantly (P<0.01) older, with a mean age of 48 years compared to processors in Kitui, Nairobi, Kilifi, and Mombasa with mean ages of 42,41,38, and 38 years respectively. The results also revealed that the overall mean household size was 4 members. Processors in Nairobi were significantly (P<0.01) less experienced in baobab processing compared to other counties with a mean of 5 years.

In terms of land ownership, the respondents had a mean land size of 1.9 acres. Households in Mombasa County significantly owned larger pieces of land with a mean size of 2.6 acres compared to those in Kilifi, Kitui, Makueni, and Nairobi Counties, whose average size of land was 2, 1.8,1.4, and 0.9 acres respectively. Noticeably, there are significant differences among the five study counties across several characteristics, including other income sources, annual processing revenues, processing cost, profits, quantity processed, and profit efficiency levels.

Table 4.4: ANOVA test results of key characteristics of baobab processors.

Characteristic	Description	Overall mean N= 304	Kitui N=42	Makueni N=34	Kilifi N=91	Mombasa N=73	Nairobi N=64	F	P
Age	No. of years	39	42	48	38	38	41	3.392	0.010***
Years of schooling	No. of years	7	8	7	7	6	8	2.203	0.069
Household size	No. of individuals	4	6	5	4	4	4	2.842	0.024***
Land Size	No. of acres	1.9	1.8	1.4	2	2.6	0.9	2.548	0.039**
Other source of income	Amount in KShs	435,794	504,371	779,025	546,647	367,999	208,039	1.972	0.099
Experience	No. of years of processing	7	9	12	8	6	5	4.234	0.002***
Total processing cost	Amount in KShs	133,119	194,312	71,109	62,022	263,337	81,591	6.122	0.000***
Annual processing revenue	Amount in KShs	423,673	587,739	192,693	151,235	964,775	213,278	6.742	0.000***
Annual profit	Amount in KShs	200,199	393,426	121,583	89,187	370,753	89,601	4.590	0.001***
Annual processed quantity	In Kilograms (Kgs)	1,092	1,006	635	787	2,159	529	2.689	0.031**
Profit efficiency levels	In Percentage (%)	59.9	67.1	69.5	55.9	67.1	53.3	9.77	0.000***

Source: Author's computation based on 2019 survey data. Note: 1$= KShs 100. ***and ** indicate 1% and 5% significance level respectively.

Variable	Mean	Std. Dev.	Min	Max
Baobab Profit	131775	179318	270	1217900
Labor cost	12805	15658	500	96000
Baobab input cost	19270	23664	0	121500
Sugar cost	27850	32107	720	168000
Fuel cost	2972	4712	0	30000
Color cost	2641	3700	0	25400
Flavor cost	2525	4777	0	41360
Packaging cost	20837	38054	30	288000
Income from other source	333559	416513	0	2400000
Years of processing	7.5	7	0	45
Age of the processor	41	12	21	84
Years of schooling	7	4.2	0	16
Amount of credit accessed	4483	11447	0	120000
Land size	1.9	3	0	30
No of adult baobab trees owned	1	2	0	20

Table 4.5: Summary statistics of business variables of baobab processors.

Source: Author's computation based on 2019 data survey. Note: 1$=KShs100.

The results reveal that the mean profit of baobab processors was KShs 131,775. Sugar cost was the highest incurred by the processors with a mean of KShs 27,850, followed by packaging cost, baobab input cost, labor cost, color cost, and flavor at KShs 20,837, KShs 19,270, KShs 12,805, KShs 2,972, KShs 2641, and KShs 2,525 respectively. These variables were later used in stochastic frontier analysis.

4.3 Principal Components Analysis Results

The Kaiser-Meyer-Oklin (KMO) and Bartlett's Test of Sphericity were conducted before conducting PCA, and the results are presented in Table 4.6.

Table 4.6: Kaiser-Meyer-Oklin and Bartlett's Test of Principal Components

Kaiser Meyer –Oklin Measure of Sampling Adequacy	0.66
Bartlett Test of Sphericity Chi-square	660.60
Degree of Freedom	78
P- value	0.000

Source: Author's computation based on 2019 survey data.

The results show a KMO of 0.66, meaning that each variable was sufficient for analysis. The BTS value was 660.60, with a P-value of 0.00, indicating that the data was appropriate for principal component analysis.

Kaiser's rule for principal component analysis provides that only factors with eigenvalues greater than 1 should be retained. Table 4.7 shows the various components resulting from PCA analysis. The results showed that only four components had an eigenvalue greater than one as shown in Table 4.7. The eigenvalues are:2.6646, 1.9319, 1.6597,1.1605.

Table 4.7: Components and Total Variance explained

Component	Eigenvalue	Proportion	Cumulative	variance
comp1	2.6646	0.2050	0.2050	2.6149
Comp2	1.9319	0.1486	0.3536	1.9075
Comp3	1.6597	0.1277	0.4813	1.6538
Comp4	1.1605	0.0893	0.5705	1.2406
Comp5	1.0128	0.0779	0.6484	
Comp6	.91124	0.0701	0.7185	
Comp7	.81419	0.0626	0.7812	
Comp8	.72233	0.0556	0.8367	
Comp9	.58731	0.0452	0.8819	

Comp10	.48669	0.0374	0.9193
Comp11	.41907	0.0322	0.9516
Comp12	.33250	0.0256	0.9772
Comp13	.29686	0.0228	1.0000

Source: Author's computation based on 2019 survey data.

Figure 4.1 shows the scree plots for the retained eigenvalues. In this analysis, 4 components met this criterion and were retained. The four components accounted for 57 % of the total variance.

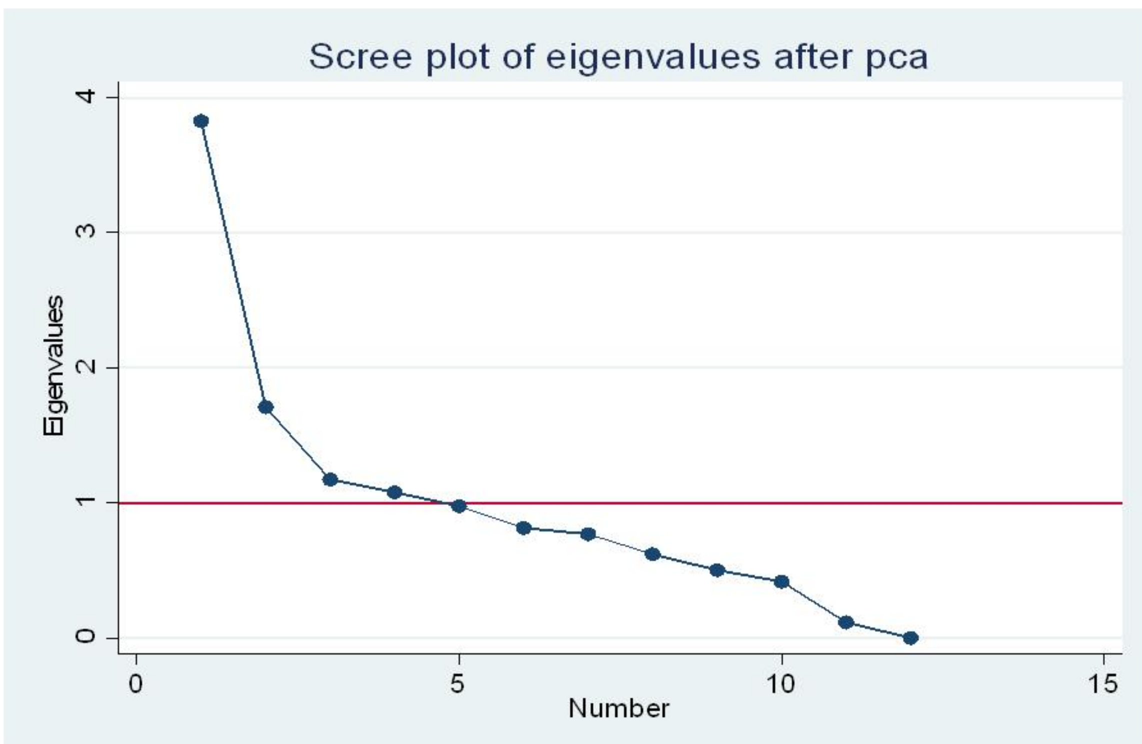

Figure 4.1 Scree plot for eigenvalues.

