ACCESS AND USE OF KNOWLEDGE ON FRUIT PROCESSING TECHNOLOGIES BY SMALLHOLDER FARMERS: CASE STUDY OF MWALA, MACHAKOS COUNTY.

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL INFORMATION AND COMMUNICATION MANAGEMENT OF THE UNIVERSITY OF NAIROBI

DEPARTMENT OF AGRICULTURAL ECONOMICS

2015

DECLARATION

This thesis is my original work and has not been presented for an award of a degree in any other academic institution.

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DEDICATION

I dedicate this thesis to my family, my husband Dennis Orina, our son Allan Yarves Orina whose toothless angelic smile kept me going. My parents, Mr. and Mrs. Ndege for their support throughout my studies. My sister Christine Ndege who sacrificed to take care of Allan during my field trips and my entire family for their continued support.

ACKNOWLEDGEMENT

First and foremost, I want to give my thanks to Almighty God. I would like to extend my heartfelt thanks to my supervisors, Prof. Jasper K. Imungi, Dr. Stepha McMullin and Dr. Katja Kehlenbeck, as without their encouragement and guidance, the completion of this work may not have been possible. Thus, I am very much indebted to Dr. McMullin and Dr. Kehlenbeck for their support and willingness to also allow me collect data and at the same time be there for my family and to successfully finalize the thesis.

I would like also to express my sincere appreciation to IFAD, Fruit Africa Project for covering full funding of my research work. I greatly acknowledge ICRAF/SD3 staffs Sallyannie Muhoro, Nelly Mutio, ICRAF's capacity development staff, Ms Hellen Ochieng my mentor, Nicholas Matti and Imelda Ingumba for their valuable advice and encouragement. Without their assistance, the completion of this paper would have been hardly possible.

I also remain thankful to Morris Mutua, the field assistant who assisted me in the field data collection during that extreme hot temperature time with patience, commitment and dedication.

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LIST OF ACRONYMS

APO	Asian Productivity Organisation
AICAD	African Institute for Capacity Development
CBO	Community Based Organisations
FAO	Food and Agriculture Organisation
FBOs	Farmers Based Organisations
GOK	Government of Kenya
HCDA	Horticultural Crops Development Authority
HDI	Human Development Index
IFAD	International Fund for Agricultural Development
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
KHCP	Kenya Horticultural Competitiveness Project
KNBS	Kenya National Bureau of Statistics
MNL	Multinomial logit
NEMA	National Environment Management Authority
NGO	Non-Governmental Organisation
NUS	Neglected underutilized species
RDA	Recommended Daily Allowance
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organisation
USAID	United States Agency for International Development
WHO	World Health Organisation

ABSTRACT

Many fruits are produced and consumed in Kenya. They are eaten either fresh or in processed form. Processing is commonly by formal industry. The Government of Kenya strategy on reducing post-harvest losses to promote economic development, reduce poverty and increase food security is to support farmers to transition from subsistence to commercial. To support fruit farmers, processing and preservation technologies are being transferred through training. However, the training provided is not wide-spread and is undertaken by multiple agencies with variations in the training content and approach. This study was designed to assess the access and use of knowledge on fruit processing technologies with particular reference to *Mangifera indica* and *Syzygium cuminii.* The study was conducted as a case study in Mwala, Machakos County, Kenya. A literature review was undertaken on the processing technologies to identify the technologies that would be appropriate for the farmers. The farmers were randomly selected in a systematic way from 21 trained groups to obtain a sample size of 100 farmers. Data was collected using a pre-tested interview schedule on the socio-demographic and socio-economic characteristics of the farmers, their level of knowledge and on the use of processing technologies, training activities carried and knowledge sources on fruit processing technologies. Data was analysed using descriptive analysis and Multinomial logit (MNL) model. The study established that various technologies exist that are appropriate to exotic and indigenous fruits; they include pulping for beverage production and the manufacture of jams and jellies, drying, fermentation into wine, pickling, production of emulsions and production of vinegar. Out of the 100 trained respondents only 77% could remember and list the fruit processing technologies they had been trained on. Seventy-five-percent of the respondents have used processing technologies at least once for jam and juice manufacture. Use of fruit value adding/processing technologies was most common for home use (63%), with only 12% indicating processing for sale. Twenty- five-

percent indicated not having used the technologies that they had been trained on. Out of the 75 respondents, only six respondents were active adopters of the technologies at the time of the interview while 69 respondents were no longer practising at the time of the study. The fruit species most commonly used for the value addition/processing technologies training was *Mangifera indica*. It was established that processing for home consumption and for sale was significantly influenced by the number of trainings attended, number of technologies trained on, hands-on experience and own fruits production.

The study established that 51% of the respondents have been trained on juice making, followed by 21% on jam making and 11% on drying technologies. Very limited training had taken place with the use of the indigenous fruit, *Syzygium cuminii* (or any other indigenous fruits). The Ministry of Agriculture Livestock & Fisheries (MOALF) had trained the largest number of the interviewed respondents. In addition to training as a source of knowledge on processing, respondents indicated other sources of knowledge including radio (55%), formal and informal groups doing processing (18%), farmer's field days and agricultural shows (11%), extension officers (9%) and friends and neighbours (7%). Challenges encountered in the use of the technologies included seasonality of the fruits, high cost of packaging materials, lack of processing equipment and lack of skills. The study concludes that the farmers have ample knowledge on fruit processing particularly from training but the practice is low.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND INFORMATION

Tropical fruits are among the most important crops with potential to improve the diet and quality of life of sub Saharan Africa (SSA) communities (Williams *et al.,* 2002). The fruits are integral to world commodity trade. Exotic tropical fruits have had their taste, appearance, texture and nutritional quality accentuated through research (Akinnifesi *et al.,* 2008; Fernandes *et al.*,2010) to meet consumers preferences (Akinnifesi *et al.,* 2008). On the other hand, indigenous fruits are still to a large extent collected from the wild and very little research has been undertaken (Akinnifesi *et al.,* 2008). Recently, however, attempts have been made to domesticate some for increased utilization (Akinnifesi *et al*., 2008). Because of the non-domestication of the indigenous fruits, exotic fruits are commonly consumed because of ease of and availability (Horticultural Crops Development Authority (HCDA), 2013 ; Kehlenbeck *et al*., 2013) although the former possess cultural values, provide resilience and are better adapted to ecological conditions.

Fruits are eaten fresh or when processed into pulps, purees, sugar concentrates (jam and jelly), beverages (juices nectar and drinks), pickles, dried products and many more. Unfortunately, fruits are seasonal and the harvest comes as gluts and because of lack of processing and preservation technologies, this leads to high post- harvest losses. This is exacerbated by inconsistent markets (Gathambiri *et al*., 2009). Among the most commonly grown and consumed fruit in Kenya is the *Mangifera indica* (mango). In the *Mangifera indica* value chain the losses in Kenya are estimated at 40-45% (Gathambiri *et al*., 2009).

Various processing technologies for fruits exist although these are often confined to commercial industry and are not conventionally practiced at the cottage level by most

smallholder producers. Some of the technologies like pulping for jam and juice manufacture, drying, fermentation into wine and pickling which are barely simple and can be transferred to smallholder farmer through tailor-made training. Training of the farmers on these simple processing technologies can address seasonality issues and reduce post-harvest losses. It will also help to diversify use and markets of the fruits (Gitonga *et al*., 2014).

There is very high potential of agro-processing in Kenya (Gathambiri *et al.,* 2009). This is indicated by the fact that most farmers in Kenya grow Tommy Atkins which is an appropriate variety for processing (Gathambiri *et al.,* 2009). There is also ready market for the processed product. However the challenge remains in the fact that most of the producers are lacking when it comes to processing information and training. Previous studies in Kenya, Tana River Kipini division, indicated that only two farmers knew how to process *Mangifera indica* juice and had tried it before (Ndungu *et al.*, 2008). Another study by Musyimi *et al.* (2012) indicated that a value added product like *Mangifera indica* wine exists but there is no proper documentation of information regarding its processing and production. It is against this background that the study was designed to assess farmers' access to trainings on the technologies and to what extent they practice the technologies. The study was designed as a case study on smallholder farmers in Mwala, Machakos County. Mwala is located in the semi-arid region of Eastern Kenya with high potential for production of high value crops. The area's poverty levels are at 59.6% which is against the national average levels due to frequent draughts. Some of the interventions to curb drought have been introduction of cultivation of mango fruits by organisations as the Kenya Agricultural Research and livestock organisation (KARLO). Statistics from the Horticultural Crops Development Authority (HCDA), 2013 indicate that Machakos County where Mwala is located is third highest in Kenya in terms of production of the mango fruit. However, during gluts, high losses of this perishable fruit do occur which limit the smallholder farmers from getting their expected income.

To therefore understand the access and use of trainings received, the study was based on two fruits *Mangifera indica* as an example of an exotic fruit, because of its high demand/market value and one indigenous fruit in the area, *Syzygium cuminii*, an example of an indigenous fruit because of its very high yielding and great potential for processing.

1.2 PROBLEM STATEMENT

There are many missed opportunities for smallholder farmers for adding value to fruits for preservation, nutritional benefits and for income diversification through fruit based enterprise development (Kehlenbeck *et al*., 2013). Kehlenbeck *et al*. (2013); HCDA (2013) indicates that focus on both local and export market on fruits has been on fresh market and not processed fruit products. Therefore, the potential of most fruits in Kenya remain underutilised (HCDA, 2013). Processing is quite low and confined to large scale commercial industries. The fruit value chains have not been fully developed (Kehlenbeck *et al*., 2010) and strengthened to mitigate post-harvest loss and wastage. According to Kehlenbeck *et al*. (2013) this is attributed by high losses during the seasonal gluts. Among the most commonly grown and processed fruits in Kenya is the *Mangifera indica.* There are between a 40 and 50% loss in *Mangifera indica* value chains in Kenya due to inappropriate post-harvest handling at the smallholder farmer level (Gathambiri *et al*., 2006; Government of Kenya (GOK), 2012). Poor organisation of fruit marketing and largely informal, limited information on fruit processing is available to the Kenyan smallholder farmer which severely limit fruit processing in the sector (Kehlenbeck *et al*., 2013).

According to GOK (2012), the challenge in the use of processing technologies by farmers is due to many factors including lack of knowledge and training, lack of capacity to operate in a competitive market because of bottlenecks of poor access to the available technologies, poor

technical expertise, low production, poor infrastructure, lack of market information and organized markets and failure to meet the required international standards.

There has not been any significant expansion of *Mangifera indica* processing in Kenya. GOK (2012b) estimates processing operations are not at full capacity in Coast and Central province and is between 40%-80% due to constraints/ limitations in consistent supply of good quality raw material. Local raw materials have not been fully utilized in juice and beverage processing and most processors (HCDA, 2013) import raw materials from South Africa, Mauritius and Egypt (Gitonga *et al*., 2014; Msabeni *et al*., 2010). In Kenya, the fruit processing sector provides an opportunity for fruit producers and smallholder farmers to engage in due to market potential.

1.3 JUSTIFICATION

Training the smallholder farmers on processing and preservation would help to reduce post-harvest loss and increase availability of processed products at a local level. The value addition process can also offer income diversification opportunities for farmers to benefit from surplus fruit yields. The choice of *Mangifera indica* and *Syzygium cuminii* for this study is very appropriate because the former is the most commonly grown and consumed exotic fruit while the latter is an indigenous fruit, widely available in the study area and has the potential to provide farmers with additional income/ revenue from agricultural production due to ease of production and high yields.

The results of the study will be useful to provide much needed information on the current status of value addition/processing by smallholder farmers who received training in the study area and further, in guiding policy makers, government institutions, local and international organisations in designing appropriate training programmes for value addition for the smallholder farmers.

1.4 OBJECTIVES

1.4.1 Main Objective

To assess the access and use of knowledge gained from training in fruit processing technologies by smallholder farmers.

1.4.2 Specific Objectives

1. To review the available technologies for fruit processing with a view to identifying the ones with potential for adoption by smallholder farmers in Kenya.
2. To determine the socio-demographic and socio-economic characteristics of fruit farmers with particular reference to *Mangifera indica* and *Syzygium cuminii*.
3. To establish the level of knowledge and practice of fruit processing technologies by the farmers with reference to *Mangifera indica* and *Syzygium cuminii*.
4. To identify the knowledge sources by the farmers on fruit processing with particular reference to processing of *Mangifera indica* and *Syzygium cuminii*.

CHAPTER TWO: LITERATURE REVIEW

This section provides a review of the literature in the *Mangifera indica* and *Syzygium cuminii* sub-sector as well as other studies that have focused on provision of training and agricultural related information.

2.1 TECHNOLOGIES FOR FRUIT PROCESSING

2.1.1 *Mangifera indica*

Mangifera indica fruit has originally been cultivated in India for over 400 years from where it spread to other countries (Litz, 2009). It is a very important fruit in the tropics and sub-tropics. *Mangifera indica* belongs to the family Anacardiaceae consisting of ever green crown that reaches great heights (Orwa *et al*., 2009). *Mangifera indica* fruit have variations when it comes to size, it may be oval, round or stretched oval. The fruit skin colour is also different depending on the variety grown ranging from green, yellow or red (Litz, 2009).

Commercial *Mangifera indica* growing is done in more than 90 countries with the production being over 28.5 million Metric Tonnes (MT) in 2005 (Musyimi *et al.,* 2012). Main countries growing *Mangifera indica* in the world are China, India, Brazil, Mexico, Pakistan, Bangladesh, Philipines, Nigeria (Bally, 2011) and other countries where Kenya belongs, accounting for 17.72% world total share production (GOI, 2013). Only 3% of the world production of *Mangifera indica* is traded globally (UNCTAD, 2013). There is potential of increasing *Mangifera indica* production in Africa by identifying cultivars with good flavour, low fibre content, and that which can grow under local conditions (Griesbach, 2003), to increase *Mangifera indica* trading.

2.1.2 *Mangifera Indica* Production in Kenya

The average *Mangifera indica* production in Kenya in 2013 was 581,290MT (HCDA, 2013). *Mangifera indica* are grown for both export and domestic consumption. Recent statistics in 2013 indicate that, Kilifi County accounted for a higher production (106. 269 MT), followed by Kwale County (91, 390MT) thirdly Machakos County at (51, 546MT) (HCDA, 2013) as presented in Table 1.

Table 1: *Mangifera indica* production statistics for period 2011-2013, Kenya

	2011		2012		2013	
County	Quantity (MT)	Area (Ha)	Quantity (MT)	Area (Ha)	Quantity	Area(Ha)
Kwale	43,196	2136	52,574	2636	91,390	4135
Kilifi	98,309	5727	101,655	5729	106,269	5793
Migori	23,888	1722	26,055	1874	28,898	2061
Machakos	41,532	4520	54,329	4825	51,546	5133
Meru	45,371	4097	46,010	4176	48,432	4135
Makueni	40,038	9224	44,482	10237	48,494	10632
Bungoma	17,813	919	22,370	1155	24,391	1258
Embu	9,171	1857	27,388	3290	39,588	3605
Tana river	18,540	1133	22,054	1211	23,204	1276
Lamu	31,778	2158	32,466	2187	24,440	2189
Others	83,308	5874	91,049	6457	94,638	6764
National	452,944	39367	520,432	43777	581,290	46980

(Source; Horticultural crops development authority (HCDA), 2013)

Two seasons exists in *Mangifera indica* production in Kenya. In the Coast there are two seasons with the main running from November to February, while the second runs from June

to August (Griesbach, 2003). In higher altitude areas like Central province the season is four-six weeks later than Coast with the peak in February and March (Griesbach, 2003).

Two varieties of *Mangifera indica* grown in Kenya include, local variety which comprises of Ngowe, Dodo , Boribo and Batawi which are unpopular for fresh fruit consumption as a result of stringiness due to high fibre (Griesbach, 2003). Apple, Mathius, Azacus, Van Dyke, Tomm Atkins, Zill, Nimrod, Irwin, Hadin, Bombo, Pech, Maya, Sabre, Maya, Sensation, Sabine are all exotic (HCDA, 2010). The fruit has become popular in recent times but only a few consumers and growers are familiar with the characteristics of the different cultivars of *Mangifera indica* grown in Kenya (Griesbach, 2003). *Mangifera indica* produced in Kenya is dependent on a variety of factors which include the cultivar, altitude, weather, soil profile, pest and diseases as well as fertilization (Griesbach, 2003).