Table 4.8: Principal components factor loading

Factor and item description	Factor loading	% Variance explained
Factor1: baobab output factor		20.1
Annual processed quantity	0.4368	
Annual baobab profit	0.5189	
Annual baobab revenue	0.5169	
Annual processing cost	0.5045	
Factor 2: input factor		14.67
Access to baobab trees	0.6177	
No of baobab trees	0.5727	
Factor 3: socio demographics factor		12.72
Age of the processor	0.6496	
Years of schooling	0.4191	
Years of processing	0.5406	
Factor 4: Household income factor		9.54
Non processing income	0.4146	
Credit access	0.5565	

Source: Author's Computation based on 2019 survey data.

The first factor was named the baobab output factor. It accounted for 20.1% of the variance. The factor was made up of four items with their associated factor loading i.e., annual processed quantity (0.4368), baobab profit (0.5189), processing revenue (0.5169), and annual processing cost (0.5045). The second retained component was baobab input factor which accounted for 14.6% of the total variance. The input factors component was composed of items: access to baobab trees (0.6177) and the number of baobab trees owned (0.5727). The third component was the socio-demographic factor which accounted for 12.7% of the total variance. The socio-demographic factors were composed of three items, i.e. age of the processor (0.6496), years of schooling (0.4191), and years of processing (0.5406). The fourth component was the income factor which accounted for 9.5% of the total variance. It was composed of the income from other sources (0.4146) and credit access (05565). Based on the factor loadings and the eigenvalues it is evident that - income, output, input, and socio-demographic factors are important factors in the characterization of baobab processors.

4.4 Cluster Analysis Results.

The four retained components in PCA were used as inputs for cluster analysis to characterize the processors. The processors were grouped into three clusters as shown by the dendrogram in figure 4.2.

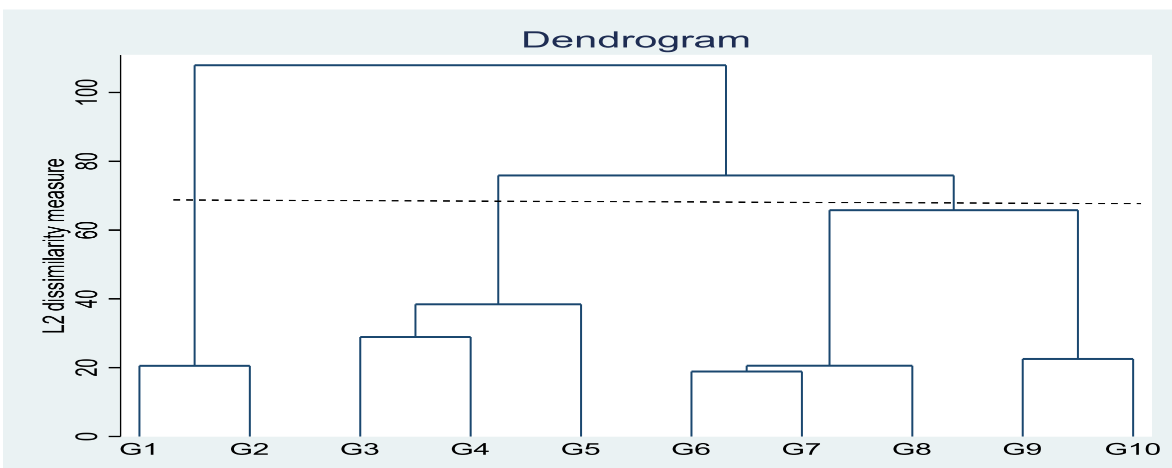

Figure 4. 2: Dendrogram

The results for the baobab processor clusters from the cluster analysis are presented in Table 4.9. The ANOVA analysis results reveal that three clusters were uniquely identified based on various characteristics.

Table 4.9: Characteristics of the clusters based on the means.

Socio economic characteristic	Cluster 1	Cluster 2	Cluster 3	F value	P value
Age of the processor (Years)	41	38	41	1.67	.191
Gender (1=male,0=female)	.06	.05	.04	0.22	.803
Years of schooling (Years)	8	6	7	1.85	.160
Household size (no.)	6	5	5	1.61	.203
Access to land (Yes=1, No=0)	0.58	0.93	0.44	23.88	.000
Size of land (Acres)	1.4	3.4	1.3	11.04	.000
Years of processing (Years)	11	6	7	7.48	.000
Credit Access (Yes=1, No=0)	.36	.44	.51	1.69	.187
Access to training (Yes=1, No=0)	.10	.14	.04	3.24	.041
Profit levels (KShs)	290,981	149,850	80,350	43.12	.000
Baobab Total revenue (KShs)	464,709	176,815	119,822	56.86	.000
Quantity processed (Kg)	1,203	407	372	30.14	.000
Income from other sources (KShs)	618,471	344,439	218,048	21.12	.000
Total variable cost (KShs)	174,199	69,050	59,548	42.19	.000
Frequency (No)	*52*	*59*	*135*		
Distribution (%)	*21%*	*24%*	*55%*		

Source: Author's computation based on 2019 survey data. Note: 1$=Kshs100. *** and ** indicate 1% and 5% significance level respectively.

4.4.1 Baobab processor typologies

Based on the baobab clusters identified in figure 4.2, the baobab processors fit three clusters 1, 2, and 3. Type 1 refers to high quantity processors. This group included 52 households representing 21% of the study sample. Households in this cluster are characterized by high quantity of baobab processed. Respondents in this group processed an annual average of 1,203 kg of baobab, were relatively educated with an average of 8 years of schooling, and their average land size was 1.4 acres. They had a mean annual profit of KShs 290,981. Similarly, their processing costs were high with an annual average of KShs 174,199. Households in this cluster were relatively wealthy with an annual average income of KShs 618,471 from other sources.

Type 2 refers to average processors. This group was made up of 59 households who represented approximately 24% of the study sample. They had low levels of education with an average of 6 years of schooling. The respondents in this cluster had an average household size of 5 individuals. The processors had a mean of 6 years of baobab processing; hence they were least experienced. In terms of land ownership, processors in this group, owned land with an average size of 3.4 acres, which was the highest among the groups. The production volume of this group was far lower than for the high quantity processors with an annual average quantity of 407 kg of processed baobab. Their annual average profit was KShs 149,850. Similarly, revenue from baobab processing was moderate with an annual average of KShs 176,815. They exhibited moderate annual average processing cost of KShs 69,050. Their mean annual income from other sources was KShs 344,439.

Type 3 refers to low quantity processors. This group is composed of 135 households which represented 55% of the respondents. Respondents in this cluster had an average of 7 years of schooling. The processors had a household size of 5 persons, had access to land, and owned an average of 1.3 acres. Processors in this group exhibited low profits with an annual average of KShs 80,350. This cluster produced lower volumes with an annual average of 372 Kg of processed baobab but with a wide spread in production volumes. They had lower processing cost with an annual average of KShs 59,548. Similarly, they exhibited low income from other sources averaging KShs 218,048 per year. Similar to land access, they also had low access to training.

4.4.2: Factors influencing variations in baobab processing

The PCA and CA results presented in Tables 4.8 and 4.9 identified factors that caused variations in baobab processing namely; years of processing, access to training, access to land, land size, profit levels, baobab total revenue, total quantity processed, income from other sources, and processing costs.

Years of processing considerably varies among the baobab processors. Processors in type 1 were more experienced compared to their counterparts in type 2 and 3. Experience caused differences in baobab processing under various economic environments. Processors with many years of processing managed their processing well in terms of acquiring input and their use. This enabled them to realize more yields at lower cost and therefore receiving more income compared to those with less experience. Additionally, experience enables the processors to produce quality products due to the practical skills in baobab processing. Highly experienced processors have more information on the markets of the processed products. Therefore, they are better placed to sell their products compared to processors with low experience.

Access to training facilities significantly varies among the clusters. Type 2 had more access to training compared to type 1 and 3. Training is an important factor in baobab processing. Training empowers processors with information on the baobab products, processing skill and processing regulations. Well informed processors make better decision on the input use to avoid wastage, thus lowering the processing cost. In terms of quality, trained processors produce high quality products compared to untrained processors. Quality products attracts more customers in the markets, in turn increasing sales. These findings are in agreement with the study by Adeyonu, *et al*. (2016) who found out that training promoted sweet potato value addition in Nigeria.

Access to land significantly varies among the processor types. It is higher for the average as well as low for the low volume processors. Type 2 had more access to land compared to type 1 and 3. Land is a key aspect of agricultural production and processing. In the case of baobab processing, some of the processors had access to land which had baobab trees. Having land with baobab trees reduced the cost of the baobab processing business, since it enabled the processor to readily access baobab input at relatively low costs. Additionally, the land was used for crop and livestock production which increased household income. Some proportion of the income received from farming was employed towards baobab processing, thus providing an advantage to the people with access to land. The land could also be used as collateral when applying for financial assistance to fund baobab processing.

The results show that the quantity of baobab processed significantly differed between processor clusters. Type 1 produced highest amount of processed baobab while type 3 produced the lowest volume. The quantity processed was affected by seasonality of the baobab fruit. During the off-seasons baobab input is low in the market leading to higher prices while during the high season there is increased supply of baobab leading to low prices of inputs. The quantity processed was also constrained by poor processing practices and the high cost of other inputs such as sugar and packaging materials.

Household income from other sources significantly ($P>0.01$) differs among the clusters. Cluster 3 registered the lowest amount of income from other sources while cluster 1 recorded the highest. Household income often determines the processor's ability to finance both processing and non-processing projects. Income from other sources could be used to buy baobab inputs and other markets inputs needed in baobab processing. This finding is in tandem with study by Musyoka *et al*. (2020), who revealed that access to off-farm income increased the monetary power of farmers to participate in the acquisition of value addition equipment. It enables the processors to buy inputs at affordable prices during the season, reducing processing costs. Additionally, the income could be crucial in the adoption of improved processing technology which seems risky. Improved technology increases the processor's efficiency and in turn improves returns.

The processing cost significantly ($P<0.01$) varies as well. The high quantity processor group had the highest processing cost while low quantity processor group had the lowest processing cost. This may be attributed to the quantity of baobab processed and the price of the inputs. The cost of input used in baobab processing was high due to the low supply in the market. Baobab inputs (pulp on seed, pulp, and fruit) were affected by the seasonality of baobab production. This increased their prices during the baobab off-season. The cost of packaging increased with the ban of plastic bags in Kenya forcing processors to shift from plastic bags to plastic containers. The prices of plastic containers were higher compared to the plastic bags which consequently increased the operation cost of the processors.

The types of baobab processors also differ in total revenue. Highest revenues were registered by the processors in cluster 1 while the lowest revenues were recorded by their counterparts in cluster 3. Baobab processors recorded better revenue during peak season and festive season due to the huge supply of baobab input and markets for the product respectively. Cluster 1 recorded higher revenue compared to other clusters due to their ability to process high quantities of baobab products thus enjoying economies of scale. Jackering *et al*. (2019), observed that revenue from baobab is limited by inadequate inputs and markets.

4.5 Determinants of choice of baobab product to process.

Table 4.10 provides the results of the logistic regression model on the choice of baobab product to process. The logit model was used to determine the factors influencing the choice of baobab products to process by the baobab processors. The model had a chi-square value of 50.03, which was significant at 99%. This implies that the log ratio of the exploratory variables was not linearly related to the log odds of the dependent variables. It had a pseudo R^2 of 0.2691 which means that independent variables explain 26.91% of the variation in dependent variables. The results indicate that years of schooling, marital status, number of trees owned, size of the land, and access to credit influenced the choice of product to process.

Variables	Coef.	Std.Err.	z	95% Conf	Interval
Age	-.018	.024	-0.76	-.065	.029
Years of schooling	-.179**	.071	-2.54	-.318	-.041
Marital status	.6**	.297	2.02	.018	1.182
Household size	-.091	.103	-0.89	-.292	.11
Land size	.555**	.267	2.07	.031	1.079
Total awareness score	-.091*	.054	-1.70	-.196	.014
Access to baobab trees	1.785	.962	1.86	-.1	3.669
Number of trees owned	-.376***	.144	-2.62	-.658	-.094
Years of processing	.102	.055	1.88	-.005	.209
Credit access	-1.208**	.539	-2.24	-2.265	-.151
Access to training	-.925	.756	-1.22	-2.406	.557
Income from other sources	0	0	-0.21	0	0
Constant	4.785***	1.464	3.27	1.916	7.653
No. of observations		304			
LR Chi^2		50.3			
Prob>Chi^2		0.000			
Log-likelihood		-68.295			
Pseudo R^2		0.269			

Table 4.10: Results for logistic regression model

Source: Author's computation based on 2019 survey data. *P < 0.1, **P < 0.05, ***P < 0.01.

Table 4.11 indicates the marginal effects results. The findings are presented in the form of effects expressed as percentage change in the probability of picking candy as choice of product to process.

Table 4. 11: Marginal effects results

Variables	Dy /dx	Std. Err.	z	95% Conf.	Interval
Age	-0.000	0.001	-0.740	-0.002	0.001
Years of schooling	-0.005**	0.002	-2.090	-0.009	-0.000
Marital status	0.015*	0.009	1.680	-0.002	0.033
Household size	-0.002	0.003	-0.860	-0.008	0.003
Land size	0.014**	0.006	2.510	0.003	0.025
Total awareness score	-0.002	0.002	-1.430	-0.005	0.001
Access to baobab trees	0.045	0.029	1.580	-0.011	0.101
Number of trees owned	-0.010**	0.004	-2.410	-0.017	-0.002
Years of processing	0.003	0.002	1.630	-0.001	0.006
Credit access	-0.031*	0.017	-1.770	-0.064	0.003
Access to training	-0.023	0.021	-1.140	-0.064	0.017
Income from other sources	-0.000	0.000	-0.210	-0.000	0.000

Source: Author's computation based on 2019 survey data. *P < 0.1, **P < 0.05, ***P < 0.01.

The results show that holding all other factors constant, each additional acre of land is associated with 1.4% in the likelihood of processing candy. The effect is positive and significant, showing that land size favors candy processing. This may be attributed to the fact that the income from farm related activities such as farming is used in candy processing. The income may be used to purchase baobab processing inputs such sugar, pulp and packaging materials. Similarly, processors with land might have baobab trees in the land which provides baobab input (pulp on seed) for candy processing.

The coefficient of education was significant (P<0.05) and negatively influenced the choice of candy as the product to process. The probability of choosing baobab candy as the product to processing was predicted to shrink by 0.5% with each additional year of education. This means that as the processor becomes more educated, the chance of processing baobab candy decreases, and they shift to other new baobab products. This may be due to added information and knowledge on other baobab products. Additionally, formal education enables the processors to learn and understand the markets and respond to the market needs. These results are in agreement with Agwu *et al*. (2015), who investigated factors influencing cassava value addition by rural agribusiness entrepreneurs in Nigeria. They established that education positively influenced the value addition of cassava.

The results further showed that marital status was significant ($P<0.05$) and positively influenced the choice of candy. This implies that the probability of processing candy increased by 1.5% for the married processors compared to the single and divorced processors. A possible explanation for this result is that married processors have extra income and labor to put in candy processing because it is labor-intensive than their single or divorced counterparts.

The number of baobab trees owned by the processors was significant ($P<0.01$) and negatively associated with candy as the choice of product to process. This means that the probability of processing candy decreased by 1% with each additional baobab tree. A possible explanation for this observation is that additional baobab trees were likely to increase the amount of baobab pulp input needed to process other commodities such as juice, powder, and ice cream.

The results revealed that access to credit facilities influenced the choice of processed products. Access to credit facilities was significant ($P<0.01$) and favored the processing of other products. An increase in the access to credit by one unit lowers the probability of candy processing by 3.1 %. The processors can use funds from the credit to acquire input and other equipment needed to process other products such as fridge used in ice cream and juice processing. This implies that access to credit is an essential institutional input for baobab processing. These findings are consistent with Ngore *et al*. (2011), who found that credit influenced meat value addition in Igembe North District, Kenya.

4.6 Profit efficiency of baobab processing

4.6.1 Profit efficiency results

Table 4.12 presents the MLE estimates for profit efficiency. The findings reveal that the estimated coefficient of sugar cost had a positive sign and was statistically significant.

Table 4. 12: Maximum likelihood estimates of stochastic profit frontier function.