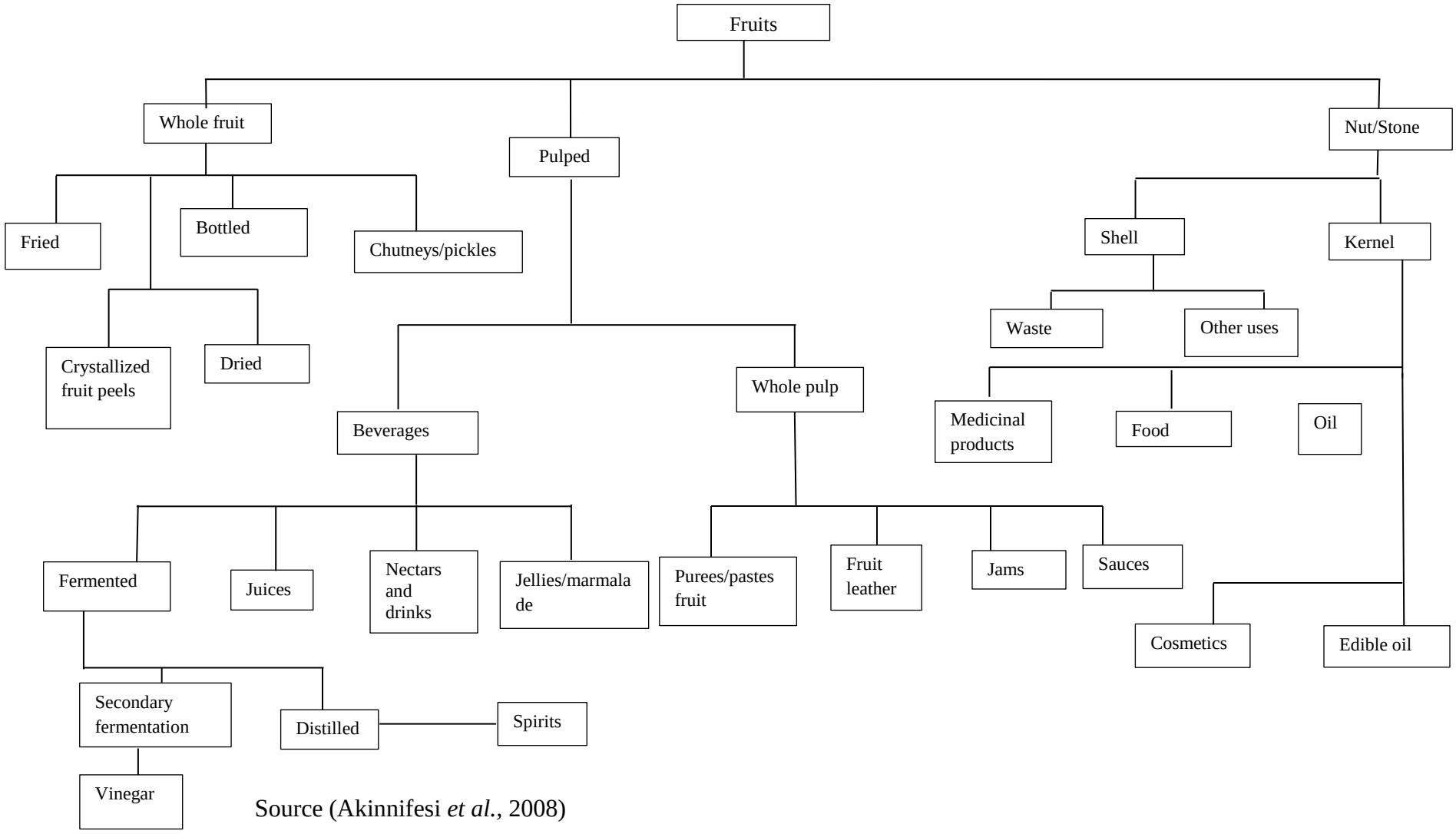
Although Kenya is a producer of many varieties of fruits, most Kenyans are unable to obtain the recommended daily allowance (RDA) and thus the human development index (HDI) is very low (APO and FAO, 2006). Considerable quantities of fruits produced in Kenya go to waste because of improper post-harvest practices and lack of processing knowledge. It is therefore essential for the farmers to be well equipped with processing technologies to reduce losses and diversify their diets for improved nutrition and income generation.

2.1.3 Processing of *Mangifera indica*

Processing is generally done to add value and value addition in recent times has really diversified (APO and FAO, 2006). Aseptic packaging, deep freezing, cryogenic freezing and accelerated freeze drying have accelerated shelf life (APO and FAO, 2006) and Kenya should not be left out to confine itself to products like juices, jam, jellies and squash. Therefore appropriate processing technologies should be better researched

Processing entails transforming *Mangifera indica* fruit into various semi-finished or ready to consume products for different purposes and markets (Msabeni *et al.*, 2010). According to United Nations Industrial Development Organisation (UNIDO), (2004) *Mangifera indica* are processed to extend shelf life by slowing natural decay process caused by micro-organisms, enzymes and factors such as heat, moisture and sunlight. Other reasons for processing as identified by Msabeni *et al.* (2010) include; value addition for income generation, broadening market base, decreasing post-harvest losses, creation of employment and improving nutritional value of *Mangifera indica* through pickling. In India where *Mangifera indica* growing originated, processing of fruits and vegetables is only about 2.2% indicating how this area is greatly neglected (Karthick *et al*., 2013). Value addition to the raw fruit in Kenya is only 7% compared to China (23%), Philippines (45%) and the United Kingdom (UK) (88%) (UNIDO, 2004). Main processors in Kenya include, Milly Fruit Processors, Kevian Limited and Premier Foods (HCDA, 2011). These processors only receive 5% of fresh *Mangifera indica* sold by middlemen, farmers and farmer groups (Msabeni *et al*., 2010) while the rest are imports as concentrates (HCDA, 2013). This therefore presents a good opportunity for local companies and actors in the mango value chain as ready market is present and available.

Mangifera indica is consumed both fresh and in preserved state. In the preserved state, the fruit can be processed into a variety of products which include; *Mangifera indica* juice, *Mangifera indica* concentrate, *Mangifera indica* squash, *Mangifera indica* wine, jam, jellies, dried *Mangifera indica*, and chutney (Figure 1).



Source (Akinnifesi *et al.*, 2008)

Figure 1: Fruit products from processing technologies

2.1.4 Syzygium cuminii

Syzygium cuminii is a fruit that belongs to the family myrtaceae and is widely spread/found in places like South Asia but remains underutilized (Ayar *et al*., 2011; Roy *et al.,* 2013). It is native to India and Indonesia and is present to moist and dry situations (Orwa *et al.*, 2009). It is fast growing found both in the wild and cultivated reaching heights of 30Metres and life span of ≥ (greater than or equal to) 100 years (Chowdhury and Ray, 2007) . The ripe fruit is purple in colour due to presence of anthocyanin. Common names include, Jamun, Black plum, and Indian black berry (Chowdhury and Ray 2007). It is one of the neglected and underutilized species (NUS) in Kenya, there is therefore the need to "create awareness on their economic and nutritional value'' (Padulosi *et al.,* 2013).

2.1.5 Processing of *Syzygium cuminii*

The fruit is consumed fresh and is very juicy but has "slightly bitter and astringent taste" (Orwa *et al*., 2009). It can also be processed into beverages, jelly, squash, wine, jam, vinegar and pickles (Ayar *et al*., 2013). In Philippines it has been expansively used in wine making. Apart from its nutritive value, the tree is also used for timber, making railway sleepers, and in apiculture to yield high quality honey (Chowdhury and Ray, 2007; Orwa *et al*., 2009).

The fruit is highly perishable and this makes its storage and transportation to the market very difficult (Roy *et al*., 2013).This has limited its use in processing to add value. These fruits do not also remain on the tree when ripe, they drop immediately after ripening (Roy *et al*., 2013). Unfortunately this is the same situation in Mwala especially when rains come and the entire fruits drop down resulting to huge amounts of damage which makes them unfit for consumption and also processing. This is also one of the challenges that should be addressed for farmers to be

equipped with knowledge on proper harvesting of indigenous fruits with maturity indices indicators.

In tropical countries for example, the fruits are in surplus from May to June but have found little application (Chowdhury and Ray 2007). Little studies have been done on production of beverage from *Syzygium cuminii* fruits and they remain underutilized (Chowdhury and Ray 2007). The same is also true for Kenya. Chowdhury and Ray (2007) suggests that African and Asian countries require processing technologies which are affordable and use locally available materials and equipment in order to meet the challenges of food and nutritional security by utilizing NUS.

So many companies in India exist for processing the fruit. The fruit has been extensively used in Asia to make three products which include; juices and squashes, ice-cream and vinegar (Chaudhary and Mukhopadhyay, 2012). In India many consumers have accepted the fruit products which are now very popular. In Africa, people have always employed traditional methods of processing indigenous fruits to make alcoholic and non-alcoholic beverages (Akinnifesi *et al.*, 2008). Indigenous knowledge that exists can still be relied upon to make beverages out of black plum fruits in Kenya. This priceless knowledge can be revisited, documented to aid in black plum fruits value addition. The bright purple colour of the fruit can also be used as a natural food colouring. The seeds also have a lot of market for pharmaceutical purposes especially in Europe and England (Ranjan *et al*., 2011). In Kenya not much has been done in terms of processing and marketing but the country can borrow heavily from Asia.

2.2 AGRICULTURAL KNOWLEDGE AND INFORMATION

Knowledge and information are used interchangeably in this study**.** Varying scholars define knowledge differently from their own perspective, however according to Zins (2007), knowledge is human expertise that exists in a person's mind and is embedded in people as the

"capacity to understand, explain and negotiate concepts, activities and intentions". If particular knowledge does not exists in someone, it can be elicited through education or training.

Information is another term that has to be understood from the knowledge perspective. It is characterized as the occurrence of communication that takes place between the sender and receiver. According to Zins (2007) when information has been properly assimilated it results to knowledge, therefore information is a term that includes all knowledge. This is where extension services come in to support people in Agriculture production to solve problems and to obtain knowledge and information to improve their well-being (Asenso-Okyere and Davis, 2009). Both formal and informal knowledge through extension must be linked to accelerate sustainable agriculture development to foster innovation (Asenso-Okyere and Davis, 2009).

Access means obtaining timely and relevant information. It implies physical and economic access to written materials, print, mass media, extension, researchers, and any other form of communication. Formal sources like newspapers, learning institutions, farmers unions are less dependent upon and used as information sources. Instead, new knowledge is shared in informal networks like family networks, social platforms, group meetings, field days and shows (Gwandu *et al*., 2014) . Therefore trainings and knowledge dissemination programs should take advantage of this to ensure farmers get adequate access of agricultural knowledge.

Agricultural information is therefore defined as information ranging from production technologies, farm management, marketing, produce processing as well as community development (Kaske, 2007). This information is transmitted from research to farmers who are the end users through extension process (Nlerum *et al*., 2012).

2.2.1 Farmers' Access to Information

Knowledge and information is the least expensive input in agricultural production yet most farmers cannot find access. According to Okwu and Umoru (2009) farmers need access to information on processing technologies, market, credit, agricultural innovations, fertilizers and management of pests and diseases. This range of information helps farmers augment their productivity (Salleh *et al.,* 2012). Most farmers and farmer-groups engaged in agricultural production live far away from the sources like extension agents, libraries, information centres limiting their access to information. Lack of these has resulted to status quo resulting to poor agricultural productivity.

According to Obidike (2011) knowledge and Information access is very essential to help the rural people maximize their yields, production and post-harvest processing capacity. Lack of these has forced many rural people to urban centres in search of employment. Farmers' face various constraints in accessing agricultural information. Obidike (2011); Nlerum *et al.* (2012) identifies the constrains as follows; financial inadequacy, unavailable extension staff and illiteracy. Lack of infrastructure like telephone, electricity and road network, few extension workers that is the ratio between extension workers and farmers and lastly poor reception of radio and television in most village communities are other challenges farmers face (Obidike, 2011).

One of the determinants for access to processing technologies includes the information seeking behaviour of a farmer. Information seeking behaviour is a term which encompasses ways in which people seek, select, evaluate and comprehend information needs. In the process of information seeking, people interact with other individuals, computers, various information channels like radio and various information systems. People seek information for various reasons. Spurk *et al*. (2013) identifies the following reasons for seeking information, perceived

need for particular information, social pressures to be informed as other members and personal factors- which may include risk acceptance, avoidance, innovation readiness, accessibility to and availability of information. Singh and Satija (2007) posit that information seeking behaviour is purposed to find information in order to achieve a need to meet a particular objective defined here as information utilization.

Utilization of various sources of information ensures exchange of ideas and thus increases production. Information use should be encouraged among communities in both men and women to achieve desired results. Where information use has not been encouraged, objectives of most initiatives have not been met. For example, in Pakistani, the government failed to get desired targets in equipping farmers with lasts agricultural information simply because women lagged behind than male counterparts in utilizing information sources because of little access in agricultural messages and extension services (Hassan *et al*., 2007).

Familiarity to information sources is key to ensure information utilization. Rodgers diffusion theory encourages the use of familiar sources like subject matter specialist to spread new technologies. This is because users always identify with a familiar source regardless of the quality of information. This is demonstrated by a study by Singh and Satija (2007) on information seeking behaviour by agricultural scientists, their findings revealed that access and preference to scientific information was based on personal knowledge of sources and their accessibility.

2.2.3 Factors Affecting Access and Usage of Agriculture Information

Very few people in developing countries have access to adequate agricultural information. Information needs of the rural people are diverse due to varied social, demographic, psychological and economic factors (Mtega, 2012). It is therefore important to understand the factors influencing information access and use like farm size, size of household (HH), age, years in farming, level of education, income, and market access in order to improve access and use of information. There isn't so much literature on specific factors affecting access and use of processing technologies. Therefore this study will rely on previous studies that have been carried out on factors affecting adoption of new technologies/agricultural information. The factors will be categorized as demographic, psychosomatic, and socio-economic status.

2.2.3.1 Demographic factors

In this study demographic characteristics included the age of respondents, gender, education, family size, and marital status. Empirical studies reveal gender is a key factor that plays a significant role in information access and on how end users obtain new agricultural information. A few empirical evidence discussed in this section depicts how gender affects technological adoptions.

Rural women face lots of difficulties than men in gaining access to agricultural information. Naveed *et al*. (2012) study on information seeking behaviour by Pakistani farmers showed that female farmers had 75% information access from television sources, friends 67.5%, relatives 61%, radio 39% and local farmers 89%. The male counterparts had 73% from local farmers, 73% relatives, 66.5% friends, television 62% and lastly radio 54.5%. This is because men tend to be in formal networks and employment while women are in informal networks and self-help groups therefore tend to have less access to information and inputs (Ayele and Bosire, 2011).

Age is a factor that affects access and utilization of processing technologies. Very many young people have access to a lot of material especially the internet, print, computers and they are able to learn very fast. This means that they are therefore able to access and use information acquired to better their production. Age also influences access and use of information both positively and negatively. Young people don't work as farmers yet later in life they access land for farming either through inheritance or as a result of retirement. In a study done by Spurk *et al*. (2013) on Kenyan farmers and their assessment of information on agricultural innovation, 32% of the farmers were older than 50 while only 19% were up to 30 years. Age will also influence the type of channel to be accessed, a study by Mwombe *et al,* (2014) on sources of information on bananas, found out that the young group access to radio, television, and mobile phone was high while access decreased with increase in age. Increase in age might lead to less access on agricultural innovations although the assumption on elderly people is that due to farming experience, they can access and adopt new technologies.

Education is also another factor that is critical in the access and use of processing technologies information. Illiteracy means that someone cannot read and write and this hampers their access and use of information. Literacy means farmers have the ability to get, understand and use agricultural information (Opara, 2012; Rehman *et al.*, 2013). Education exposure also enables farmers to store and later use that information. There is a correlation between education level and media preference on access of agricultural information, higher education level means access to more television, newspaper, less radio due to the ability to read and write (Spurk *et al.*, 2013).

When looking at marital status, various scholars found that married respondents had more networks and access to new technologies than unmarried, divorced and widowed (Ayele and Bosire, 2011). According to Opara (2010), married farmers/producers are more likely to be under pressure to produce more as well as for sale and thus necessitate agricultural information

seeking and use. Similarly, large family labour availability could motivate the farmers to grow more crops and use agricultural information (Opara, 2010). Koskei *et al*. (2013) however disagrees and he indicates that marriage negatively affects probability of access to information. He argues that the un-married participates in more social activities due to limited responsibilities while the married stay at home and help in domestic chores. In other studies by Kaske (2007), there was no correlation of marital status and access of information.