Variables	Coefficients	Standard error	t-ratio
Profit function model			
Intercept	3.6622***	0.2392	15.3117
Labor	0.1063	0.0770	1.3808
Baobab Input	0.0171	0.0335	0.5093
Sugar	0.3788***	0.0811	4.6702
Fuel	0.0106	0.0197	0.5375
Color	0.0096	0.0393	0.2445
Flavor	-0.0148	0.0242	-0.6116
Packaging	0.0818	0.0597	1.3688
Inefficiency estimate			
Constant	-4.5739	4.2992	-1.0639
Years of schooling	-0.0559	0.0567	-0.9851
Gender	-4.4094*	2.5379	-1.7375
Access to land	-0.0528	0.4772	-0.1107
Access to baobab trees	0.4988	0.7089	0.7036
Number of baobab trees owned	-0.3899***	0.0983	-3.9652
Experience	-0.0475	0.0334	-1.4211
Income from other sources	0.0000**	0.0000	-2.2348

Training	0.0936	0.8861	0.1057
Age	0.0044	0.0191	0.2314
Marital status	-1.5542**	0.7278	-2.1354
Non processing occupation	4.7951*	2.5697	1.8660
Access to credit facilities	-0.0138	0.3417	-0.0403
Access to information	1.5723	1.8860	0.8337
sigma-squared	3.0036***	1.1053	2.7176
Gamma	0.7703***	0.0971	7.9304

Source: Author's computation based on 2019 survey data. *P < 0.1, **P < 0.05, ***P < 0.01

The variance parameters presented in table 4.11 reveal a gamma value of 0.77. This implies that there are inefficiencies in the profits obtained by baobab processors. That is, about 77 % of the total variance of composed error of profit function is explained by the variance of the variables explaining profit inefficiency. The remaining 23% is from random noise. The generalized log-likelihood ratio test further confirmed the presence of inefficiencies at 1% significance. Therefore, the null hypothesis (that there is no inefficiency in baobab processing) was rejected.

The coefficient of sugar was positive and significant at 1%, meaning that a 1% increase in the unit cost of sugar cost will increase profit by 0.37 keeping all the other factors constant. According to the results, sugar is the main component in baobab processing. It is used to sweeten the product during processing. Cost of sugar differed depending on the market target. Processors in the rural areas used less sugar compared to their counterparts in the urban areas (Jackering *et al .,* 2019). Increased use of sugar implies increased processing hence higher profits. The parameter coefficients of labor, baobab input, fuel, and color had a positive sign but were not significant. The elasticity of flavor cost had a negative sign but was not significant. This implies that labor, baobab input, color, flavor, fuel, and packaging costs did not significantly affect profit efficiency of baobab processing in the study area.

4.6.2 Efficiency model results and its determinants

The inefficiency results presented in Table 4.12 indicate that the coefficient of gender, income from other sources, number of baobab trees owned, and marital status positively influenced profit efficiency, while non-processing occupation negatively influenced profit efficiency. Both the marital status ($P<.05$) and gender ($P<0.1$) variable coefficients were negative and statistically significance. This implies that profit efficiency increased with married people than their counterparts who were single. This may be attributed to the fact that married processors have more income and access to family labor compared to their single counterparts.

The negative sign on the gender coefficient implies that male processors were more efficient in baobab processing than their female counterparts. Male processors have higher chances of accessing credit facilities used in purchasing processing input than female processors due to their ability to own assets such as land that could be used as collateral. Moreover, women are disadvantaged when it comes to time availability and access to information on baobab due to the restrictions imposed on them by culture and multiple household chores. This finding agrees with Wongnaa *et al*. (2019), who also reported a positive effect on profit efficiency in maize farming in Ghana.

The coefficient of non-processing income depicts a negative relationship with inefficiency at 5% significance level, holding all the other factors constant. This suggests that processors with a high income from other sources are more efficient than those without. The result emphasizes the importance of non-processing income among smallholder processors. These processors are relatively less endowed with household assets, which might reduce other costs faced by the processors. Besides, the income may be re-introduced to the processing as working capital, thus improving revenues. These results are consistent with findings by Bahta & Baker (2015), who established that, off-farm income boosted profit efficiency of beef producers in Botswana.

The number of baobab trees owned by the processors reveals a positive relationship with the processing efficiency and significant at 1% level. This finding implies that the processors who owned trees were more efficient than their counterpart without the trees. The tree provides baobab fruit, a key input in baobab processing. Owning trees reduces cost involved in baobab processing. It also allows the processor to produce high volume due to availability of processing inputs. Processors are faced by the challenge of baobab input scarcity during the off-season. The available input is sold at inflated prices. This increases processing cost, ultimately lowering the processors' efficiency.

The positive and significant coefficient ($P<0.1$) of the non-processing occupation variable shows that processors engaged in non-processing activities tend to exhibit higher levels of inefficiency. These results are consistent with findings of Abdulai and Huffman (1998) who established that farmer's participation in nonfarm employment reduced production efficiency of rice farming in Northern Ghana. The relation suggests that an increase in non-processing work leads to reallocation of time away from processing related activities.

However, years of schooling, access to land, land size, access to baobab trees, credit access, experience of the processor, access to training, and the number of trainings attended were found not to significantly affect profit efficiency of the baobab processors in the study area.

Table 4.13 presents the frequency distribution of efficiencies of the processors in the study areas.

Table 4.13: Frequency distribution of efficiencies of the processors

Efficiency class Index	Frequency	Percentage (%)	Cumulative percentage (%)
0.00-0.10	5	2.2	2.2
0.11-0.20	6	2.7	4.9
0.21-0.30	11	4.8	9.7
0.31-0.40	14	6.2	15.9
0.41-0.50	28	12.3	28.2
0.51-0.60	30	13.2	41.4
0.61-0.70	56	24.7	66.1
0.71-0.80	60	26.4	92.5
0.81-0.90	17	7.5	100
Total	227	100	
Maximum	0.86		
Minimum	0.025		
Mean	0.599		

Source: Author's computation based on 2019 survey data.

The findings reveal that processors exhibited a mean profit efficiency of 59.9%. This suggests that, on average, about 40.1% of the profit is lost due to economic efficiency. The processors can thus increase their profit efficiency by a further 40.1% using the same level of inputs. The profit efficiency across the processors ranged with a minimum of 2.5% while the most efficient registered 86% efficiency levels.

Table 4.14 presents the average profit efficiency across the counties. The findings reveal that processors from Makueni County were the most efficient with a mean of 69%. Processors from Kitui and Mombasa counties followed at 67%, then Kilifi followed with 55% while processors from Nairobi County were least efficient with an average of 53%.

County	Mean	Std D
Kitui	.6705	.1130
Makueni	.6953	.0857
Kilifi	.5588	.1978
Mombasa	.6709	.1299
Nairobi	.5328	.2241
Overall	.5990	.1868

Table 4.14: Average profit efficiency across the study counties

Source: Author's computation based on 2019 survey data.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Baobab is a famous tree that is utilized as a source of food due to its nutritive properties. Baobab processing remains low with the processors' characteristics, choices of products, and profit efficiency not well known or documented. The purpose of the study was to characterize baobab processors, determine factors influencing the choice of product to process, estimate profit efficiency and determine factors affecting profit efficiency of baobab processing in Nairobi, Mombasa, Kilifi, Kitui, and Makueni Counties, Kenya. The study adopted a cross-sectional design. Purposive and snowball sampling techniques were employed to select 304 respondents from the five study regions. The questionnaire and interview schedule were used to collect data from the baobab processors. Principal component analysis (PCA) and cluster analysis (CA) were used to characterize the processors. Establishing the factors affecting the choice of product to process was undertaken through the logit model, while stochastic frontier analysis was used to estimate profit efficiency and the determinants of profit efficiency of baobab processing. The data analysis was run using STATA and Frontier 4.1 software.

5.2 Summary of the study results.

The socioeconomic characteristics results revealed that baobab processing was predominantly (92.4%) female business. Mombasa County had the leading number of male processors at 20.5%. In terms of education level, the findings show that the majority (55.6%) of the processors had primary education or secondary education (23.7%). Candy was primarily the main (90.8%) processed product, while powder was the least (1%) processed. Ice cream (4.6%) and juice (3.6%) were second and third in baobab processed products. The majority (59.2%) of the processors reported varied processing patterns, while the rural market (50.4%) was the main target market for the processors. Overall, only 42% of the respondents had access to credit. Nairobi County had the highest number of processors (67.2%) who had access to credit. On the other hand, Makueni processors had the least access to credit, represented by 25%. The processors exhibited a mean age of 39 years. Similarly, their mean land size was 1.9 acres. Noticeably, there were significant differences among the five study counties across several characteristics: non-processing income, annual processing revenues, processing cost, profits, quantity processed, and profit efficiency levels.

Principal component analysis and cluster analysis results identified the processor clusters. The main components that explained variation among the clusters were input, output, socio-demographics, and household income factors. Three processor clusters were identified. The first type accounted for 21% and was named high quantity processors. The second was average quantity processors and represented 24 % of the processors. The third type was the low quantity processors and accounted for 55% of the processors. The factors influencing processor variations were years of processing, access to training, access to land, land size, profit levels, baobab total revenue, total quantity processed, income from other sources, and processing cost.