2.2.3.2 Socio-economic factors

In this study socio-economic variables were defined as the farm size, cultivating of fruit trees on the own farm, on-farm and off -farm income. Farmers with higher income are in a better position to invest in processing technologies and seek more agricultural information (Opara, 2010). It also means a farmer has more financial capacity hence a higher probability in uptake of new technologies (Koskei *et al*., 2013). As identified by Ali (2012) on the factors influencing adoption of post- harvest processing technologies, growers of vegetables with a minimum of Indian Rupee (Rs) 500 were 27% likely to use post- harvest technologies. A study by Koskei *et al*. (2013) indicated that off-farm income increased the probability of access to information on tea production by 48%. In another study by Mtega (2012), low income limited some respondents using some information sources; this was due to high cost of information like newspapers and magazines. Also depending on the size of farm, farmers who have very small land might not seek more information since production might be for subsistence purposes. On the other hand those who own huge chunks of land might be motivated to look for lots of information for subsistence and commercial production.

2.2.3.3 Psychosomatic factors

In this study, exposure to mass media and information seeking behaviour on processing technologies were considered important in influencing access and use of fruit processing.

2.3 TRAINING AS A METHOD FOR KNOWLEDGE DISSEMINATION

Extension services is a range of information which includes training, advice and knowledge related to agriculture, livestock production, processing and marketing provided by governments, non-governmental organisations (NGOs) and other sources aiming at increasing farmers ability to improve their productivity and income (Meinzen-Dick *et al*., 2011). According to Okunade (2007) extension remains the primary process through which farmers learn the reason and value for change. The underlying principle for extension services, farmers' education programs, formal and informal trainings is to expand farmer's human capital and income (Feder *et al.,* 2004; Meinzen-Dick *et al.*, 2011). New technologies facilitate some form of education, training and information exchange (Black, 2000). This study focused on trainings provided on processing of fruits as the extension methodology provided. The literature relied on various extension services provided on trainings (on agricultural technologies generally), their role and impact.

Training events in this study were defined as avenues in which participants interact with experts trainers to assist participants in altering values/beliefs towards new practices and gaining knowledge (Kilpatrick, 2000).

There are many other information sources through which farmers acquire knowledge from apart from trainings. They include both formal and informal media channels as well as their own involvements and experimentation (Feder *et al*., 2004).

According to Feder *et al*. (2004) the key source of information is usually other farmers as is a source that is readily available and its use does not inflict high transaction cost. Farmer trainers have proven to be very effective as they are familiar with the audience and instil some level of confidence to the farmers (Mulanda *et al.,* 1999). However, Feder *et al*. (2004) adds that on technical matters for example technologies on processing, farmers require high skilled trainers knowledgeable on the particular technology or specialized information sources. This is

confirmed by a study by Lukuyu *et al.* (2012) who found out that farmers trainers are suited to disseminate simple technologies compared to complex one. Lukuyu *et al*. (2012) however notes that this doesn't mean doing away with the farmers trainers rather integrating them to extension services to increase reach of extension services.

If information diffuses from farmer to farmer through informal communication, then very little effort focused on a nucleus of trained farmers could achieve large impact (adoption) at a reasonable cost (Feder *et al.*, 2004). However, if knowledge expected to be diffused is complex with a costly technology, then diffusion (adoption) will be less efficient (Feder *et al*., 2004). Therefore Feder *et al*. (2014) suggests that the number of farmers to be trained on such complex technology has to be large for the training to achieve a significant impact.

There are various types of trainings given as "formal", "Informal" and on job/hands-on experience. Formal trainings are more organized and could be provided in modules with topics for a number of days. These named trainings have a different impact altogether. For example, in Southern province of Cambodia formal and on job training/hands-on experience resulted in more successful outcomes on cattle production, marketing and animal health (Nampanya *et al*., 2012). Another study by Soon and Baines (2012) indicated that education and training program improved food safety of participants and more preference was on youtube video and hand hygiene demonstration. In Asia, farmers were trained in groups throughout growing season with two hours weekly session dominated by practical field activities and group discussions (Fliert, 1993), lectures and hand-outs were avoided and the results were that farmers identified pest problems better and trusted more in their own decision making ability. This is a clear demonstration that practical and handson sessions create more vivid experience (Soon and Baines, 2012). Kitinoja and Cantwell, (2010) further adds that offering training via video, posters, discussion, and role play increases accessibility and relevance to the non-literate

As Seger (2011) suggests, for newer technologies a combination of progressive knowledge and hands-on experience is necessary for successful outcomes. On the other hand Kilpatrick and Rosenblatt (1998) disagree and assert that formal training environment can be detrimental as those who have been away from education for a long time may feel threatened by a formal training environment. Non-formal trainings empower people to solve problems by fostering participation, self-confidence, dialogue, joint decision-making and self-determination (Fliert, 1993). Despite formal or informal training methods, trainings generally improves farmers willingness and ability to make successful changes on their farms (Kilpatrick and Rosenblatt, 1998)

Since training and education has benefits, the question remains how to best deliver education and training. Kilpatrick (1997) posits that effective delivery should promote participation, be cost effective and the result should be positive outcomes for individuals, farms and generally rural society. According to Kilpatrick and Rosenblatt (1998), effective training requires a valuable information source and should be interactive with opportunity for discussion from the participants and the experts. This is to encourage a two-way learning process. The training should cover relevant topics appropriate for the target group situation, and have credible facilitators and teaching materials/programs that participants can diffuse in manageable hunks (Kilpatrick and Rosenblatt, 1998).

According to Hashemi *et al*. (2012) trainings provided to farmers should assess the target group's needs to establish curricula for the training programs. The knowledge and skills of the participants must also be considered (Kilpatrick, 1997). Hashemi *et al*. (2012) further suggests that the participant/groups to be trained should be divided into clusters based on variables as age, gender, income etc. Training needs of various groups differ considerably and are often difficult in reaching smallholder farmers, women, the youth and food processors (Kitinoja *et al*., 2011).

Kitinoja *et al.* (2011) suggest that future trainings should include these special groups of men and women. For example reaching women would be easier if the training programs would be offered near/or in their market places or planned around their free time and provide child care to allow them focus on the information and participate actively (Kitinoja *et al.*, 2011). Training and education requires careful planning by the trainers and should therefore be delivered in a multiple of ways to accommodate farmers varied learning styles to meet trainees needs (Kilpatrick and Rosenblatt, 1998; Soon and Baines, 2012).

2.3.1 Training of Farmers

Extension services have increased tremendously in the past providing educational programs and training activities on post-harvest related topics (Kitinoja *et al*., 2011). Most agricultural trainings have been provided through government extension services with few done by NGO's. In other countries like Bangladesh, NGOs are the biggest extension providers parallel with the government extension services while in others, NGOs are not important but community based organisations (CBO's) are in providing extension services (Meinzen-Dick *et al*., 2011). Although the NGOs trainings are contributive especially in generating new ideas, they are not likely to become main channel for trainings to millions of farmers because of the smallholder operation (Fliert, 1993), as well as their limited coverage (Rutatora and Attee, 2001) compared to public extension.

Extension in the case of post-harvest technology encompasses creation of links between research and smallholder producers (Kitinoja *et al*., 2011). Smallholder farmers lack access to training, useful tools, and information on simple post- harvest technologies (PHT's) to use on farm, at home, and in the local markets (Kitinoja and Cantwell, 2010). There is need to create awareness campaigns, provision of information and training to help farmers realize benefits of some fruits like NUS (Padulosi *et al*., 2013). Training of farmers and other groups along value chain and

product development particularly women is important as they play a role in promoting the products in the market (Padulosi *et al.,* 2013).

Training in post-harvest processing horticulture increases readiness and willingness for farmers to adopt practices for multiple benefits. Training should go hand in hand with infrastructure and support for markets so that training is effective. The vice versa is also true, in that providing infrastructure without training on post-harvest processing can equally be devastating (Kitinoja and Cantwell, 2010). This is demonstrated by the training received by goat farmers in Cape Town where animals were of better quality as a result of training but lack of market structure, infrastructure and access to credit affected commercialization. Despite this, Bandara and Sivayoganathan (1999); Bekele *et al.* (2013) found that training farmers increases their knowledge base and adoption of technologies. The lack of follow-up through support after training is what contributes to failure of technology adoption (Kitinoja *et al*., 2011).

Training can be done in various ways. Training the participants or training trainers of trainers (TOT) who will go and train others. Either way the people trained initially, can be the TOT's. Kitinoja and Cantwell (2010) postulates that training should be able to leave behind a team of local trainers to continue with training if at all that training is termed as effective.

There are many locally available recipes for use in food processing.However information on nutrition value and food safety during processing is lacking. Hands-on practical training is needed due to food safety hazards that may arise as the women who carry out processing might skip vital processes as boiling, estimate measurements, temperatures which may lead to food poisoning. It is therefore important for training to be carried on and evaluations of such trainings.

Farmers have been trained across the world in various agricultural technologies with different outcomes. In Northern Cape, training farmers in goat production changed their goat production positively and a secondary effect was technological transfer to other members of the co-

operative Sacco (Bungess, 2009). In Uganda, farmers increased their access to information on lowland rice production and income although training did not provide irrigation facilities making fewer farmers continue with the adoption (Kijima *et al.*, 2012).

This research evaluated the trainings provided by using Donald Kirkpatrik model to see whether the objectives/outcomes of the training have been met. Four aspects that were evaluated included reaction, learning, behaviour and results (Kirkpatrick, 1994). According to Kirkpatrick (1994), the approach top evaluation included the following…

Reaction/responses measured by questions like, did you like the training?

Learning which looked at the understanding and skills learned,

Behaviour through willingness to carry out the process at home and

Results which is normally administered at a later stage gauging if the farmers actually went and used the training.

Kirkpatric (1994) however states that establishing if trainings yield results is not easy as some of the measurements like income, productivity take time. Other variables like unavailability of fruits would play. Therefore the limitation when using this model in this study is that measuring results and behaviour may take time as this research was constrained by time due to University semester and submission dates. This research therefore identified groups that had been previously trained and projects that had provided training and conducted questionnaires on them to assess the training received.

2.4 USE OF AGRICULTURAL TECHNOLOGIES BY INDUSTRY

The farmers characteristics and the technology characteristics affects farmers decision to use or not to use a particular technology (Joladele, 2005; Ofuoku *et al*., 2008). Considerable evidence exists to show that demographic variables, information sources, awareness, attitude affect use of technologies (Joladele, 2005; Oladele and Adekoya, 2006). Pattanayak *et al.* (2003) argues that such generalization of factors affecting use of technologies is not appropriate as the studies might be limited in the sampled population, time, variables included and variations in technology. However in this study, general literatures on factors affecting the use of technologies were identified. Traditional adoption model is concerned with only uptake or time of first use of innovation, use-diffusion model takes into account the rate and the variety of use (Jara-Rojas *et al*., 2012). Many studies have also focused on just the use of the technologies but not on the intensity of use (Ngombe *et al*., 2014). The intensity is defined as the level of use of a particular technology (Nkonya *et al.*, 1997). This study looked at the use for home consumption, use for income and non-use of the processing technologies. One limitation of many adoption studies is the fact that they are based on a "single snapshot in time" (Kiptot *et al*., 2007). Therefore, they cannot permit study of the dynamics of technology adoption (Doss, 2006). For example, in adoption of agroforestry technologies, literature provides adoption only at a particular time yet studying use over time provides lessons that can be used for future project planning (Kiptot *et al*., 2007). Doss (2006) suggests that it is very important to look at the users and non-user before they encounter a new technology in order to know if the technologies had an impact on their income or wealth. This might be important in understanding the dynamics of technology use. This was not the case in this particular study.

Factors affecting technology use differ across countries as a result of socio-economic, natural resources, cultural and political differences (Nkonya *et al.*, 1997). Most reviewed factors as discussed in literature include the following.

Education (as a factor) has been extensively established as a factor affecting the use of technologies (Knowler and Bradshaw, 2007). Mercer (2004) suggests that farmers with more education are earlier and more efficient adopters. Ofuoku *et al.* (2008) also found out the educated farmers adopted fish production technologies more than their counterparts. Baumgart-Getz *et al*. (2012) contradicts this since in his study he found that education was insignificant in farmers' adoption.

Age has also been assessed but is also difficult to link to adoption (Knowler and Bradshaw, 2007) since some studies have shown positive (Ngombe *et al.*, 2014), negative (Baumgart-Getz *et al.*, 2012) and insignificant correlations. Other farmer household characteristics as gender, marital status, income also affect use of technologies (Ngombe *et al*., 2014). For example male households are usually positioned better to attend extension meetings and have access to agricultural information. Females may equally be very ambitious and adopt a particular technology, thus gender might have an uncertain effect on the use of the technologies (Ngombe *et al.*, 2014). In other studies (example Nkonya *et al*., 1997; Marenya and Barrett, 2007; Ofuoku *et al*., 2008) farm size has been found to positively affect the use of technologies. Duzdemir *et al.*(2008) found that farm size does not affect use of technologies. There are many other variables not discussed herein that affect use of the technologies as different researches are location, variable and time specific.

There is little research carried out on the factors that dispose farmers to discontinue the use of the technologies (Oladele and Adekoya, 2006). Most studies look into either adoption or non-adoption with very few looking at discontinuance (Marenya and Barrett, 2007; Miller and

Mariola, 2009), testers and re-adoption of the technologies (Kiptot *et al*., 2007). Many factors however depending on a technology might lead to discontinuance. Joladele (2005) ; Oladele and Adekoya (2006) suggest that lack of extension visit "follow-up" led to discontinuance by farmers who had adopted improved maize varieties. It is important after the adoption of the technologies, the trainers/extension officers do a follow up to reinforce the message and ensure implementation (Joladele, 2005). Unavailability of inputs is also another factor that leads to discontinuance of a technology/innovation (Joladele, 2005). Inputs like fertilizers, equipment are important for continued use of a particular technology. If the farmers cannot access this nor acquire correct inputs, the technology gets abandoned.

The lack of "understanding knowledge" as described by Rogers (2010) is another factor necessitating discontinuance of the technologies earlier used. Most farmers discontinued irrigation due to inability to install the drip kit (Kulecho and Weatherhead, 2005). Knowledge after the introduction of the technology is important for continuity of the technology. The major concern remains on how to "test" the understanding of the adopters of technologies. It is therefore necessary as earlier indicated for extension agents, training providers to do a follow-up after the training to ensure technologies are effectively used and correct insufficient/lack of understanding of the technology. This study briefly looked at the discontinuance of the technologies the respondents had adopted.

2.5 CONCEPTUAL FRAMEWORK

The conceptual framework of this study is based on the assumption that access to and use of training on processing technologies are influenced by the constraints the farmers face, such as, insufficient information sources, inadequate training received and factors such as socio-economic and socio- demographics conditions.

In order to enhance productivity and consumption of fruits in Kenya, it is important to raise awareness and capacity building in such skills and also provide general information of potential fruit based enterprise development and nutritional benefits. It is important to look at the various factors that affect access and use of processing technologies, communication tools (both mass media and interpersonal sources-direct) employed; training received and constraints.

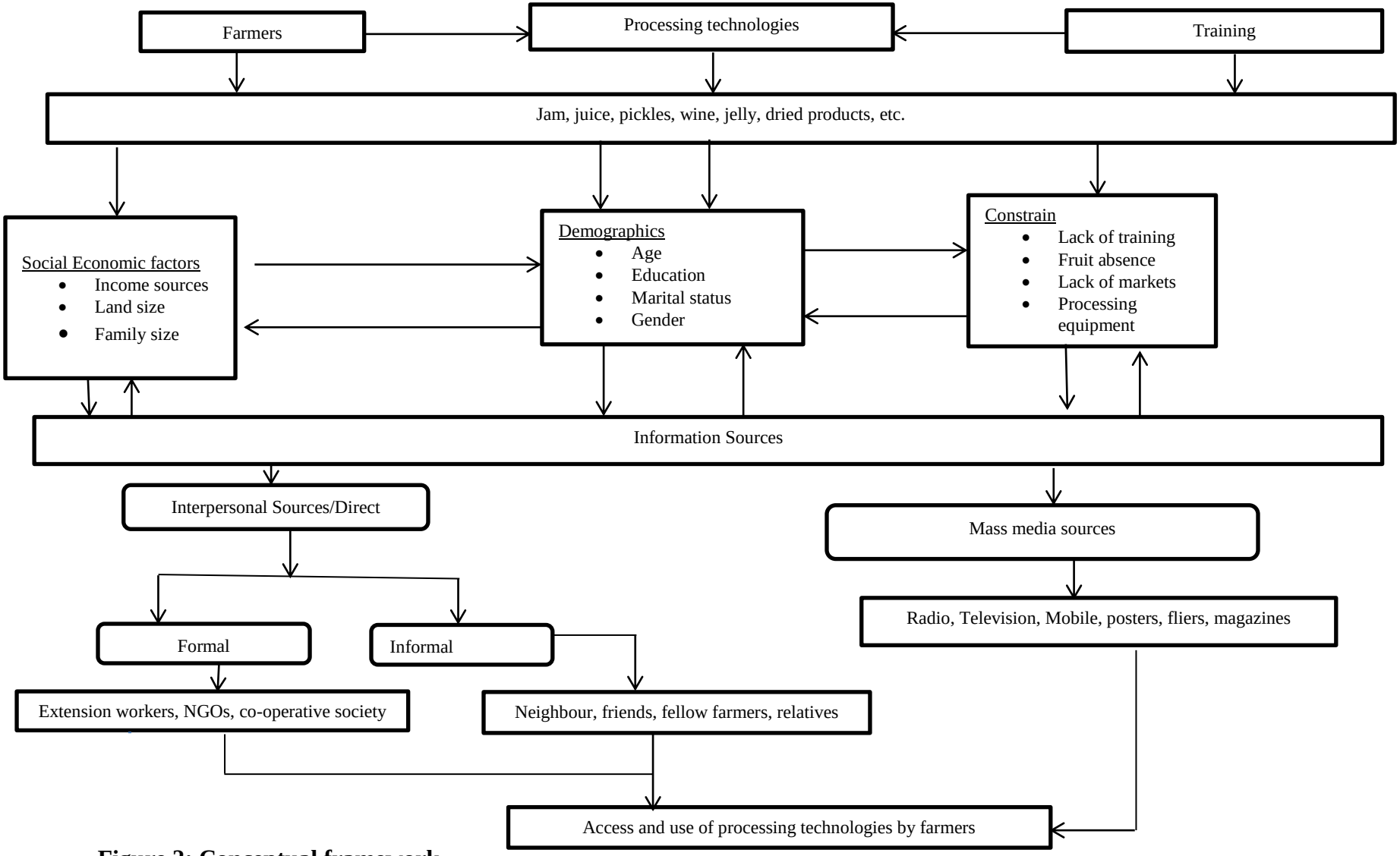


Figure 2: Conceptual framework

Source-Authors own conception

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

3.1 STUDY DESIGN

The study was cross-sectional. According to Olsen (2004) this type of design selects an entire population or a subset thereof and data collected to answer objectives of the study. The study involved both qualitative and quantitative data collection through semi-structured questionnaire, key informant's interview, informal discussions with farmers and personal observations.

3.2 STUDY AREA

The study area was Mwala a sub County of Machakos County, Kenya (Figure 3).

The local climate is semi-arid with an annual average rainfall of 500mm-1300mm, the mean temperature is 18-25°C with July being the coldest month and December and March the hottest (NEMA, 2009). The landscape is hilly with an altitude of 1000 to 1600 meters above sea level. The County stretches from latitudes 0° and 45' South to 1° 31' South and longitude 36 45' East to 37 45' East (NEMA, 2009). The soils are generally alfisols (sandy and clay) and vertisols (Black cotton) (Mwanda, 2000).

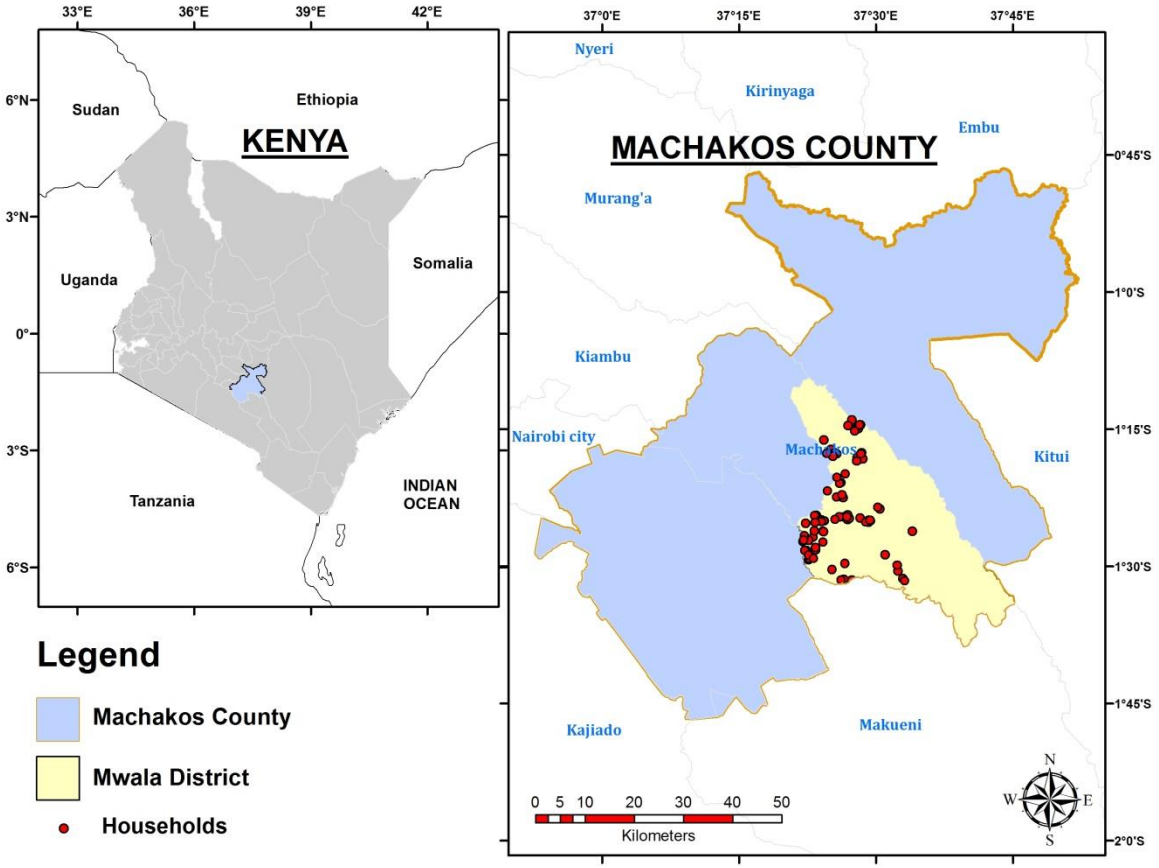


Figure 3: Map of Kenya with Machakos County showing the study area Mwala

According to Jaetzold and Schimidt (1983) subsistence farming is mainly practiced with the main crops grown on farm as maize and beans. Other crops grown include pigeon peas, cowpeas, cassava, and cultivation of drought resistance crops such as sorghum and millet due to the areas semi-arid state (Jaetzold and Schimdt, 1983; NEMA, 2009). Main on farm cash crops includes coffee, cotton, horticulture (cut flower, vegetables and fruits) (Jaetzold and Schimdt, 1983) although the crop yields are mostly affected by lack of rainfall. Erosion rates are very high as a result of hilliness and this also affects crop farming. The fruits most commonly grown include *Mangifera indica*, *Caricus papaya*, *Citrullus lanatus*, *Passiflora edulis*, *Citrus cinensis* and

Psidium guajava (Kiilu *et al*., 2002). Livestock farming is also practiced with cows, sheep and goats being reared.

The County's population is 1,099,000, with male accounting for 49% and female 51% (Source: census, 2009). The population density is 177 persons per km² an increase from 144 persons per km² in 1999 (KNBS, 2009) indicating a growth in population. The ethnic group found is mostly the Akamba people.

The poverty levels are at 59.6% (this is against a national average of 47.2%) (KNBS, 2009).

Among the sub counties, Mwala is among the high potential division which receives slightly higher rainfall. This is where the study focused because of its potential for high value fruits crops production for the market and was as well the pilot site for the Fruit Africa project.

3. 3 SAMPLE SIZE DETERMINATION

3.3.1 Study Population

The study conducted a scoping study to identify trained groups in the area. This was done through consultation with key informants, like the ministry of Agriculture Livestock and Fisheries, group leaders and various NGO's based in the area. Snowball effect was also used to further identify the groups. The scoping study established 21 trained groups in Mwala who participated in different trainings on fruit processing. These groups were randomized and it was found that they were homogeneous in nature. That is they similarly grow the same crops, are of the same tribe and attended training on fruit processing. Homogenous sampling is usually applied to a group of subjects /units and the aim is to describe these particular groups in depth. The total trained participants from the groups were 220 individuals. The sample size was determined using published tables which provided the sample size necessary for given

combinations of precision, confidence levels and variability (Oakland, 1953). According to Oakland (1953), the sample size *n* is given by Equation 1.

$$\boldsymbol{ME} = \sqrt{\frac{\boldsymbol{z}\hat{\boldsymbol{\rho}}(\boldsymbol{1}-\hat{\boldsymbol{\rho}})}{\boldsymbol{n}}} \qquad \text{Equation 1}$$

Where ME the desired margin of error n is the sample size desired

$\hat{\rho}$ is the confidence interval Z is the Z score

From the Tables, if *N* (Where *N* is the population)=225 to select *n* (Where *n* is the sample) for precision (e) ±7% , *n*=107 (Oakland, 1953). However to ensure that the response rate to the survey is the minimum 70% provided in literature, at most 110 respondents were selected through a systematic random sampling. Oakland (1953) suggest that many researchers commonly add 10% to the sample size to compensate for persons the researcher is unable to contact or increase by 30% to compensate for non-response.

3.3.2 Sampling Procedure

Mwala division was purposively selected because of its potential for high value fruit crops production for the market, both indigenous and exotic. In addition to this, it was the pilot site for the Fruit Africa Project part of which this study was based. The trainings were all listed and the participants identified. The totals trained were 220 individuals. Systematic random sampling was used by selecting every second person to obtain a sample of 110. Some of the respondents could not be reached as they had travelled/away from their homes during data collection while some were not willing and the study ended up with a total sample size of 100 respondents. The response rate was 80% and this satisfies the minimum (70%) response rate required provided in

literature. The sampling frame of the study was all similar farmers trained in Mwala although in different groups and attended explicitly different trainings.

3.4 DATA COLLECTION

The farmers were interviewed using a pre-tested questionnaire (Appendix one) to collect data on socio-economic and demographic characteristics, current knowledge on and use of fruit processing technologies, knowledge sources and training on fruit processing.

3.5 METHODS OF DATA ANALYSIS

3.5.1 Statistical Analysis

All the questionnaire data were entered in Statistical Package for the Social Sciences (SPSS) and analysed in the SPSS version 21. This study used descriptive statistics (frequency, cross tabulations, percentage, and ranking) to determine current knowledge on and the use of fruit processing technologies by the surveyed farmers (objective 2 and 3). The descriptive statistics was also used to identify the knowledge sources of the surveyed farmers on fruit processing technologies with reference to *Mangifera indica* and *Syzygium cuminii* (objective four).

In addition, the data analysis process utilized inferential statistics, particularly the regression analysis. Data analysis and statistical software (STATA) was used to analyse the Multinomial logit (MNL) model which was used to establish the socio-economic and socio-demographic factors (independent) affecting adoption/use (dependent) of processing technologies.

3.5.2 Multinomial Logit Analysis

Models are derived from information-theoretic principles which try to find the most arbitrary predictions consistent with the observations and average of the selected populations. Multinomial logit models are applied if the nominal dependent variable have more than two categories and

they cannot be ordered practically (McFadden, 1987). This model is often considered because it doesn't assume linearity, normality or homoscedasticity. This model fits well in this study as the study tried to determine the use for home consumption, use for income and non-use of the processing technologies. In addition the model was adopted for this study as it is easy to estimate and its interpretation is more often quite easy. According to Panda and Sreekumar, (2012) the equation takes the below form:

$$logit(p_i) = In\left({P_i}/{1 - P_i}\right) = \propto + \beta_1 X_1 + \cdots \beta_n X_n + E_t \quad \text{Equation 2}$$

Where $\boldsymbol{In}\left({\boldsymbol{P_i}}/{\boldsymbol{1 - P_i}}\right)$=Logit for different choices of use of the technologies

p_i=non-use of the technologies, $1 - P_i$=use of the technologies

β=Coefficient; X=covariates; E_t=Error term

In the model, use of technologies with three choices, use for home consumption, use for income and non-use was set as the dependent variable. Non-use of the technologies was set as the base outcome and it took a value of zero. Use for sale/income took a value one while use for home consumption took the value two. Since the non-adopters were more than those who practice for sale and less than respondents for home use, they were used as the base outcome for comparison. It was assumed that the use depends on the number of trainings one has attended, the number of technologies one has been trained on, whether or not participants carried out hands-on experience during the training, socioeconomic and demographic characteristics. Unfortunately, other factors influencing use of processing technologies were precluded due to data limitations.

Estimation procedure:

The dependent variable included the following as listed in (Table 2). Based on past research by different scholars, a number of suitable independent variables likely to influence use and their expected signs (Ayele and Bosire, 2011; Mwombe *et al.*, 2014; Ngombe *et al.*, 2014; Okello *et al.*, 2012; Spurk *et al.*, 2013; Tarnoczi and Berkes, 2009) were identified.

Table 2: Independent models used in coding for the surveyed respondents

Variables	Description	Expected signs
Agex	Age (25–75)	+
education	Level of education (1=none, 2=some primary, 3=primary finished, 4=secondary, 5=tertiary)	+
nooftechno~s	Number of technologies trained on (1–4)	+
notrangad	Number of trainings attended (1–3)	+
acquireany~o	Acquired any other information sources (1=Yes, 0=No)	+
avaityoffr~s	Number of fruits cultivated (0–6)	+
endproduct	Handson experience (1=Yes, 0=No)	+

By fitting the dependent variables, the model can be presented as:

$$In\left({}^{P_i}/_{1-P_i}\right) = \beta_0 + B_1 \text{agex} + B_2 \text{education} + B_3 \text{ nooftechno~s} + B_4 \text{ notrangad} + B_5 \text{ acquireany~o} + B_6 \text{ avaityoffr~s} + B_7 \text{ endproduct} + E_t \quad \text{Equation 3}$$

Before the model estimation, it was necessary to check for multicollinearity and the test for the Assumption of Independence from Irrelevant Alternatives (IIA).

3.5.3 Special tests

3.5.3.1 Multicollinearity

Independent variables in a model can be related and this brings a problem when interpreting the models outcome. For this study, Variance Inflation Factor (VIF) was estimated using STATA software. As a rule of thumb, if the VIF exceeds 5, the variable is said to be highly collinear.

3.5.3.2 Testing for the assumption of independence from irrelevant alternatives (IIA) in the MNL

Hausman Specification test is the standard test for IIA. This test infers that the ratio of selecting any two alternatives is autonomous of the third choice (Small and Hsiao, 1985). "The assumption of IIA is rejected if the probability of chi-square result falls below 0.5, in the 5% level of significance and vice versa" (Nyaupane, 2010).

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 FRUIT PROCESSING TECHNOLOGIES OF *MANGIFERA INDICA* AND *SYZYGIUM CUMINII* APPROPRIATE FOR SMALL PROCESSORS

Table 3 lists the technologies applicable to *Mangifera indica* and *Syzygium cuminii* that have potential for use by small processors. These technologies were identified based on availability of the markets for the processed products, simplicity and affordability of the technologies. The technologies were identified from secondary sources.