The logistic regression model results revealed that years of schooling, access to credit, and the number of baobab trees owned favored choice of other products over candy while marital status, and land size favored candy processing. The stochastic frontier analysis indicated that the average efficiency of the processors was 59.9%. The coefficient of sugar cost significantly affected profit efficiency of baobab processing. Further, the inefficiency model showed that gender, income from other sources, number of baobab trees owned, and marital status increased profit efficiency while occupation in non-processing activities lowered the profit efficiency.

5.3 Conclusion.

The study investigated profit efficiency and determinants of the choice of the baobab products to process. The study concluded that candy was the main processed product, with other products such as juice, ice, and powder processed at low levels. This implies that baobab is underutilized. The high preference of candy may be attributed to the lack of awareness of other baobab products and the huge cost of equipment involved in processing other products such as freezers.

It was further observed that, processors' access to credit was not satisfactory, with a high number of processors not able to secure credit facilities. In Kenya, baobab value addition is characterized by subsistence processing. These processors are lowly endowed in terms of resources and most are faced with financial constraints. Therefore, the study concluded that, providing affordable credit facilities is key to baobab processing.

Baobab processing was a profitable venture and plays a crucial role in income generation and poverty reduction, especially for women in the arid and semi-arid areas where crop production is not viable. Women were predominately involved in baobab processing. However, this does not mean that baobab was only a women's job, because men provide resources to their spouse which is used in baobab processing. Moreover, men were involved in baobab processing activities such as packaging and selling. Baobab processors were heterogeneous and were relatively profit efficient. Therefore, the study concluded that, efficiency could be improved further by focusing on better processing technologies.

5.4 Recommendation.

In the midst of the discussions, the study recommended the following: First, all the stakeholders in baobab value addition should come up with ways to improve the processors' profit efficiency. Profit efficiency can be enhanced by providing better processing technologies. This will reduce the wastage or loss attributed to inefficient processing technologies. Similarly, training processors on better processing skills will enhance efficiency by using correct amounts of inputs and observing the set guidelines. Besides, this improves the quality of processed products. Second, there is need to address gender-related issues to bridge the gender disparity gap in processing. Women processors are less efficient compared to their male counterparts. Bridging the gap can be addressed by empowering women with the needed information and other economic resources such as credit access. Third, investment in better ways of conserving the existing baobab trees and planting more will promote baobab processing. Moreover, supporting research that aims to reduce the maturity period of baobab is a game-changer. It will increase baobab input, hence lowering processing cost and increasing processing revenue. Fourth, there is a need to provide affordable credit to the processors. The majority of the processors are financially constrained, which hinders their processing capacities. Funds from the credit facility will enable them to adopt better processing technologies, thus improving their efficiency. Besides, it will enable them to buy baobab inputs when in season and store them for use during the off-season. Additionally, it would be prudent to encourage baobab processors to form financial associations such as self-help groups, merry-go-rounds, and cooperatives. The processors can contribute money in the form of savings and borrow when need arises, such as buying large quantities of baobab input. Fifth, investing in human capital, particularly informal education on is key to baobab value addition. Similarly, it would be important to encourage people to conserve baobab trees and to teach them on better harvesting skills to improve baobab input volumes. Lastly, there is a need to reform land policies to increase land access and streamline ownership. Processors need to be given access to baobab trees in the protected areas such as game parks and reserves. This will enable them to get enough baobab fruits which are key in processing.

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APPENDIX I: PROCESSOR QUESTIONNAIRE

Study area________________________________ Questionnaire no ____________

Introduction

We are a team of researchers from Jomo Kenyatta University of Agriculture and Technology (JKUAT), undertaking Baobab research in collaboration with Rhine-Waal University of Applied Sciences, Kleve, Germany and other stakeholders. The study seeks to develop an understanding of baobab processing. As part of the research, we are conducting a survey of baobab processors in Kitui, Makueni, Kilifi, Nairobi and Mombasa Counties. You have been identified as one of the respondents. Your participation is entirely voluntary and we do hope that you will agree to participate. The survey will involve you in a semi-structured interview/discussion with some members of our research team. The findings of the research will be written up in research reports and for academic purposes only. We wish to assure you that your responses will be treated with utmost confidentiality and only for the intended purpose.

Definition of Terms

Collectors: the collector in this survey is the producer or the gatherer or harvester of baobab fruit in their own lands, other people's lands and or from the forest.

Assemblers: in this study the assembler is the individual buying baobab fruit/pulp from the collectors or collector group either independently or as an agent in a rural market and sells the baobab mainly to rural wholesalers but also to dealers in urban towns/cities. They are characterized by a limited amount of resources, small trading quantities and the use of simple means of transportation. In Kenya they are also referred to as brokers.

Rural wholesaler: in this survey rural wholesaler will refer to an individual who buys baobab fruit/pulp from the collectors or assemblers in the rural market and accumulates stock to sell in bulk to an urban wholesaler or in small quantities to other traders and processors. They are normally situated in a rural town or market. They may also be referred to as collecting wholesaler.

Urban wholesaler: in this survey urban wholesaler will refer to an individual who buys baobab fruit/pulp mainly in bulk from the rural wholesaler or from the assemblers with the intention of accumulating large stock for distribution to various parts of the country in relatively large quantities or sometimes small quantities to other traders and processors. They are normally situated in urban towns and cities and are also referred to as distributing wholesaler.

Retailers: Retailers constitute the final link to the baobab consumer. *Rural retailers* are stationed in the rural areas while *urban retailers* are stationed in the urban areas. Both rural and urban retailers could buy baobab fruit/pulp from the collectors, assemblers and wholesalers. Rural retailers are likely to buy baobab from the collectors, and assemblers while urban retailers are likely to buy baobab from the urban wholesalers.

Processors: in this study a processor refers to an individual that adds value (see value addition) to baobab fruit/pulp by changing its form. Processors are likely to buy baobab fruit/pulp from collectors, assemblers, wholesalers and retailers. They either sell their produce to retailers or directly to consumers.

Exporters: exporters buy baobab fruit/pulp with the aim of selling outside the country of origin (Kenya). They may buy their produce from any of the actors as long as it satisfies their requirements.

Income: Income in this survey will refer to the gross revenue generated from sale of agricultural or non-agricultural commodity.

Value addition: in this study value addition refers to a change in the physical state or form of baobab fruit/pulp in a manner that enhances its value

Permanent or Full-time employees*:* work on a regular basis for an average of 40 hours per week set by an award or registered agreement between the employer and the employee. Full-time employees are entitled to annual, personal, sick, and career leaves and public holiday pay and are eligible for long service.

Casual employees: these are workers engaged on an irregular basis according to business demands. They have: no expectation of ongoing work; no obligation to accept offers of work; no sick or annual leave pay; and no obligation to provide notice of ending their employment, unless this is a requirement of an award, employment contract or registered agreement.

Self-employed: is a situation in which an individual works for himself instead of working for an employer that pays a salary or a wage. A self-employed individual earns his income through conducting profitable operations from a trade or business that he operates directly.

Household: The **household** consists people who have resided in the same dwelling and share meals or living accommodation for more than six months. They may consist of a single family or some other grouping of people.

Tracking: General Identification: To be Filled by the Enumerator

Identification Data

Item	Response	Item	Response
Consent	Yes=1 [ ] No=0 [ ]		
If the processor is not able to participate in the survey, why so? Refused = 1 [ ], Processor committed = 2 [ ], Processor cannot be found = 3 [ ], Processor moved from the area 4 [ ], Processor died =5 [ ] N/A = 889 [ ]			
If Yes continue with the interview; if No, terminate the interview			
Date of interview	**Date/Month/Year: _____ /_____/2018**	County:	
Interview start)	(hh:mm): ______:________	Sub county	
Interview end time	(hh:mm): ______:________	Ward	
Name of enumerator		Market/Town Name	
Processor number (TID)		GPS coordinates	Latitudes
Name of the respondent			Longitudes
Gender of the respondent	Male=1 [ ] Female=0 [ ]	Telephone	
Age of the respondent			
Are you the processor/ owner/manager/ CEO?: Yes= 1 [ ], No=0 [ ]			
If No, name of the processor/ owner/manager/ CEO: ____ N/A = 889 [ ]			
What baobab products do you process? 1=mabuyu [ ] 2=powder [ ] 3=jam [ ] 4=juice [ ] 5=paper [ ] 6=yoghu [ ] 7=ice cream [ ] 8=chutney [ ] 9=sweet/Chocolate [ ] 10=beads/Decorations [ ] 11=ropes [ ] 12=medicine[ ] 13= cakes 14= others (specify)			
County codes:			
Kitui=1, Makueni=2, Kilifi=3, Mombasa=4.Nairobi=5,			
Sub county code:			
Kitui South=1, Kitui East=2, Kitui Central=3, Kitui Rural=4, Kitui West=5, Mwingi Central=6, Mwingi West=7 Mwingi North=84			
Kibwezi East=9, Kibwezi West=10			
Kilifi=11, Magarini=12, Kaloleni=13 Rabai=14 Ganze=15 Malindi =16			
Mvita=17, Kisauni 18, Mombasa=19, Changamwe=20, Jomvu=21, Nyali=22			
Starehe=23, kamkunji=24, Makandara=25			