Table 3: Fruit processing technologies of *Mangifera indica* and Syzygium cuminii appropriate for the smallholder farmers

Technology	Methods	Products	Criteria for choice of technology
Production of pulps and beverages (Kormendy, 2006)	Pulping	Juice Pulp	Market pulp and juice available Nectar and drink formulations Products can be prepared locally
Production of sugar concentrates (Kormendy, 2006)	Concentration	Jam and jellies	Local market available
Drying (Kitinoja *et al*., 2011;Swanson and Mccurdy, 2009)	Sun drying Solar drying Artificial driers	Dried slices, pieces and cubes	Market available (local and export) Product sold in Kenya and outside Can be applied locally Low cost sun and solar drying technology
Fermentation (Canovas *et al.*, 2005;Kormendy, 2006)	Yeast fermentation	Wine	Market potential
	Yeast fermentation	Chutney	Both domestic and international market available
Pickling (Nyanga *et al.*, 2008)	Lactic acid fermentation	Pickles	Both domestic and international market available
Production of vinegar (Grewal *et al.,* 1988)	Oxidation	Vinegar	Both domestic and international market available
Production of fruit emulsions (Grewal *et al.,* 1988)	Extraction	Flavours for beverages	Market potential in carbonated beverage manufacture

Locally produced juice, juice concentrate, nectars and drinks from *Mangifera indica* are available in the market and will effectively compete with imported fruit juice concentrates of similar quality from countries like Mauritius, South Africa and Egypt (Gitonga *et al.*, 2014). The fruit pulp can still be pasteurized used in making jam and jelly. Markets already exist for these products domestically and internationally. However for *Syzygium cuminii*, jelly may not be financially feasible as the product has high water content as a lot of heat treatment and evaporation has to be incorporated.

There is also scope for pulps for use in flavouring ice cream and yoghurt. Kenya has existing industries for ice-cream and yoghurt manufacture. To ensure availability of the pulps to these industries all year round, processing of shelf-stable pulp should be considered. *Syzygium cuminii's* color would also add to exciting ice cream and yoghurt products.

Dried *Mangifera indica* product are already processed in Kenya and sold in the supermarkets. In addition, dried mango products are also found selling outside Kenya. For example, the US imports in 2008 for dried mango was 3,481 tonnes (New, 2010). Mango drying is a simple technology which can easily be practiced by small producers. The low cost solar and sun drying technology is available with both local and international market which makes it a very ideal technology that should be promoted among small processors. The small producers should only work hard to improve on the quality of the dried mangoes as quality is an issue with the smallholder farmers.

Mangifera indica and *Syzygium cuminii* pulp can be used for fermentation into wine, however as Musyimi *et al*, (2012) suggests, grapes are the main raw materials for wine production but production of wine from these fruits will offer cheaper alternatives especially in countries where

grapes are not grown. Similarly, wine from *Syzygium cuminii* should be explored as the colour and its astringency makes it a good fruit for wine production.

Green *Mangifera indica* can be used to make pickles and chutneys as they have both domestic and international market and hence a very feasible product for the small processors to undertake.

Vinegar from fruit fermentation is a superior food additive over synthetic vinegar as fruits are high in vitamins and minerals. This is an important technology especially in the *Mangifera indica* sub-sector. The high carbohydrate content and sugars in the fruit makes it ideal for fermentation and production of vinegar. There is a great market potential of vinegar for use as a food preservative, dressing and as a disinfectant.

Fruit emulsions are very important as ingredients for beverage formulations. These fruit emulsions enhance aroma, taste and colour of most beverages. There is a huge market potential for emulsion in beverage manufacture locally.

4.2 SOCIO-DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Table 4 presents the socio-demographic characteristics of the respondents. The mean age was 47 years with range of 25-70 years. Majority of the respondents had secondary (37%) education and 36% only had completed primary education. Almost all the respondents had therefore achieved literacy level and they could comprehend the training information. However, 21% of the respondents were still illiterate. Majority of the respondents were female representing 85% while the rest were male (15%). This study contradicts Doss (2001) who states that extension and training do not reach women as they are poor. Women were majority of the participants in the trainings probably because the process of cooking jam, drying and pulping is viewed culturally as the domain of women therefore men tended to shy away from the trainings. Also in Kenya today most of the projects and/ or extension services are targeting women groups with majority as women members. Kiptot and Franzel (2011) report that growing and processing of certain fruit trees e.g *Irvingia gabonensis* (bush *Mangifera indica*) are considered to be the domain of women. They are therefore grown around the homestead for easy management. Women are therefore responsible for collection and processing of such fruits.

Table 4: Socio-demographic characteristics of the respondents

Personal description		Percentage	Range	Mean
Gender				
Male		15		
Female		85		
Age			**25-75**	**47**
27-35		24		
36-44		13		
45-53		36		
54-62		21		
62-75		5		
Marital Status				
Single		6		
Married		77		
Widowed		17		
Education Level				
Secondary		37		
Primary finished		36		
Some primary		18		
Tertiary		5		
Illiterate		3		
Family size (number of persons)	**House hold size**	**percent**	**1-11**	**4**
	1	2		
	2	14		
	3	16		
	4	12		
	5	21		
	6	15		
	>6	14		

The mean average farm size was 2.5 acres. Nearly half of the respondents (48%) had an income range of 10,000-25,000. Ninety three of the surveyed respondents said they had fruit trees cultivated on own farm with 63% growing *Mangifera indica* as the most important fruit. Forty-six percent of the respondents indicated growing the fruits mainly for home consumption with only 20% indicating for sale/income generation. The three most important fruits on farm as listed by the respondents were *Mangifera indica*, *Carica papaya* (papaw) and *Citrus sinensis* (oranges). Sixty three percent of the respondents indicated growing mangoes as the most important fruit followed by oranges and papaws. Other fruits on farm included *Citrus tangerine* (tangerines), *Persea Americana* (avocado), white sapote, lemons and *Syzygium cuminii*.

Table 5: Socio-economic characteristics of the respondent

Personal description	Percentage	Mean
Farm size (Acre)		3
< 1	32	
1.5-2.5	31	
3.0-4.5	25	
5.0-7.0	9	
>8.0	3	
Availability of fruits on farm		
Fruits on farm	93	
No fruits on farm	7	
Fruits grown for home consumption	46	
Fruits grown for sale	20	
Fruits grown both for sale and home consumption	34	
Income per year in (Ksh.[1])		
10,000-25,000	44	
25,001-50,000	37	
50,001-75,000	7	
75,001-100,000	6	
100,001-150,000	3	
>201,000	3	

[1] 1 USD=88.4 KSH., September-October, 2014

4.3 THE LEVEL OF KNOWLEDGE ON FRUIT PROCESSING TECHNOLOGIES AND THEIR USE BY THE FARMERS

The study sought to determine the respondents' knowledge about processing technologies and whether they had used the technologies before. It was established that 75% of the farmers admitted to having carried out fruit processing at least once while 25% indicated not having ever processed previously.

Among the reasons indicated for having used processing and value addition technologies were; to 'add value (20%)', for income generation potential (8%), 32% for home consumption and 20% indicated for purpose of practicing the knowledge and skills acquired from trainings attended. Other reasons as mentioned by 20% of the respondents were to utilize available resources and fruits. Similar reasons for the use of processing technologies have also been found in studies by others (Msabeni *et al*., 2010)

Out of the 100 trained respondents only 77% could remember and list the fruit processing technologies they had been trained on. A total of 57% of the respondents indicated juice manufacture as the technology they were familiar with for *Mangifera indica* fruit and 19% indicated jam manufacture. These results are shown in Table 6. The respondents indicated having processed *Mangifera indica* more than *Syzygium cuminii* probably because of availability of the fruit for processing and market for the processed products of the former than the latter. *Mangifera indica* is one of the fruit that is commonly commercially processed in Kenya.

Table 6: Technologies for *Mangifera indica* and *Syzygium cuminii* familiar to the farmers

Technologies respondents are familiar with for *Mangifera indica*			Technologies familiar for *Syzygium cuminii*		
Technology	% knowledge	% Practice	Technology	% Knowledge	% Practice
Drying	24	9	Pulping for jam	12	12
Pulping for juice	57	66	Pulping for juice	4	4
Pulping for jam	19	25			
Total	**100**				

4.3.1 PRACTICE AND USE OF TECHNOLOGY

The uses of fruit value adding/processing technologies were commonly used for the purpose of home use (63%). Only 12% of respondents indicated use of the technologies to process for sale/ income generation. Up to 45% of the respondents have used *Mangifera indica* fruit for processing compared to 16% who have used *Syzygium cuminii*. The most commonly used technologies are juice technology (51%) and jam technology (21%). It can be seen that most of the respondents quite use exotic fruits (*Mangifera indica*) for production and less of indigenous fruits (*Syzygium cuminii)*.

Twenty-five- percent of respondents indicated non-use[2] of technologies that they had received training on. The reasons for this are provided in Table 7 ranked in order of importance, as indicated by respondents.

Table 7: Challenges in the non-use of technologies by the respondents (n=25)

Challenge	Ranking	No. of respondnets
Lack of access to fruits	1st	12
Insufficient knowledge due to poor training methods	2nd	7
Lack of access to processing equipment	3rd	6

Many farmers had practiced the technologies, however, this referred to either soon after the training and some were no longer practicing it at the time of the study. Table 8 shows that pulping for juice making is the technology most people had practiced then but no longer practicing at the time of the study (66%), followed by pulping for jam making (25%). Although

[2] Non-use respondents had not ever used the technologies after having received training

drying is ranked second as the technology respondents are familiar with, its use is not very common amongst respondents due to the challenges of obtaining the equipment, drier and low training on that particular technology.

Table 8: Different technologies used in the past and currently by respondents (n=75)

Time of use of technology	Percent
Pulping for juice past, but now stopped	66
Pulping for juice making currently frequently in use	5
Pulping and cooking jam tried/frequently used in the past, but now stopped	25
Pulping and cooking jam currently frequently in use	2
Fermentation into fruit wine tried/frequently used in the past, but now stopped	2

The study sought to know how often and when last the respondents had used the technologies. This was done in order to know if there was current use and if the training was effective. Only 6 respondents indicated using the technologies throughout the year and were currently processing at the time of the study, 69 respondents said the technology use was seasonal due to the unavailability of raw materials. Production was low and only for domestic consumption mostly occurring between the months of December to March when the fruit were in season (*Mangifera indica* specifically).

A large proportion of respondents (69%) indicated that they did not actively continue to use the technologies they had been trained with multiple reasons for this provided ranked in order of occurrence. Those that also used the technologies for commercial use stated their challenges provided in Table 9.

Table 9: Challenges on the continued use of the technologies for home and commercial use (n=75)

Challenge type	Home use	No. of respondnets	Commercial use	No. of respondnets
Challenges in procurement of raw materials				
1. Seasonal variations of fruits	1st	48	2nd	3
2. High cost of raw materials	2nd	15	1st	7
3. Insufficient amounts of raw materials	3rd	9	3rd	2
Challenges in procurement of packaging materials				
1. High cost of packaging materials			1st	8
2. Poor quality of packaging materials			2nd	7
3. Lack of credit to purchase			3rd	4
Challenges in processing				
1. Inefficient processing equipment	2nd	31	1st	10
2.lack of processing premises			2nd	6
3.Lack of skills/technology	1st	44	3rd	2
4.Lack of time	3rd	8		
Challenges in packaging/ labelling				
1.Difficulty in obtaining certification with standard organisations e.g Kenya Bureau of Standards (KEBS),			1st	5
2.Expensive labels			3rd	3
3.Inaccessible labelling materials			2nd	4
Challenges in marketing				
1.Low selling prices			2nd	4
2.low demand/ consumer preference			3rd	1
3.Lack of markets(nowhere to sell)			1st	7
4.Spoilage of product/short shelf life			3rd	1

From the data on the users, the respondents who had discontinued the use of the technologies were computed. The active users were only 6 respondents. Kiptot *et al.* (2007) in their study categorized those who discontinue into two groups: "genuine testers/rejecters and pseudo-adopters". This study borrows much from Kiptot *et al.* (2007) to categories those who generally tried once and a few time after the training as genuine testers. The pseudo-testers are those who try out the technologies depending on the benefits they get, they decide on whether to go on with it or not (Kiptot *et al.*, 2007). For example some respondents indicated having been given equipment like blenders, but after they broke down, they discontinued. Other reasons for pseudo adopters might include gaining prestige in the use of the technologies.

4.3.1.1 Factors influencing use of processing technologies

Before estimating the models, it was necessary to check if multi-collinearity exists among the independent variables. The Variance Inflation Factor (VIF) test was used to check for this. The VIF are given in (Appendix 3). The VIF was found to be less than five therefore multi-collinearity does not exist in the selected variables. The likelihood ratio test P-value found was less than 0.0000, indicating that the coefficients of independent variables are not jointly equal to zero. Moreover, the model fit is within the range commonly seen using cross-sectional data with pseudo R^2 of 0.30. Also findings revealed that there was no reason to conclude that MNL model violates IIA assumptions as all choices gave a P-value of 1.

Parameter estimates (coefficients and marginal effects) from the multinomial logit model are presented in Tables 10 and 11. The parameter estimates of the multinomial logit provide direction and not probability or magnitude of change. The marginal effects measure the actual effect of a unit change in each of the explanatory variables on farmers' use of the technologies.

Table 10: MNL parameter estimates for determinants of use of processing technologies (Non-use set as base outcome)

	Use for sale			Home use		
Variable	**Coef**	**Std error**	**p>|z|**	**Coef**	**Std error**	**p>|z|**
Age (25–75)	-0.000	0.000	0.197	-0.000	0.000	0.322
Level of education (1=none, 2=some primary, 3=primary finished, 4=secondary, 5=tertiary)	0.096	0.473	0.838	-0.241	0.325	0.458
Number of technologies trained on (1–4)	0.972	0.544	**0.074***	0.436	0.372	0.242
Number of trainings attended (1–3)	1.922	0.647	**0.003*****	-1.326	0.489	**0.00*****
Acquired any other information sources (1=Yes, 0=No)	0.521	0.982	0.596	-0.130	0.594	0.826
Number of fruits cultivated (0–6)	0.152	0.485	0.754	-0.670	0.325	**0.039****
Handson experience (1=Yes, 0=No)	2.501	0.466	**0.011****	1.072	0.569	**0.059***
Cons	-5.562	2.897	0.055	-2.476	1.906	0.194

N=100;Pob>Ch^2:0000; Pseudo R2:0.2095;Log Likelihood-69.673239*:significant at 1% level;**:significant at 5 level;* significant at 10 level; base outcome non-use.**

Coefficients from multinomial logit can be quite difficult to interpret because they are relative to the base outcome; therefore a better way to assess the effect of covariates is to examine the marginal effect of varying their values on the probability of observing an outcome. Table 10 shows the marginal effects computed.

Table 11: Marginal effects of the MNL regression model for determinants of use of fruit processing technologies

	Use for sale			Home use		
Variable	**Discrete change of dummy variable from 0 to 1**	**Std error**	**p>|z|**	**Discrete change of dummy variable from 0 to 1**	**Std error**	**p>|z|**
Age (25–75)	-0.000	0.000	0.285	-0.000	0.000	0.651
Level of education (1=none, 2=some primary, 3=primary finished, 4=secondary, 5=tertiary)	0.007	0.035	0.851	-0.048	0.066	0.465
Number of technologies trained on (1–4)	0.054	0.040	0.174	0.039	0.073	0.591
Number of trainings attended (1–3)	0.079	0.044	**0.074***	0.182	0.089	**0.042****
Acquired any other information sources (1=Yes, 0=No)	0.33	0.065	0.610	-0.000	0.120	1.000
Number of fruits cultivated (0–6)	-0.028	0.036	0.436	0.141	0.063	**0.024****
Handson experience (1=Yes, 0=No)	0.142	0.077	**0.063***	0.090	0.125	**0.047****

****, * significance levels at 5 and 10 % respectively**

4.3.2.1 The number of technologies participants had been trained on

This factor was significant at 10% when it comes to use for sale for income generation in the MNL parameter estimates. This was not the case in the marginal effect. This might be explained by the fact that may be the respondents were relatively homogenous in those factors.

4.3.2.2 Number of trainings attended

This factor was highly significant at 5% for use for sale and significant at 10% for home use. The number of trainings attended increases the probability of the respondent using the technologies by 8% for use for sale and 18% for home use. It was observed that those who attended more than one training adopted the technology both for home use and for sale to generate income. Non adopters did not attend more than one training program. This study is consistent with Ngombe *et al.* (2014) who also found that the more the trainings farmers attended the more the adoption of conservation agricultural technologies.

4.3.2.3 Availability of fruits

The cultivation of fruits on farm by the respondents was quite significant at 5% when it comes to use for home consumption. There was a greater likelihood of processing fruits for home use (14%) if fruits were grown on farm. This is because it is usually observed that those who grow a variety of fruits tend to do so mainly for subsistence use. They usually grow many varieties on a small piece of land. It is also observed that most people who engage in commercial processing tend to grow only one variety of fruit for commercial purposes and on a large piece of land.

4.3.2.4 Practical during trainings

Hands-on experience in this study was defined as the actual practice by the respondents themselves during the training sessions. This factor had a very positive influence on the use of the technologies. It was observed that both the respondents who practice the technologies for sale and for home use did hands-on experience at the training programs. This factor has a positive influence on use. The results indicate that doing handson during the training increases the probability of processing for sale and for home use by 14% and 9% respectively. This implies that the trainings should actually incorporate handson activities in order to encourage use of the technologies. This shows that participants will remember and practice the technologies after the trainings. This study also agrees with Tarnoczi and Berkes (2009) who found that information that involved observations and experimentation led to adoption of new practices. Trainings should therefore integrate hands-on for them to be very effective to the end-user. Zossou *et al.* (2009) recommends reaching many farmers and enhancing knowledge sharing, video demonstrations is much effective in reaching many respondents than carrying out hands-on in training workshops.

4.3.2.5 Age and education

Household characteristics such as age and education level were found to be insignificant. This contradicts with Mercer (2004); Okello *et al.* (2012) who suggested and found that farmers with more education are earlier and more proficient users of technologies. The insignificance may be because of the respondents' being relatively homogenous in those factors.

4.3.2.6 Other sources of knowledge

Other information sources which include radio, farmers field days and agricultural shows, extension officers, friends and neighbours were found to be insignificant. This contradicts

Tarnoczi and Berkes (2009) who found that the greater the number of information sources farmers had, the more likely they were to adopt new practices. The study however agrees with Läpple (2010) who reported no correlation between the number of different sources of information and the use adoption of organic farming.

4.4 SOURCES OF KNOWLEDGE ON FRUIT PROCESSING

The knowledge sources in this study included the training the respondents attended. It also included any other source apart from the training received like mass media channels and interpersonal/direct sources.

4.4.1 Training

Sixty-one -percent of the respondents have received trainings on processing of *Mangifera indica* and *Syzygium cuminii* and some other fruits (Figure 4). Fifty-five-percent of the respondents have received training in *Mangifera indica* fruit, only 6% indicated receiving training on *Syzygium cuminii.* The most commonly grown fruit on farm by respondents is *Mangifera indica.* This perhaps explains why most organisations and the government have focused on provision of training on this fruit.

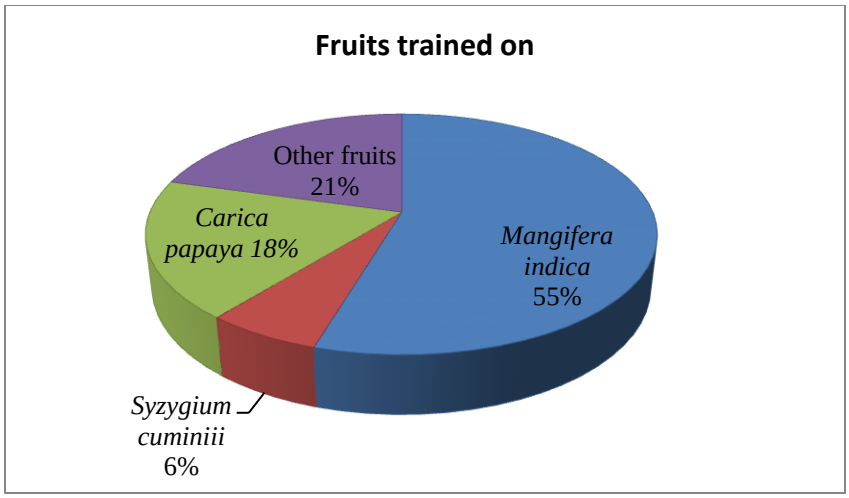


Figure 4: Distribution of farmers by training

On specific technologies trained on, majority of the respondents (51%) indicated having been trained on pulping for juice production followed by pulping for jam making (21%). This explains the reason why juice processing and jam manufacture were the technologies indicated as key practiced by the respondents.

4.4.1.1 Training providers

The following were identified as the training providers in the area: The trainings were categorized into 1,2,3,4 as follows:

1. Research Institutions –World Agroforestry Centre (ICRAF), Kenya Agricultural Research Institute (KARI)
2. Ministry of Agriculture Livestock & Fisheries (MOALF) (and its partners)
3. Universities and NGOs
4. Others (Church / teachers, group chairman, group members, horticulture Naivasha, family, neighbours)

Table 12 shows that the (MOALF) was the leading training provider (29%), and as partners with various NGO's (26%), with the respondents attending up to a maximum of three trainings. This study confirms Rivera and Alex (2004) who indicated that the main extension providers in terms of coverage is the government. The results agree with reports by Meinzen-Dick *et al*. (2011) who indicated that NGOs, research institutions and CBOs play a vital role in providing extension services where activities such as fruit/food processing is provided These groups should not be left out in designing any interventions/ training programs.

Table 12: Training providers as indicated by the respondents

Training provider	**Training classes**		
	1	**2**	**3**
Research Institution (ICRAF, KARI)	16	3	4
NGO's and Universities (INADES,JICA,TECHNOSRVE,USAID,WVK,AICAD, JKUAT	31	26	9
MOALF	29	3	1
MOALF and Partners	8	26	10
Others (Church / teachers, group chairman, group members, horticulture Naivasha, family, neighbors)		14	3

4.4.1.2 Training Methods

The trainings involved practical, theories, group discussions and field work. Forty percent of the respondents said they did practicals while 69% respondents indicated having carried out only theory. Seventeen percent undertook both practical and theory training. Other training methods included field visits on correct harvesting of fruits, group discussions, fruit processing/commercial industry /factory visits and farmers field days. The study further went to investigate if the respondents carried out handson experience at the training (carrying out the practicals themselves). It was established that 58% produced the end product themselves during that training.

4.4.2 Other Knowledge Sources

Out of the 100 respondents surveyed, 68% indicated to have received information from other knowledge sources apart from the training attended.

A total of 54% of the 68 respondents' ranked radio as the highest source of fruit processing information (Table 13). Out of the 54% who indicated radio, 39% indicated that the main fruit discussed was *Mangifera indica* fruit with only one respondent indicating *Syzygium cuminii*. The study further went to find out the technology the 54% accessed from radio, majority of the respondents (44%) listed pulping for juice technology as the main technology they accessed. These findings are consistent with the findings of previous studies such as those of Spurk *et al*. (2013); Agwu *et al*.(2008); Opara (2008) who found that radio is the most used channel of seeking information from farmers. The popularity of radio among respondents is not startling in view of the fact that many respondents, 97%, acknowledged owning a radio. Effectiveness of radio in information delivery is well researched in literature. As Opara (2008) suggest radio has its own limitations because of its "monologic culture", the respondents do not have a chance to interact with the presenter. This is true since the use of these technologies such as drying; pulping requires physical interaction and demonstration with the trainer. Groups already carrying out processing are also a key source of knowledge on fruit processing technologies (Table 13). This demonstrates that social networks are an important means of disseminating new technologies. Farmers learn better from each other as this presents itself as a familiar source of agricultural information. Field days and agricultural shows cannot be ignored as they also come as an important source of information on processing technologies as indicated by 11% of the respondents. Again 20% of the respondents indicated that it was about *Mangifera indica* fruit and pulping for juice technology with none indicating *Syzygium cuminii* fruit. There is so much

work that needs to be done in promoting the processing and knowledge on indigenous fruits as shown from these results. Friends and neighbours were found to be the least sought information source on processing at 7% maybe because it is not the most effective way of information dissemination.

Table 13: Knowledge sources of the respondents (n=68)

Knowledge sources	%
Radio	55
Farmer field days and agricultural shows	11
Extension officers	9
Friends and neighbours	7
Members of other groups	18
Total	**100**

The respondents indicated radio (55%) as an important information source and extension programs should be incorporated into them. One important fact that was noted is the media, field days and groups seem to focus on only the exotic fruits. Organisations concerned with promoting indigenous fruits should also use these avenues to promote the indigenous fruits and technologies available.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

On the basis of this research, the study concludes the following;

There is existence of varied technologies for fruit processing, this study identified from various literature sources technologies with potential for processing *Mangifera indica* and *Syzigium cumiii*. The technologies included production of pulps and beverages, production of sugar concentrates, drying, fermentation, production of vinegar and production of fruit emulsions.

The findings of this study suggest that socio-demographic and socio- economic factors are central in determining farmers' use of fruit processing technologies. The factors found to influence use of training were the number of technologies trained on, the number of trainings attended, the cultivation of fruits on own farm and the hands-on experience during the training. Trainings are therefore important in promoting the use of the technologies.

The study also concludes that the respondents are quite knowledgeable on the fruit processing technologies but the practice is still quite low.

In addition, capacity building of farmers along the fruit value chain is key to development as training was the main source of knowledge on fruit processing technologies. Other knowledge sources on fruit processing technologies included radio, farmers' field days and agricultural shows, extension officers, friends and neighbours and members of other group already carrying out processing activities.

5.2 RECOMMENDATIONS

1. The primary market development should focus on production of pulp for local, regional and global markets. Dried products already exist and the focus should be on quality improvement for export market. The government should build the capacity of small processors already organized in groups, to promote processing as an activity for diversifying income. Training organisers should equally take advantage of the varied fruit processing technologies available to help farmers diversify on the products produced.

2. The importance of extension services in agriculture cannot be over emphasized; training and advisory services to farmers will ensure farmers engage in processing to reduce post-harvest losses. Government, NGOS and private partnership on the trainings will increase outreach to farmers. Based on the findings on the challenges in the discontinuance of use of the technologies, a generic constraint established was the frequently limited and interrupted supply of raw materials which is the fruit. Production of pulp as a technology should be prioritised and promoted to ensure availability for processing into jams, juice when fruit is out of season. In addition, extensive organisation on the part of the smallholder farmers should be necessitated to achieve the commercially -necessary volumes of raw materials. Alternatively, the government can create alternative links of smallholder processors with the formal industries to enable them access markets. The government and various organisations can also take initiatives of setting up a factory for solar drying and processing. They can also assist in provision of processing equipment and credit facilities for the farmers to take initiative.

3. The study used MNL model to investigate factors influencing the respondents' use of the technologies for both income and home consumption. The results from the model indicate that the number of trainings attended, number of fruits grown on farm and hands-on experience

during the training influenced the use of the processing technologies. The most significant and predominant variable was the number of trainings attended. Therefore the study recommends that the respondents should be encouraged to attend multiple trainings to encourage use of the technologies. This also implies the need for smallholder farmers to develop business skills, acquire better access to both processing and market information to reap the benefits of engaging in fruit processing activities.

4. Multiple information/ communication sources such as radio, field days, group members and extension agents were found to be key in provision of fruit processing information. Focus has to be given to these knowledge sources in a way that they will be coordinated and farmers can easily access and benefit from them. Effectiveness of informal networks/sources like field days/shows should be addressed to see the impact in disseminating processing technologies.

5.3 Suggestions for further research

There is need for future studies to focus on both the training providers and the end users, this study focused more on the recipient of the technologies and discussions are based on the perspective of the smallholder processor. Further research on the opportunities and constraints faced by training providers will help in coming up with broad based all-inclusive policy and/or practice interventions.

Development of processed products seems to offer better opportunities in future for smallholder farmers. However, further research on the quality and competitiveness of these processed products should be conducted to determine their profitability when the raw material that is the fruit out of season is offered at a realistic price.

6.0 REFERENCES

Agricultural Business Development (ABD) and Danish International Development Agency (DANIDA) (2009). The mango sub-sector in Kenya. The results of the mango tree census and baseline survey for Coast Province. Final Report. Institutional development and management services, Mombasa, Kenya

Agwu, A. E., Ekwueme, J. N., and Anyanwu, A. C. (2008). Adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State , Nigeria. *African Journal of Biotechnology*, *7*(9), 1277–1286.

Akinnifesi, F. K., Sileshi, G., Ajayi, O. C., Chirwa, P. W., Mng'omba, S., Chakeredza, S., and Nyoka, B. I. (2008). Domestication and conservation of indigenous Miombo fruit trees for improving rural livelihoods in southern Africa. *Biodiversity*, *9*(1-2), 72–74.

Ali, J. (2012). Factors influencing adoption of post-harvest practices in vegetables. *International Journal of Vegetable Science*, *18*(1), 29–40.

Asenso-Okyere, K., and Davis, K. (2009). Knowledge and innovation for agricultural development.

Ayar, K., Singh, S., and Chavda, J. C. (2011). Effect of post harvest treatments on quality of Black plum (Syzygium cuminii Skeels) fruits during storage ν. *The Asian Journal Of Horticulture*, *6*(2), 2011.

Ayele, S., and Bosire, C. (2011). Farme rs ' use of improved agricultural inputs and practices : review and synthesis of research in Ethiopia.

Bally, I. S. E. (2011). Advances in research and development of mango industry. *Revista Brasileira de Fruticultura*, *33*, 57–63.

Bandara, R. M. G., and Sivayoganathan, C. (1999). Impact assessment of farmer training in integrated pest management in irrigated rice cultivation. *Tropical Agricultural Research and Extension*, *2*(1), 51–54.

Baumgart-Getz, A., Prokopy, L. S., and Floress, K. (2012). Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature. *Journal of Environmental Management*, *96*(1), 17–25.

Canovas, G. V. Barbosa, Altunakar, B., and Lorio, D. J. Mejia. (2005). Freezing of fruits and vegetables An agribusiness alternative for rural and semi-rural areas. FAO agricultural services bulletin 158. FAO, ROME.

Chaudhary, B., and Mukhopadhyay, K. (2012). Syzygium cumini (L.) skeels: A potential source of nutraceuticals. *International Journal of Pharmacy and Biological Sciences*, *2*(1), 46–63.

Chowdhury, P., and Ray, R. C. (2007). Fermentation of Black plum (Syzgium cumini L .) fruits to form red wine. *ASEAN Food Journal*, *14*(1), 15–23.

Doss, C. R. (2001). Designing agricultural technology for african women farmers: Lessons from 25 years of experience. *World Development*, *29*(12), 2075–2092.

Doss, C. R. (2006). Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. *Agricultural Economics*, *34*(3), 207–219.

Duzdemir, O., Akca, H., and Sayili, M. (2008). Factors affecting fertiliser use in chickpea (Cicer arietinum) growing: A case from Turkey. *New Zealand Journal of Crop and Horticultural Science*, *36*(1), 53–57.

Feder, G., Murgai, R., and Quizon, J. B. (2004). The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. *Journal of Agricultural Economics*, *55*(2), 221–243.

Fernandes, F. A. N., Rodrigues, S., Law, C. L., and Mujumdar, A. S. (2010). *Drying of Exotic Tropical Fruits: A Comprehensive Review*. *Food and Bioprocess Technology* (Vol. 4).

Fliert, E. (1993). *Integrated Pest Management : farmer field schools generate sustainable practices Elske van de Fliert*. Wageningen Agric.Univ.

Gathambiri, C. W., Gitonga, J. G., Kamau, M., Njuguna, J. K., Kiiru, S. N., Muchui, M. N., and Muchira, D. K. (2010). Assessment of potential and limitation of post-harvest value addition of mango fruits in Eastern province:A case study in Mbeere and Embu districts. In Transforming agriculture for improved livelihoods through agricultural product value chains. *Proceedings of the 12th KARI biennial scientific conference, Kenya Agricultural Research Institute, Nairobi, Kenya* (pp. 564-566).

Gitonga, K. J., Gathambiri, C., Kamau, M., Njuguna, K., Muchui, M., Gatambia, E., and Kiiru, S. (2014). Enhancing small-scale farmers' income in mango production through agro-processing and improved access to markets.

GOI. (2013). Post-harvest profile of mango. A document of the directorate of marketing and inspection head office branch. Government Of India.

GOK. (2012). Kenya ' s LAPSSET corridor mango production investment opportunity, Investor Presentation, May 2012. Government of Kenya.

Grewal, H. S., Tewari, H. K., and Kalra, K. L. (1988). Vinegar production from substandard fruits. *Biological Wastes*, *26*(1), 9–14.

Gwandu, T., Mtambanengwe, F., Mapfumo, P., Mashavave, T. C., Chikowo, R., and Nezomba, H. (2014). Factors influencing access to integrated soil fertility management information

and knowledge and its uptake among smallholder farmers in Zimbabwe. *The Journal of Agricultural Education and Extension*, *20*(1), 79–93.

Hashemi, S. M., Hosseini, S. M., and Hashemi, M. K. (2012). Farmers' perceptions of safe use of pesticides: determinants and training needs. *International Archives of Occupational and Environmental Health*, *85*(1), 57–66.