Section A

Demographic and Socio-Economic Data

1. Age of the processor/ owner/manager/ CEO?: _________
2. Gender of the processor/ owner/manager/ CEO? Male=1 [ ], Female=0 [ ]
3. Highest level of education of the processor owner/manager/ CEO?
   None = 0 [ ] Tertiary colleges = 3 [ ]
   Primary = 1 [ ] University = 4 [ ]
   Secondary = 2 [ ] Number of years of schooling _____________________Years
4. Marital Status of the processor/ owner/manager/ CEO?:
   Single = 0, [ ], Married = 1, [ ] divorced =2 [ ] Widowed = 3, [ ] Separated = 4 [ ]
5. Apart from baobab processing do you have other source of income? Yes =1 [ ] No= 0 [ ]
   If yes please indicate
   Full time employment =1 [ ] shop/Kiosk/retail business =2 [ ] Crop production =3 [ ]
   livestock =4 [ ] , casual employment=5 [ ]
   Part time employment =6 [ ] other =7 [ ] specify
6. Employment status of the spouse: *(N/A for industrial)*
   None =0 [ ] Permanent = 1, [ ] Casual employee (Hired labor) = 2 [ ] self-employed =3 [ ], N/A =889 [ ]

7. What is the number of members in the household?	Total	males	Female
How many household members are there in each of the following age groups			
Less than 5 years			
5-17 years old			
18-34 years old			
35-64 year s old			
65 years and above			

8. Do you have access any family land in rural or urban area? Yes =1 [ ] No= 0 [ ]
9. Where is the land located.______________, what is the size of the land______________________?
10. Size of your rural land in acres _________ size of the business land (plots)
11. What is the nature of tenure of the rural l land? N/A=889 [ ] what is the nature of tenure of the business land?
    Own with title = 1 [ ], Otherwise = 0 [ ] Own with title = 1 [ ], Otherwise = 0 [ ]
    Own without title = 1 [ ] Otherwise = 0 [ ] Own without title = 1 [ ] Otherwise = 0 [ ]
    Leasehold = 1 [ ] Otherwise = 0 [ ] Leasehold = 1 [ ] Otherwise = 0 [ ]
    Communal = 1 [ ] Otherwise = 0 [ ] Communal = 1 [ ] Otherwise = 0 [ ]
    Others, specify ____ others, specify ___________________________
12. Where is your baobab business situated?
    Operate from rural home = 1 [ ] home in urban town =2 [ ] home in rural town=3 [ ]

Name of where the processing business is located ____

Section B

Technology used in baobab processing

1. What method do you use to separate the pulp on seed from the shell
   Using a panga =1 [ ], use of machines= 2 [ ] other = 4, [ ] specify N/A= 889 [ ]
2. What method did you use to extract powder from the pulp on seed?

Pestle and mortal = 1 [ ], Use of pulp extractor= 2 [ ] others = 4 [ ] specify N/A=889 [ ]

3. What methods of heating do use during baobab processing?
   Firewood = 1 [ ] charcoal = 2 [ ] gas stove =3 [ ] kerosene stove = 4 [ ] others = 6 [ ] specify N/A=889 [ ]
4. What cooking appliance do you use for cooking?
   Pot =1 [ ], Sufuria= 2 [ ], boiler=3 [ ], others =5 [ ] specify , N/A =889 [ ]
5. What package materials do you use in packaging your processed products?
   Sachets [ ] plastic bottles= 2 [ ] punnets (plastic packets) = 3 [ ] sacks =4 [ ] others = 5 specify _____________
6. What method do you use to package your products?
   Using lighter =1 [ ], manual machine =2 [ ] automated machine = 3 [ ], manual packaging =4 [ ] other =5 specify ______

Section C

Awareness on the number of baobab products

1. Kindly indicate the number of baobab processed products that you are aware of. Please indicate the products that you have ever processed.

	Baobab products	**Aware of the product**	**Processed the product**
1.	***Bark related products***		
a)	Ropes	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
b)	Baskets	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
c)	Medicine	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
2.	***Leaves related products***		
a)	Vegetables	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
b)		Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
3.	***Seed related products***		
a)	Cooking oil	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
b)	Massage oil	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
4.	***Pulp related products***		
a)	Biscuits,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
b)	Porridge	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
c)	Cakes	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
d)	Yoghurt	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
e)	Chocolate,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
f)	Sweets (tablets)	Yes = 1 [ ], No = 0	Yes = 1 [ ], No = 0 [ ]

		[ ]	
g)	Juices,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
h)	Ice-creams	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
i)	Pharmaceutical products	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
j)	Cosmetics	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
k)	Sodas,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
l)	Alcoholic drinks,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
m	Chutneys,	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
n)	Sauces	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
o)	Energy bars	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
p)	Mabuyus "candies"	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
q)	Pulp " Processed pulp"	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
r)	Others(specify)	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
s)		Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
5.	**Waste related products**		
a)	Firewood from shells	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
b)	Bowls from shells	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
c)	Decorations(beads, necklaces) etc	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
d)	Others, specify	Yes = 1 [ ], No = 0 [ ]	Yes = 1 [ ], No = 0 [ ]
	Total awareness / process score	……………………	…………………

2. What factors influenced you to choose the product to process.

Knowledge of product to process	Yes= 1 [ ] No= 0 [ ]
Skill on how to process the products	Yes= 1 [ ] No= 0 [ ]
Availability of baobab inputs	Yes= 1 [ ] No= 0 [ ]
Demand for the baobab products	Yes= 1 [ ] No= 0 [ ]
Availability of capital to start processing business	Yes= 1 [ ] No= 0 [ ]

Market information on prices of processed products and baobab inputs	Yes= 1 [ ] No= 0 [ ]
Low Cost of processing the products	Yes= 1 [ ] No= 0 [ ]
High profit margin from the products	Yes= 1 [ ] No= 0 [ ]
Time spent in processing (not time consuming)	Yes= 1 [ ] No= 0 [ ]
There are few processor involved in baobab processing	Yes= 1 [ ] No= 0 [ ]

Section D

Baobab processing

1. Do you have access to Baobab trees? Yes = 1 [ ], No = 0 [ ]
2. If yes, How many adult (have produced at least once) baobab trees do you have on your farm?________ N/A = 889 [ ]
3. Were you involved in baobab harvesting/ collecting in 2018? Yes = 1 [ ], No = 0 [ ] N/A= 889 [ ]
4. What is the scale of operation in your baobab processing business.

   Individual Processor = 1 [ ];

   Industrial Processor = 2 [ ]

   Any other (specify) = 3 [ ]

5. What is the form of your processing business?

   Sole proprietorship =1 [ ], partnership = 2 [ ], company = 3 [ ] , others =4 [ ] specify

   ____

6. . What motivated you to venture in baobab processing business?