Hassan, S. M., Mohamed Shaffril, H. A., Abu Samah, B., Shamshahkat Ali, M., and Ramli bte Ramli, N. S. (2012). The credibility of Television in Disseminating Agricultural Information to Farmers in Malaysia. *Asian Social Science*, *8*(12), 133.

Hassan, Z., M., Y., Tanvir, A., and Ahmad, M. (2007). Determination of participation in agricultural activities and access to sources of information by gender: A case study of district Muzaffargarh. *Pak.j.Agri.Sci.*, *44*(4), 664–669.

HCDA. (2011). *National horticultural exports perfomance 2011.Horticultural Crops Development Authority Report*, Kenya.

HCDA. (2013). Export statistics. *National horticulture validated report.Horticultural Crops Development Authority*.

Jaetzold, R., and Schmidt, H. (1983). *Farm managemnt handbook of Kenya.* (Volume II., Vol. II).

Jara-Rojas, R., Bravo-Ureta, B. E., and Díaz, J. (2012). Adoption of water conservation practices: A socioeconomic analysis of small-scale farmers in Central Chile. *Agricultural Systems*, *110*, 54–62.

Joladele, O. (2005). A tobit analysis of propensity to discontinue adoption of agricultural technology among farmers in southwestern Nigeria. *Journal of Central European Agriculture*, *6*(3), 249–254.

Karthick, K., Mani, K., and Anbarassan, A. (2013). Mango pulp processing industry in Tamil Nadu-an economic analysis. *American International Journal of Research in Humanities, Arts and Social Sciences*, *2*(1), 48–52. Retrieved from www.iasir.net

Kehlenbeck, K., Asaah, E., and Jamnadass, R. (2013). Diversity of indigenous fruit trees and their contribution to nutrition and livelihoods in sub-Saharan Africa: examples from Kenya and Cameroon. In *Fanzo J., Hunter D., Borelli T., Mattei F. (eds.) Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health. Earthscan Routledge, New York, USA, p. 257-269.* (pp. 257–269).

Kehlenbeck, K., Rohde, E., Njuguna, J. K., Omari, F., Wasilwa, L., and Jamnadass, R. (2010). Mango cultivar diversity and its potential for improving mango productivity in Kenya. In *Transforming agriculture for improved livelihoods through agricultural product value*

chains. Proceedings of the 12th KARI biennial scientific conference, Kenya Agricultural Research Institute, Nairobi, Kenya (pp. 657-665).

Kiilu, F. M., Muhammad, L., and Wambugu, S. M. (2002). *Market opportunities for fruits and vegetables processing in ukambani , eastern Kenya.*

Kilpatrick, S. (1997). *Effective delivery methodologies for education and training to rural Australia. Report to the Tasmanian Rural Industry Training Board Author:*

Kilpatrick, S. (2000). Education and training: Impacts on farm management practice. *The Journal of Agricultural Education and Extension*, *7*(2), 105–116.

Kilpatrick, S., and Rosenblatt, T. (1998). Information vs training: Issues in farmer learning. *The Journal of Agricultural Education and Extension*, *5*(1), 39–51.

Kiptot, E., and Franzel, S. (2011). Gender and agroforestry in Africa: a review of women's participation. *Agroforestry Systems*, *84*(1), 35–58.

Kiptot, E., Hebinck, P., Franzel, S., and Richards, P. (2007). Adopters, testers or pseudo-adopters? Dynamics of the use of improved tree fallows by farmers in western Kenya. *Agricultural Systems*, *94*(2), 509–519. doi:10.1016/j.agsy.2007.01.002

Kitinoja, L., and Cantwell, M. (2010). Identification of appropriate post-harvest technologies for improving market access and incomes for small horticultural farmers in sub-saharan Africa and South Asia.

Kitinoja, L., Saran, S., Roy, S. K., and Kader, A. A. (2011). Post-harvest technology for developing countries: challenges and opportunities in research, outreach and advocacy. *Journal of the Science of Food and Agriculture*, *91*(4), 597–603.

KNBS. (2009). Kenya Population and Housing Census, August 2009.Kenya National Bureau of Statistics.

Knowler, D., and Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy*, *32*(1), 25–48.

Kormendy, I. (2006). Fruit processing:principles of heat treatment. In Y. . Hui, J. Barta, P. M. Cano, W. T. Gusek, J. S. Sidhu, and N. K. Sinha (Eds.), *Handbook of fruits and fruit processing* (1st ed., pp. 45–58). Blackwell Publishing Ltd.

Koskei, R. C., Langat, J. K., Koskei, E. C., and Oyugi, M. A. (2013). Determinants of agricultural information access by smallholder tea farmers in Bureti district , Kenya. *Asian Journal of Agricultural Sciences*, *5*(5), 102–107.

Kulecho, I. K., and Weatherhead, E. K. (2005). Reasons for smallholder farmers discontinuing with low-cost micro-irrigation: A case study from Kenya. *Irrigation and Drainage Systems*, *19*(2), 179–188.

Läpple, D. (2010). Adoption and abandonment of organic farming: An empirical investigation of the irish drystock sector. *Journal of Agricultural Economics*, *61*(3), 697–714.

Litz, R. E. (2009). *The Mango: botany, production and uses*. CABI. Retrieved from http://books.google.co.ke/books?id=3Pq9wzuje1MC

Lukuyu, B., Place, F., Franzel, S., and Kiptot, E. (2012). Disseminating improved practices: are volunteer farmer trainers effective? *The Journal of Agricultural Education and Extension*, *18*(5), 525–540.

Marenya, P. P., and Barrett, C. B. (2007). Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy*, *32*(4), 515–536.

McFadden, D. (1987). Regression-based specification tests for the multinomial logit model. *Journal of Econometrics*, *34*, 63–82.

Meinzen-Dick, R., Quisumbing, A., Behrman, J., Biermayr-jenzano, P., Wilde, V., Noordeloos, M.,Beintema, N. (2011). *Engendering agricultural research, development , and extension*. Washington.

Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems*, *61-62*(1-3), 311–328.

Miller, M., and Mariola, M. J. (2009). The discontinuance of environmental technologies in the humid tropics of Costa Rica: results from a qualitative survey. *Journal of Agricultural Education and Extension*, *16*(1), 31–42.

Msabeni, A., Muchai, D., Masinde, G., Samuel, M., and Gathaara, V. (2010). *Sweetening the mango : Strengthening the value chain an anlysis of the organisational linkages along and within the mango value chain in Mbeere district, sweetening the mango :strengthening the value chain*.

Mulanda, J., Mwenya, E., and Namalambo, E. (1999). Draught animal power : experiences of farmer training in the Northern communal areas of Namibia. In *Empowering farmers with Animal Traction* (2000th ed).

Musyimi, S. M., Okoth, E. M., Sila, D. N., and Onyango, C. A. (2012). Prodcution, optimization and characterisation of mango fruit wine: towards value addition of mango produce.*In 7th JKUAT scientific Conference proceedings*.

Mwanda, C. O. (2000). A note of weed control in Machakos District, Kenya. In *Starkey P and Simalenga T (eds), 2000. Animal power for weed control. A resource book of the animal traction network for Eastern and Southern Africa (ATNESA). Technical centre for Agriculture and Rural coorporation (CTA), Wageningen, The Netherlands.* (pp. 238–239).

Mwombe, S. O. L., Mugivane, F. I., Adolwa, I. S., and Nderitu, J. H. (2014). Evaluation of information and communication technology utilization by smallholder banana farmers in Gatanga district, Kenya. *Journal of Agricultural Education and Extension*, *20*(2), 247–261.

Nampanya, S., Suon, S., Rast, L., and Windsor, P. A. (2012). Improvement in smallholder farmer knowledge of cattle production, health and biosecurity in southern Cambodia between 2008 and 2010. *Transboundary and Emerging Diseases*, *59*(2), 117–127.

Naveed, M. A., Anwar, M. A., and Bano, S. (2012). Information seeking by Pakistani farmers : A review of published research. *Pakistan Journal of Library and Information Science*, *13*. Retrieved from http://pu.edu.pk/home/journal/8

Ndungu, J. M., Pole, F. N., and Katama, C. (2008). Value chain analysis: A case study of mangoes in Tana delta. In *Proceedings of the 11th KARI biennial scientific conference, Kari, Nairobi, Kenya* (pp. 10–14).

NEMA. (2009). Machakos district environmental action plan 2009-2013.National Environment Management Authority.

New, S. (2010). Market opportunities for mango growers-Kenya Horticultural Development Program 2004-2010.

Ngombe, J., Kalinda, T., Tembo, G., and Kuntashula, E. (2014). Econometric analysis of the factors that affect adoption of conservation farming practices by smallholder farmers in Zambia. *Journal of Sustainable Development*, *7*(4), 124–138.

Nkonya, E., Schroeder, T., and Norman, D. (1997). Factors affecting adoption of improved maize seed and fertiliser in northern Tanzania. *Journal of Agricultural Economics*, *48*(1-3), 1–12.

Nlerum, F. E., Albert, C. O., and Prince-Kaye, E. S. (2012). Access of rural women to agricultural information in the Eleme area of Rivers State, Nigeria. *Journal of Agricultural and Food Information*, *13*(2), 192–197.

Nyanga, L. K., Nout, M. J. R., Gadaga, T. H., Boekhout, T., and Zwietering, M. H. (2008). Traditional processing of Masau fruits (Ziziphus Mauritiana) in Zimbabwe. *Ecology of Food and Nutrition*, *47*(1), 95–107.

Nyaupane, N. P. (2010). Louisiana crawfish farmer adoption of best management practices. *Journal of Soil and Water Conservation 66*(1), 61-70.

Oakland, G. B. (1953). Determining Sample Size. *The Canadian Entomologist*, *85*(3), 108–113.

Obidike, N. A. (2011). Rural farmers ' problems accessing agricultural information : A case study of Nsukka local government area of Enugu State , Nigeria. *Library Philosophy and Practice (e-Journal)*.

Ofuoku, A. U., Olele, N. F., and Emah, G. N. (2008). Determinants of adoption of improved fish production technologies among fish farmers in Delta State, Nigeria. *The Journal of Agricultural Education and Extension*, *14*(4), 297–306.

Okello, J. J., Kirui, O., Njiraini, G. W., and Gitonga, Z. (2012). Drivers of use of information and communication technologies by farm households: the case of smallholder farmers in Kenya. *Journal of Agricultural Science*, *4*(2), 111–124.

Okunade, E. (2007). Effectiveness of extension teaching methods in acquiring knowledge, skill and attitude by women farmers in Osun State. *Journal of Applied Sciences Research*, *4*(2). Retrieved from https://www.unilorin.edu.ng/publications/ayindetayo/Analysis of the Impact of Globalization on Nigerian Agricultural.pdf#page=28

Okwu, O. J., and Umoru, B. I. (2009). A study of women farmers ' agricultural information needs and accessibility : a case study of Apa local government area of Benue State , Nigeria. *African Journal of Agricultural Research*, *4*(12), 1404–1409.

Oladele, O. I., and Adekoya, A. E. (2006). Implications of farmers' propensity to discontinue adoption of downy-mildew resistant maize and improved cowpea varieties for extension education in southwestern Nigeria. *The Journal of Agricultural Education and Extension*, *12*(3), 195–200.

Opara, U., N. (2008). Agricultural information sources used by farmers in Imo state, Nigeria. *Information Development*, *24*(4), 289–295.

Orwa, C. (2009). Syzygium cuminii (L .) skeels myrtaceae Syzygium cuminii (L .) skeels. Retrieved from http://www.worldagroforestry.org/treedb2/speciesprofile.php?Spid=1576

Panda, R. K., and Sreekumar. (2012). Efficiency assessment in agribusiness marketing channel choice and marketing efficiency assessment in agribusiness. *Journal of International Food and Marketing Channel Choice and Marketing*, (January 2014), 37–41.

Pattanayak, S. K., Mercer, D. E., Sills, E., and Yang, J. (2003). Taking stock of agroforestry adoption studies. *Agroforestry Systems*, *57*(c), 173–186.

Ranjan, A., Jaiswal, A., and Raja, R. B. (2011). Enhancement of Syzygium cumini (Indian black plum) active constituents by ultra-violent (UV) irradiation method, *6*(12), 2457–2464.

Rehman, F., Muhammad, S., Ashraf, I., Ch, K. M., Ruby, T., and Bibi, I. (2013). Effect of farmers' socioeconomic characteristics on access to agricultural information: Empirical evidence from Pakistan. *The Journal of Animal and Plant Sciences*, *23*(1), 324–329.

Rivera, W. M., and Alex, G. (2004). The continuing role of government in pluralistic extension systems. *Journal of International Agricultural and Extension Education*, *11*(3), 41–51.

Rogers, E. M. (2010). *Diffusion of Innovations, 4th Edition* (4th ed.). Simon and Schuster. Retrieved from http://books.google.co.ke/books?id=v1ii4QsB7jIC

Roy, S. K., Saran, S., and Mishra, V. (2013). Harvesting cultivar physico-chemical composition of different types of Black plum.

Rutatora, D. F., and Attee, A. Z. (2001). Major agricultural extension providers in Tanzania. *African Study Monographs*, *4*(22), 155–173.

Seger, J. (2011). The New Digital [St] age : Barriers to the adoption and adaptation of new technologies to deliver extension programming and how to address them.

Sidibe, M., Williams, J. T., Hughes, A., Haq, N., and Smith, R. W. (2002). Baobab. *Adansonia digitata*, 100.

Singh, K. P., and Satija, M. P. (2007). Information seeking behaviour of agricultural scientists with particular reference to their information seeking strategies, *54*(ii).

Small, K. A., and Hsiao, C. (1985). Multinomial Logit specification tests. *International Economic Review*, *26*(3), 619–627 CR – Copyright and#169; 1985 Economics Depa.

Soon, J. M., and Baines, R. N. (2012). Food safety training and evaluation of handwashing intention among fresh produce farm workers. *Food Control*, *23*(2), 437–448.

Spurk, C., Schanna, M., Ochieng, M. M., and Ugangu, W. (2013). *Kenyan Farmers and their assessment of information on agricultural innovation. Results of a joint research project "Shortcomings of communication in agricultural knowledge transfer in Kenya-and ways to improve it."* Retrieved from http://pd.zhaw.ch/publikation/upload/205251.pdf

Spurk, C., Schanne, M., Mack'Ochieng, M., and Ugangu, W. (2013). *Agricultural information for smallholder farmers in kenya*.

Tarnoczi, T. J., and Berkes, F. (2009). Sources of information for farmers' adaptation practices in Canada's Prairie agro-ecosystem. *Climatic Change*, *98*(1-2), 299–305.

UNCTAD. (2013). Mango.United Nations Conference on Trade and Development. Retrieved from http://www.unctad.info/en/Infocomm/AACP-Products/COMMODITY-PROFILE---Mango/ accessed on 2/15/2014.

UNIDO. (2004). Smallholder Fruit and Vegetable Production methods , equipment Smallholder Fruit and Vegetable.United Nations Industrial Development Organisation.

Zins, C. (2007). Conceptual approaches for defining data, information, and knowledge. *Journal of the American Society for Information Science and Technology*, *58*(4), 479–493.

Zossou, E., Van Mele, P., Vodouhe, S. D., and Wanvoeke, J. (2009). The power of video to trigger innovation: rice processing in central Benin. *International Journal of Agricultural Sustainability*, *7*(2), 119–129.

www.post-harvest.ucdavis.edu/files/93618.pdf accessed on 2/15/2014

7.0 APPENDICES

Appendix 1-Questionnaire

ACCESS TO AND USE OF TRAINING ON FRUIT PROCESSING TECHNOLOGIES BY FARMERS IN MACHAKOS COUNTY.

Date: ___/____/____ (Day/Month/Year) Questionnaire Code:|___|___|___|

Name of Interviewer……

GENERAL INFORMATION	
COUNTY……..	
SUB-COUNTY……...	
LOCATION…….	
SUB-LOCATION…….	
VILLAGE…….	
GPS CO-ORDINATES	Longitude……. Latitude…….. Elevation…….....

An Interview Schedule for collecting data from survey male and female trained/farmers carrying out processing for MSc. Research Thesis Access to and Use of training on fruit processing technologies by farmers in Machakos County.(This research is carried out by the World Agroforestry Centre (ICRAF) Nairobi, Fruit Africa project together with the University of Nairobi, Department of Agricultural Economics).

The Information you will provide here is confidential and will only be used for research purposes only.

Section 1: **Respondent socio-demographics and socio-economic characteristics**

1. Information about the respondent

Name	Age(yrs.)	Gender (1)	Education Level (2)	Marital Status (3)	Ethnic group (4)	House hold head (HH) name and age	Relationship of respondent to HH head (5)	Household size(give number of adults and children < 16 years separately)		Farm size(acre)	Land ownership type (6)
								No.adults	No.children		

(1) Gender
1. Male
2. female

(2) Educational level
1. No education received
2. Some Primary
3. Primary finished
4. Secondary
5. Tertiary

(3) Marital status:
1. Married
2. Single
3. Widowed
4. Others

(4) Ethnic group
1. Akamba
2. Others (specify)

5) Relationship of respondent to HHH
1. Self
2. Spouse
3. Child
4. Others (specify)

(6) Land ownership type
1. Own land with title (or title in progress)
2. Own land, no title
3. Communal land
4. Others (specify)

What are the main crops/livestock you keep?		**3a).**Do you have fruit trees on farm? Yes=1, No=0
1a) Livestock	***2a)Crops***	**3b).**If yes, list the three most important ones
1b). Do you sell your livestock/livestock products? ----------	**2b).**Do you grow mainly for subsistence or for sale? ----------	**3c).**Do you grow fruit trees for subsistence or for sale? ----------
1c). What livestock products do you sell	**2c).**What crops do you sell?	**3d).**Which fruit species do you sell?

You were selected for this interview because you have received some training on (or because you are doing) fruit processing. We would like to know from you some more details on how you learned about fruit processing. Processing means any change that is made to improve the shelf life of the fruits, make them more tasty or easier to consume, make them into products (examples: making jam, juices, dried fruits, pickles, chutney, wine) by applying different technologies. Technologies are ways/ methods you use to transform the fruit into a product like (drying, pulping, fermentation etc.)

Section 2: Knowledge and use of processing technologies

4. Do you currently process any fruits/ have you done fruit processing before? Yes=1, No=0
If yes please give the main reasons why you are/were processing fruits
……
……
……..

5. Do you know any processing technologies for:
Embe (*Mangiferaindica*) Yes=1, No=0
Msambarau (*Syzygiumcuminii*) Yes=1, No=0

6. If yes, please list the technologies you are familiar

Fruit	Technologiesand end product (refer to definition of technologies above)
Embe	…… …… …… ……
Msambarau	…… …… …….. ……

7.Identify technologies that you tried or used frequently in the past/use frequently currently and please indicate the fruit used for the processing(If none proceed to section three)

Technology	Tried/Frequently used in the past, but now stopped (please tick)	Currently frequently in use (please tick)
1. Fermentation into fruit wine		
2. Fermentation into pickles		
3. Pulping for juice making		
4. Pulping and cooking jam		
5. Cutting/pulping for making chutney		
6. Drying of cut fresh fruits		
7. Drying of fruit pulp for fruit leather		
8. Making cooked sugared fruits and cooked candies		
9. Canning (packing cut fruits into air tight containers and applying heat)		
10. Others (specify)		
8. Please indicate why you use/were using the technology, how often and when last		
Use	How often	When last
1. For Income generation		
2. For home consumption		
3. Little for sale and more for home consumption		
4. More for sale and little for home consumption		
5. For both Income and home consumption		

(Enumerator; please tell the respondent that you will come back to ask them more details about the processing they mentioned here later)

Section 3: To assess trainings on fruit processing received and use of processing knowledge by the respondents

9. Have you been trained on any processing technologies of Embe or Msambarau? Yes=1; No=0,

10. If no, but you are/were processing embe or mzambarau, how did you receive your knowledge on processing embe and or msambarau? Give details……..

11. Have you received training on processing of other fruits? Yes=1; No=0

12. If yes, list the trainings and please fill the table below

Training classes no.	**13.** Level of training you attended Training of farmers-starter=1 Training of trainers=2 Advanced Agro-processor training=3	**14.** Fruit (Species)	**15.** Who organized it/ trained you?	**16.** When was this?		**17.** Duration for training (no of days)	**18.** Location (town)	**19.** No. of participants	**20.** No. of trainers	**21.** How did you become aware of the training?
				Month	Year					
1										
2										
3										

For each one of these training levels, list the fruit, technologies that you received training on, steps involved, equipment used if any, product you developed if any and how you packaged if you did so.							
Training class no. (see above)	**22**. Fruit	**23**.Technology and end product	**24**. Did you have prior knowledge about this technology? Yes=1, No=0	**25**.If yes how did you acquire the knowledge	**26.** Enumerate the steps involved in the technology you received training	**27.**Equipment used	**28.**Packaging
1							
2							

Training class no. (see above)	**28.** How was your training done/carried out? Please describe the training topics covered, the methods used to teach you, if there were printed materials or visual aids used for teaching, if the trainees took notes, if they discussed topics in smaller groups, if they had hands-on exercises etc.)	**29**. Do you think the overall training method was effective? Yes=1, No=0	**30.**If Yes, indicate which in your opinion was the most effective	**31.**suggest ways/approaches you would prefer to receive training
1				
2				
3				

Training class no. (see above)	**32**. What was your motivation behind attending the training?	**33.** Did you know your trainer before the training? Yes=1, No=0 If yes describe the relationship	**34.**During that training class, have you been able to produce the end- product yourself (hands-on)?Yes=1, No=0	**35.** If no, do you think it would have been useful for the participants to do it?	**36.**If yes, was it sufficient for understanding the practical part of the processing or do you think more hands-on would have been useful
1					
2					

Enumerator please prompt for these questions as the respondent describes how the training was carried out

37. Did you make notes during any of your training classes? Yes=1, No=0, If yes, give class numbers (from above tables)……

38. Did you ever read them again and was it useful?

39. Did you ever get any material such as leaflet, manuals, print outs during the training? Yes=1, No=0 If yes please fill the table below

40. If no, do you think it would be useful to get printed materials during trainings? If yes which ones? _____

Training class no. (from above)	**41.**Type of training material received	**42.**Describe the content	**43.** How useful was that material? Very useful=2 Somewhat useful=1 Not useful=0	**44.** Did you ever read it again? Yes=1, No=0
1				
2				
3				
45. Do you still have the training materials that maybe you could show us (possible to make photocopy?)				

46. After the training, did you teach the skills learned to others? Yes=1, No=0. If No, why not?

If yes, please indicate the details below

Training class no.	**47.**Level of training you gave 1=starters, 2=intermediate, 3=advanced	**48.** To whom (friends=1, family=2, neighbours=3,strangers=4, group members=5 others=6)	**49.** How many were trained (No. of people)	**50.** Please provide the name and contact (for those you have and can remember, kindly call/ask if they would be available for an interview)	**51.** How often did you provide this training and when last?	**52.** Why did you decide to train others (reasons/motivation)	**53.** Have you received any benefits whether direct or indirect by giving the training? If yes, please specify
1							
2							
3							

We would now like to know if you prefer to receive more training and other fruit processing related topics

54. How often would you prefer refresher trainings on topics you have already learned? No need=0, after every 3 years=1, after every 2 years=2, once a year=3, twice a year=4, three times a year=5, Others=6	**55.** Are there any other processing technologies and fruits you would like to receive training on? Yes=1, No=0 If yes indicate preferred technology and fruit		**56.** Why haven't you received training on them?	**57.** Are there other related topics on fruit processing you would like to receive follow-up training on? E.g. **packaging, marketing, linkage to buyers, business skills, group formation skills**? Please specify and rank the three most important
	Technology	Fruit		

Section 5: Technology use by the respondents

(**Enumerator, this is a continuation from section 2. Please tell the respondent that you would now like to know more details about the fruit processing technologies he/she told you that he/she is/was usi**ng)

65. From the technologies that you received training on/ have acquired, do you currently use/ actively use any of them? Yes=1, No=0.
If yes please fill the table. If No, proceed to question **108a**

Technology and end product (Tech end pdct)	**66**. Quantities of products made per production batch/day/week (units grams, jar/litre/etc.)	**67.** Needed raw materials(types and amounts) per production batch/day	**68.** Indicate the raw material sources and prices per production batch/day	**69.** How do you store your raw materials?	**70.** List the equipment used	**71.** Is ownership of equipment 1=owned individually, 2=borrowed/rented, 3=group owned (per item)
T/P1						
T/P 2						
Technology and end product (Tech end pdct)	**72.** How do you store your final product?	**73.**Sources and prices of your packaging materials	**74.** Do you label? Yes=1, No=0 If yes, what is the cost of your labeling	**75.** Sources of labor 1. Self 2. Group 3. Family members 4. Hired labor 5=other (specify) **(Enumerator please indicate that you will revisit this**	**76.** Is your production done all year round? Yes=1, No=0 If no, why not?	**77.** If seasonal, give the months of the season and the frequency of processing during the season. How many times do you process in a month/week?

				question later)		
T/P1						
T/P 2						

Tech end pdct)	**78**. Where do you sell the products (location) and to whom?		**79.** Please indicate the unit, weight and selling price per final product. E.g. Jar, 200g, 100KSh	**80.** How many of these do you sell in a day/week/month?	**81.** What is the value of the total sales (Ksh.) per day/week/month or the last time you sold?	**82.** Are there any sales related costs that you incur? for example transportation yes=1, No=2 Please identify and give the costing per /day/week/month on production batch	**83.** Do you do book keeping? Yes=1, No=0
	Location	Main buyers					
T/P1							
T/P 2							
	84. Was the buyer happy with the product? Yes=1, No=0		**85**.Did they buyer complain about the quality Yes=1, No=0 What was the complain? What quality do they value	**86.** Did they complain about Quantity? Yes=1, No=0 If yes, what quantity do they want and what traits are they looking for?	**87.** Have you ever thrown away the final product because it spoiled or for other reasons? Yes=1, No=0, If yes, indicate reason and how much	**88.** Have you ever thrown away the raw materials because it spoiled or for other reasons? Yes=1, No=0, If yes, indicate reason and how much	**89.** What is the general level of demand of your product? Has is increased/decreased/stayed the same compared to the past (since you started engaging in production)?Circle one Do you think it might increase/decrease in the next two years?
	Buyer	Happy?					
T/P1							
T/P 2							

90. Do you process as a group or individually? Group =1, Individual =0

Please give us some more information regarding labour inputs

Product	(**multiple answers possible, but then rank the importance**)		**93.**Indicate no. of people carrying out processing/day/week-	**94.**Indicate pay per day or week or indicate other ways you compensate your labor sources, if not your own/group members	**95**. If only self, how much time is devoted to processing per day/product	**96.**Length of time taken to produce/pack/label the batch mentioned above in a day/week
	91. Group processing Sources of labor 1. Group members 2. Family members of group members 3. Neighbours of group members 4. Friends of group members 5. Hired labor 6. Others (specify)	**92**. Individual processing Sources of labor 1. Only Self 2. Other Family members (please specify who) 3. Neighbours 4. Friends 5. Hired labor 6. Others (specify)				
T/P1						
T/P 2						

If processing as a group, please answer more questions below

Product T/P1=1 T/P2=2 T/P=3	**97.** Did the fruit processing occur after the training was received? Yes=1, No=0	**98.** indicate the reasons why you join/created a group (circle joined or created to indicate which and then record narrative for reason provided)	**99.**Indicate how long you have been processing as a group	**100.** How many group members are actively involved in processing?

101. How are decisions made in terms of processing /selling (price making)/ marketing?

Section 6: Constraints in processing

Enumerator, in this section, let the respondent do free list, tick the item closest to the given answer, then prompt for forgotten items and finally let the respondent rank only 3 most important

For those currently/frequently using the technologies

Are there any challenges when it comes to procurement of raw materials/ingredients and packaging materials, packaging and labeling, selling and processing? Please identify challenges for each of the following processing steps, list, and rank the three most important

102a). Challenges in procurement of raw materials 1. Poor quality of raw materials 2. Insufficient amounts of raw materials available 3. Seasonal variation of fruits 4. Inaccessible inputs/ingredients 5. High cost of raw materials 6. Lack of knowledge on what material to purchase where 7. Others (specify)	**102b) .**Please suggest some ways to overcome the named challenges. Did you try it once? Did it work?
103a). Challenges in procurement of packaging materials 1. Poor quality of packaging materials 2. Inaccessible packaging materials 3. High cost of packaging materials 4. Lack of credit to purchase 5. Lack of knowledge on what material to purchase where 6. Others (specify)	**103b)**
104a). Challenges in the processing process 1. Inefficient processing equipment 2. Lack of processing premises 3. Lack of skills/technology 4. Lack of labor forces 5. Expensive labor force 6. Lack of time 7. High operation and maintenance costs 8. Others (specify)	**104b)**

105a). Challenges in packaging/labeling 5 Difficulty in obtaining certification with standard organisations like Kenya Bureau of standards (KEBS), Halal certification 6 Expensive labels 7 Inaccessible labeling materials 8 Others (specify)	**105b)**
106a). Challenges in selling 9 Low selling prices 10 Competition from other competitors/products 11 Low demand/different consumer preferences 12 Lack of markets (nowhere to sell) 13 Spoilage of product/short shelf life 14 Transport problems 15 Transport too expensive 16 Others (specify)	**106b)**

107. In case you are doing group processing, are there any other additional challenges related to group processing? Yes=1, No=0,

If yes, what are the challenges and please suggest how you think you can overcome them/have managed to overcome them

If you are NOT processing fruits at the moment, we would like to know why you tried/frequently used fruit processing technologies in the past, but now stopped and why you were trained and never engaged in fruit processing.
Enumerator, let the respondent do free listing then prompt him from the below list and let him rank 3 most important challenges)

Type of non-processor	Challenges in engaging in fruit processing	Rank	Suggest ways to overcome the challenges	Rank
Tried/Frequently used in the past, but now stopped	**108a)**		**108b)**	
Trained but never used the technologies	**109a)**		**109b)**	

List of potential challenges in engaging in fruit processing

1. Expensive ingredients
2. Lack of access to fruits
3. Lack of access to processing equipment
4. Lack of markets
5. No economic benefits/monetary returns
6. Insufficient knowledge on processing (due to poor training methods???)
7. Involved in other activities therefore no time to engage in processing
8. Not interested
9. Others
   (specify)_____

Finally we would like to ask you about the importance of fruit processing to your overall livelihood and income.
110. How important is fruit processing for your and your family's livelihood? Please tick
Not important=0 Somehow important=1 Very important=2

111. How much percentage of your total household income in 2013 was covered by income from fruit processing activities? Please tick
0-20%=1, 21-40%=2 41-60%=3 61-80%=4 81-100%=5

Could you please tell me about your total household income range for the period 2013 (one full year)?

(7) Income range (total HH income) for 2013 (Ksh.)	Income sources and shares (in proportion of total HH income) for 2013
1. <10, 000 2. 10,001-25,000 3. 25,001-50,000 4. 50,001-75,000 5. 75,001-100,000 6. 100,001-150,000 7. 150,001-200,000 8. >201,000	Farm 1. Sale of fruits_____% 2. Sale of other crops_____% 3. Sale of livestock_____% 4. Sale of livestock products_____% 5. Others (specify) …
	Non-farm 1. Hired labor _____% 2. Salaried employment_____% 3. Business _____% 4. others

Thank the respondent for their valuable time and information and invite them to ask questions, give suggestions etc.

Appendix 2. Housman test for IIA

Choice	X	P>X2
0	0	1
1	0	1
2	0	1

Appendix 3. vif

Variable	VIF	1/VIF
nooftechno~s	1.19	0.841696
notraining~d	1.17	0.858296
numberoffr~s	1.13	0.885638
education	1.07	0.933657
endnproduct	1.07	0.934542
agex	1.07	0.935791
acquireany~o	1.04	0.957371
Mean VIF	1.11	

Appendix 4. Letter of introduction to the District Agriculture Officer

Nora B. Ndege
P.O Box 2039-00606
Nairobi, Kenya
6th August 2014

District Agricultural Officer,
Mwala Sub County,
Mwala, Machakos
Kenya

Dear sir/madam,

Re: Field study in Mwala Sub County

My name is Nora B. Ndege, a Master of Science degree student in Agricultural Information and Communication Management (AICM) at the Department of agricultural Economics, University of Nairobi.

I would like to carry out the above mentioned exercise in Mwala Sub-County in May 2014. My focus of study is **"Access and use of processing technologies by fruit farmers in Machakos County-Mwala"**. The purpose of this letter is to kindly request you to allow me to collect both primary and secondary data from your office and field. I also request you to allow me use one of your staff as a field assistant.

Kind Regards,

Nora Ndege.