   Profits = 1 [ ], Availability of baobab inputs = 2 [ ] High demand = 3 [ ]

   Less restrictions by policy = 4 [ ] Any other, specify ____________________

7. How long have you been involved in baobab processing? ________years
8. Is your baobab business formally registered/do you have a license for baobab processing Yes = 1 [ ], No = 0 [ ]
9. Who made the decision to get involved in the baobab processing?
   Husband = 1 [ ] Wife = 2 [ ] Both husband and wife = 3 [ ] Children = 4 [ ] male processor = 5 [ ]

female processor =6[ ] N/A = 889 [ ] Other, specify_______

10. Who is normally involved in the baobab processing *(N/A for processing factory)*

Involved person	Response
Husband	Yes = 1 [ ] No = 0 [ ] N/A = 889 [ ]
Wife	Yes = 1 [ ] No = 0 [ ] N/A = 889 [ ]
Male processor	Yes = 1 [ ] No = 0 [ ] N/A = 889 [ ]
Female processor	Yes = 1 [ ] No = 0 [ ] N/A = 889 [ ]
Both	Yes = 1 [ ] No = 0 [ ] N/A = 889 [ ]
Children	Yes = 1 [ ] No= 0 [ ]

11. Is your processing pattern similar throughout the year?
Yes =1 [ ] No=1 [ ]

Output from baobab processing

12. Please indicate the information on the amount of baobab processed products and their prices in relation to 2018

mont s	**Processed products** 1=mabuyu 2=powder 3=jam 4=juice 5=paper 6=yoghurt 7=ice cream 8=chutney 9=sweet/Chocolat 10=beads/Decora ons 11=ropes 12=medicine 13=others 14=cakes (specify)	**Units o Measur**	**No of units**	**Units of sale**	**Price/ Unit of sale**	**Value/ productior**	**No. of product ns /month**	**Total value /month**
Jan								
Feb.								
marc								
April								
May								
June								
July								
Aug								
Sept								
Oct								
Nov								
Dec								
	Total annual valu							
Codes of unit of measurements 1= 1kg 4=debe-20kg 7=packets 9=piece								

2= gorogoro-2kg	5= 1ltr	
3= bucket-18kg	6=sachets	8= basin =14kg

Sale of baobab output

13. Where did you mostly sell your baobab products in 2018?
Rural market = 1 [ ], Urban market = 2 [ ] Rural town market=3 [ ]

14. Whom did you sell your baobab products to in 2018?

Baobab products	Who did you sell to? (See codes below)	Who did you sell to mostly? (See codes below)
Pulp / powder		
Mabuyu		
Juice		
Ice		
Yoghurt		
Paper		
Cake		
Other specify		
Codes 1= Supermarket 2= R. wholesaler 3=U wholesaler	4=rural retailers 5=urban retailers 6=clinics	7= industries

15. Where did you sell most of your baobab products from?
From my processing point =1 [ ] Take to the buyer = 2 [ ] other s=3 [ ] specify
16. When selling baobab product, what mode of transport did you commonly use to transport your baobab products to the destination (selling) markets in 2018? Trekking = 1 [ ] wheelbarrow = 2 [ ] Bicycle = 3[ ] Motorbike = 4 [ ]
Pick-up = 5 [ ] Truck = 6 [ ] Other =7[ ] Specify _____________ , N/A=889
17. When do you sell most of the baobab?
On open market days = 1 [ ] Any other day = 2 [ ], Both = 3 [ ]
18. How do you sell your baobab products
Directly to the market = 1 [ ], On order = 2 [ ], Both = 3 [ ],
19. Where do you store your baobab inputs or baobab processed products

In my own room =1 [ ] In a different room = 2 [ ] In a special store =3 [ ]

20. Is the store rented or self –owned?

Rented = 1 [ ] Otherwise =0 [ ]

self-owned =1 [ ] Otherwise= 0 [ ]

N/A= 889 [ ]

21. If hired what is the storage cost ______________________

Source of income.

22. Indicate the sources and amount of your annual income and their seasonality for the year 2018. Please rank the sources of income. 1 represents the most important source of income. (Income in this survey refer to the gross revenue)

	Please tick the months that you receive the income												KES	
Source of income	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Income**	**Rank**
Permanent or fixed-term employee														
Casual employee														
Shop business/retail business														
Baobab processing														
Crop production														
Fruit production														
Livestock production														
Fishing														
Any other,(specify)_____________														

Section E
Inputs used in baobab processing

1. What baobab input did you purchase?
   Fruit=1 [ ], pulp on seed=2, [ ], pulp=4 [ ]

2. What is the amount of (probe for all raw material and labor used) inputs that you have purchased and used in baobab processing per month? For the year 2018

Input	**Units**	**No of unit purchased**	**Price per unit**	**Monthly cost**												
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total cost**
Baobab fruit																
Pulp on seed																
Pulp																
Other variable costs Sugar																
Cost of firewood/charcoal/gas (fuel)																
Colors																
Cost of Packaging materials **3/5** sachets																
5/7 sachets																
Plastic containers																
Sacks																
Flavors																
Water																
Storage cost (raw materials)																
Cost of packaging (lighter)																
cost of transporting inputs																
Cost of storage of inputs/ processed products																
Input	**Units**	**No of unit purchased**	**Price per unit**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total cost**
<u>Markets charges</u> Municipal cess																

Loading of inputs cost																
Police bribes																
Other market cost																
Certification cost/licenses																
Business registration fee																
Food safety and regulation																
NEMA licensees																
Medical health certification cost																
Public health cost																

Codes
1= 1kg 3=debe18 kg 5= 1ltr 7=sachet 9= kshs
2= gorogoro -2kg 4=bucket 18 kg 6= basin -14kg 8=piece 10= 20 liter Jerrican

3. Where did you buy your baobab inputs from in 2018?

products	Where did you buy from (see codes below)
Baobab fruit	
Pulp on seed	
Pulp	

Codes
1= farmer' home 3= R. Wholesalers 5= R. Retailer 7= 0ther specify
2=assemblers 4= U. wholesalers 6= U. retailer

4. When did you buy most of the baobab inputs?
   On open market days = 1 [ ] Any other days = 2 [ ], Both = 3 [ ]

Section F

Cost of labor.

1. Do you engage in hired labor? Yes =1 [ ], No=0 [ ]
2. If yes, what type of hired labor did you mostly engage in 2018
   Paid on daily basis =1 [ ] Paid on weekly basis =2 [ ]
   Paid on monthly basis =3 [ ] N/A = 889 [ ]
3. What is the general/normal wage rate for labor in this area? (Both)

   Per day _______ KES. How many hours? ______ Per day per month ______ KES

4. How many hours did you spend on baobab processing in 2018

Hired labor spent on baobab processing

			No of days worked per month											
Gender	No of persons	No. of hrs worked /day	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Male														
Female														

Family labor spent on baobab processing

			No of days worked per month											
Gender	No of persons	No. of hrs worked /day	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Male														
Female														

Section G

Capital Assets Related to Baobab processing

1. Do you own and use any of the following capital assets in your baobab processing? If yes, how many and how much are they valued in 2018?

Type of asset	**Do you own**	**How many**	**Approximate value KES**	**Type of asset**	**Do you own**	**How many**	**Approximate value KES**
Store	Yes = 1 [ ], No = 0 [ ]			Bicycle	Yes = 1 [ ], No = 0 [ ]		
Pick-up	Yes = 1 [ ], No = 0 [ ]			Wheel barrow	Yes = 1 [ ], No = 0 [ ]		
Pulp extractor	Yes = 1 [ ], No = 0 [ ]			Mobile phone	Yes = 1 [ ], No = 0 [ ]		
Lorry	Yes = 1 [ ], No = 0 [ ]			Donkey cart	Yes = 1 [ ], No = 0 [ ]		
Motor bike	Yes = 1 [ ], No = 0 [ ]			Mortar and pestle	Yes = 1 [ ], No = 0 [ ]		
Packaging equipment	Yes = 1 [ ], No = 0 [ ]			Any other specify	Yes = 1 [ ], No = 0 [ ]		

Section H
Hygiene and environment baobab processing

1. Do you have a dumping pit for litter or litter bin?
   Yes = 1 [ ] no = 0 [ ]
2. Is your processing facility supplied with clean water?
   Yes = 1 [ ] no = 0 [ ]
3. What is the source of the water:
   Privately installed from municipal supply= 1 [ ] from communal distribution=2 [ ] buy from vendors =3 [ ]
   others= 4 [ ] _______
4. Does your processing facility have waste disposal system?
   Yes = 1 [ ] no = 0 [ ]
5. Where is the final disposal of the refuse?
   Supplied to municipal service=1 [ ], Burnt at site (open burn) = 2 [ ]
   Disposed on street or in rivers= 3 [ ] other = 4 [ ](specify) _____________
6. Is there a drainage system for collection and handling of liquid waste?
   Yes=1 [ ] No=0 [ ]
7. What type of drainage system is it?
   Closed type which can collect all generated liquid waste =1 [ ]
   Open trench that can collect fraction of generated waste = 2 [ ]
   Other (specify= 3 [ ]__________
8. Do you have washroom within the processing facility?
   Yes = 1 [ ] no = 0 [ ]
9. Do you wear or use food processing garments such as gloves, caps, gumboots, during processing?
   Yes = 1 [ ] no = 0 [
10. Have you installed a functional hand washing facility in your processing premise (water & soap)?
    Yes = 1 [ ] no = 0 [ ]
11. Does staff wear any type of jewelry/nail polish during processing?
    Yes = 1 [ ] No = 0 [ ] N/A=889 [ ]
12. When you think about baobab processing how much do you agree or disagree with the following statements in relation to hygiene and safety compliance in processing environment.

Statements	**Strongly agree=5**	**Agree =4**	**Neutral = 3**	**Disagree = 2**	**Strongly disagree= 1**
Storage of raw materials together with processed products increase chances of food contamination.					
Equipments and containers that come up with food should be movable and allow disassembly for cleaning, disinfection and monitoring.					
Provision of toilet papers, soap and water for washing hands are mostly essential for a food processing facility.					
Food safety and food quality during processing are among essential buyers' requirements.					
Lack of food safety and quality systems food in food processing companies lowers customer's confidence and company's reputation.					
Training employees involved in food processing on hygiene should be conducted frequently.					

Providing litter bins, covering of little bin and frequent empting of litter bins reduces chance of food contamination.					
All staff members working in food processing industries should be examined by medical practitioners before employment					

Section I

Standard and Regulations in the baobab processing industry.

Quality and Regulations

1. Do you consider baobab input freshness when buying? Yes = 1 [ ], No = 0 [ ]
2. Do you decline to buy baobab input of low hygiene standards? Decline = 0 [ ] offer lower price = 1 [ ] Both = 2 [ ], No=3
3. Do you pay more for high price for nutritious baobab input? Yes = 1 [ ], No = 0 [ ]
4. Do your buyers take into consideration quality attributes of baobab products when buying? Yes = 1 [ ], No = 0 [ ]
5. Do buyers decline to buy baobab products which are poor packaged? Decline = 0 [ ] offer lower price = 1 [ ] No=2[ ] N/A = 889 [ ]
6. Do buyers pay high price for well flavored and nutritious baobab products? Yes = 1 [ ], No = 0 [ ] ,
7. Kindly indicate the quality standards and regulations for food processing business/ industries that you are aware of. Please indicate your level of adherence to these standards.

Standards in food processing industries	**Aware of the standards**	**Adherence to the standards**
Raw material should be purchased from approved suppliers to ensure safety of the inputs	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Raw material should be stored separately with the processed products	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Ensure that the food is free of foreign matter other than unavoidable defects. Should include inspection of raw materials	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
All employees should be examined by medical practitioner before employment	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
All staff members should be given induction and appropriate training on hygiene	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
All staff and visitors should wear protective gear when entering the processing unit	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Adequate toilet facilities and associated hand washing facilities should be provided	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Hand sanitizing solutions or sanitizing liquid soap in appropriate dispenser should be provided at each hand washing point	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Access to processing areas and particularly areas where food is exposed	Yes = 1 [ ] no= 0	Yes = 1 [ ] no=

shall be restricted	[ ]	0 [ ]
Personnel working in a food factory should maintain a high level of person hygiene, which include maintaining clean hands and nails.	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Staff should not engage in any behavior that may contaminate materials o products. Eating, spitting, nose cleaning or the use of tobacco in any form including smokin or chewing should be prohibited within the processing, packing and storag area of the factory.	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Detergents and sterilizing materials should be stored in a separate area to food and should be clearly labeled or marked	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Equipment such as storage containers and processing appliances should be cleaned before or after use, as appropriate	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Stores should be rodent, insect and bird proofed and should be maintaine in a hygienic condition.	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
Storage tanks, reservoirs, etc. for water should be covered so as to preve the contamination of the water.	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]
containers for waste, and other waste material should be covered and emptied frequently as is consistent with minimizing the risk of infestation.	Yes = 1 [ ] no= 0 [ ]	Yes = 1 [ ] no= 0 [ ]

9. What problems do you face in complying with these regulations?

Challenges	**Rank**
Lack of awareness about the regulations Yes = 1 [ ], No = 0 [ ]	[ ]
Inadequate information about the regulation Yes = 1 [ ], No = 0 [ ]	[ ]
The regulations are difficult to comply with Yes = 1 [ ], No = 0 [ ]	[ ]
Lack of resources and facilities Yes = 1 [ ], No = 0 [ ]	[ ]
Lack of training Yes = 1 [ ], No = 0 [ ]	[ ]
Any other, specify	[ ]

Section J

Attitude towards baobab processing

10.When you think about baobab processing how much do you agree or disagree with the following statements
(Tick appropriate, 5 = strongly agree, 4 = Agree, 3 = Not sure, 2 =Disagree, 1 = strongly disagree)

Items	5	4	3	2	1
Baobab processing is a source of employment					
Baobab processing activity is a key source of income					
Baobab processing improves peoples' livelihoods.					
Starting baobab processing business requires high amount of capital.					
Buyers pay high prices for fresh and nutritious baobab products					
Processing baobab increases the cost of a commodity.					
You are arrested if you fail to adhere to food safety and hygiene regulation during baobab processing.					
Your baobab will be confiscated and destroyed if you fail to adhere to food safety and hygiene regulation.					
Quality of final processed products is affected by the quality of raw materials.(such as baobab fruits, color)					
Quality products improve consumers' trust and loyalty on baobab products.					
I intend to expand my processing business					
I intend to process more baobab product in future					

Section K

Networks and association of baobab processors.

Information Access in 2018

1 .Did you have access to any information on baobab? Yes = 1 [ ] No = [ ]

2. If yes what type of information?

Information type	**Response**
Baobab inputs (pulp, pulp on seed, pulp) pric before buying	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Baobab price for processed products before selling	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Baobab Value addition	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
International Prices	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Market information	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Quality information	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Standards and certification	Yes = 1 [ ] No = 0 [ ] N/A = 889 [
Other, specify	

3. What type of information about baobab would you be more interested in receiving

Information type	**Response**
Baobab input prices	Yes = 1 [ ] No = 0 [ ]
Prices of baobab processed products	Yes = 1 [ ] No = 0 [ ]
Baobab Value addition	Yes = 1 [ ] No = 0 [ ]
Source of baobab inputs	Yes = 1 [ ] No = 0 [ ]
Markets information	Yes = 1 [ ] No = 0 [ ]
Quality information	Yes = 1 [ ] No = 0 [ ]
Standards and certification]	Yes = 1 [ ] No = 0 [ ]
Other, specify	

Credit

1. Did you need any credit for baobab processing in 2018?
   Yes = 1 [ ] No = 0 [ ]
2. Did you apply for the credit in 2018

Yes = 1 [ ] No = 0 [ ]

3. Did you obtain the credit, Yes = 1 [ ], No = 0 [ ]
4. If yes how much? KES ___________________________ N/A = 889 [ ]
5. If you obtained the credit who provided it?

Family/relative = 1 [ ], Otherwise = 0 [ ]
Friend/neighbour= 1 [ ], Otherwise = 0 [ ]
Commercial Bank = 1 [ ], Otherwise = 0 [ ]
Table banking /Microcredit = 1 [ ], Otherwise = 0 [ ]
Cooperative/SACCO = 1 [ ], Otherwise = 0 [ ]
Baobab trader/processor = 1 [ ], Otherwise = 0 [ ]
Mobile based sites = 1 [ ], Otherwise = 0 [ ]
N/A = 889 [ ]
Other (specify) ____

6. If you tried to get credit/loan but did not get, what was the reason for not getting?
No collateral=1 [ ], Outstanding loan=2 [ ], Don't know=3 [ ], Lender lacked cash=4 [ ], N/A = 889 [ ]

Training

1. Have you or any member of your household/industry received any formal training/advice on baobab processing?
Yes = 1 [ ], No = 0 [ ]
2. How many seminars or training on baobab processing have you attended so far?
Once =1 [ ] twice= 2 [ ], thrice= 3 [ ], four times =4 [ ], five times 5 [ ] more five times = 6
3. If you received any training, when was the most recent training you received?
Within a month ago = 1 [ ] Within 3 months ago = 2 [ ]
Within 6 months = 3 [ ] Within 1 year = 4 [ ]
More than a year ago= 5 [ ] N/A = 889 [ ]
Any other, specify ____
4. If you received any training what was the training about?

Composition of ingredient used in processing =1 [ ] , processing hygiene =2 [ ] processing regulations =3 [ ]
Packaging =4 [ ] , marketing =5 [ ] , any other = 6 [ ] specify_______________________

Enumerator's views

How do you judge the quality of the response based on the ability of the respondent to recall information and stay focused during the interview? Very good = 4 [ ] Good = 3 [ ] Fair = 2 [ ] Not good = 1 [ ]

Can you make any observations[1] about the household or the interview that might be relevant for interpreting the data?

____
____
____
____
__

Thank you

.