THE EFFECT OF POSTHARVEST HANDLING PRACTICES ON THE QUALITY OF SELECTED KENYAN SWEETPOTATO VARIETIES

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DECLARATION

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

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
AOAC	Association of the Official Analytical Chemists
CIP	Centro Internacional de la papa (International Potato Centre)
cP	Centipoise (viscosity unit)
CPV	Cold Paste Viscosity
DM	Dry Matter
Dwb/DW	Dry weight basis
ERA	Economic Review of Agriculture
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Statistical data
FGDs	Focused Group Discussions
FV	Final Viscosity
Fwb	Fresh weight basis
GDP	Gross Domestic Product
HPV	Hot Paste Viscosity
IFFJP	International Federation of Fruit Juice Producers
KALRO	Kenya Agricultural and Livestock Research Organization
KHCP	Kenya Horticulture Competitiveness Project
KNBS	Kenya National Bureau of Statistics
LSD	Least Significant Difference

MoA	Ministry of Agriculture
MT	Metric tonnes
NRI	Natural Research Institute
NGO	Non-Governmental Organization
NOFV	Non- Orange Fleshed Varieties
OFSP	Orange Fleshed Sweetpotato
OFV	Orange Fleshed Varieties
ppm	Parts per million
PT	Pasting Temperature
PV	Peak Viscosity
pVAC	proVitamin A Carotenoid
RH	Relative Humidity
RoK	Republic of Kenya
SBV	Set Back viscosity
SDA	State Department of Agriculture
SP	Sweetpotato
SPSS	Statistical Package for Social Scientists
SPVD	Sweetpotato Virus Disease
SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
USD	United States of America Dollar
VAD	Vitamin A Deficiency
WHO	World Health Organization

ABSTRACT

Sweetpotato (*Ipomea batatas*) is a versatile crop that serves the roles of food and nutrition security, cash crop, feed for livestock and can provide raw materials for processing in the commercial industry. The hidden commercial potential of the sweetpotato in Kenya is yet to be exploited since little attention has been paid to postharvest harvest practices thus, little documented information exists on postharvest practices. Maximum utilization of sweetpotato roots is also hindered by lack of adequate information documented on current varieties. This study aimed at assessing the effect of sweetpotato postharvest handling practices on the physicochemical properties of roots of selected varieties in Kenya. A survey was carried out in Homabay and Bungoma counties to assess the postharvest handling practices. Structured questionnaires were administered to a total of 165 respondents comprising 96 farmers, 64 traders and 5 processors. Eight selected sweetpotato varieties were then evaluated for their physicochemical properties and for the pasting profiles of their flours. To establish the effect of storage conditions on the quality of the roots, Kabode (orange fleshed) and Kenspot 2 (white fleshed) varieties of sweetpotato were harvested and subjected to similar storage conditions in an experiment with factorial arrangement of 24 treatment combinations. Half of the samples were washed while the similar half unwashed before storage. Half of the samples were stored under room temperature 22-24^{o}C, relative humidity of 60-70% and the other half stored at temperature of 12-13^{o}C, relative humidity of 80-90% for three weeks. Changes in moisture content, starch, reducing sugars, beta carotene and vitamin C were monitored during the three-week period.

The survey results showed that 68%, 87% and 40% of sweetpotato farmers, traders and processors respectively, were women. Marketing systems that quantified roots using bags, buckets and heaps were prevalent. Motorcycles, donkeys and bicycles, were used by 26%, 21% and 11% respectively to transport roots to the markets. Storage was rarely practiced by 43% of farmers and 45% of traders. Processed products included flour, puree and dried chips. High perishability and unreliable supply of roots were major challenges indicated. There were significant ($p < 0.01$) variations in the physichochemical attributes of the eight varieties. Orange fleshed varieties had comparatively higher moisture, beta carotene, fat, reducing sugars and mineral contents but lower pasting profiles compared to the non-orange fleshed varieties. Flour from the orange fleshed varieties showed lower Peak viscosities (124-590cP) and lower cold paste viscosities (89.5-319cP) compared to that of the non-orange fleshed varieties. During the storage experiment, significantly ($p \leq 0.05$) more changes in physicochemical attributes of the roots were recorded in samples stored at room temperature (22-24^{o}C) with relative humidity 60-70% compared to samples stored at 12-13^{o}C with relative humidity ranging 80-90% at the end of three-week storage. Loss of over 50% in moisture content, beta carotene, vitamin C, about 30% starch and increase in reducing sugars by more than 50% were noted after three-week storage. Washed samples experienced higher deteroriation in quality compared to unwashed samples irrespective of variety. Sisal and gunny bag packaging showed slower deterioration of quality of the roots compard to the roots that were not packaged prior to storage. In conclusion, postharvest handling practices and challenges were similar in both Bungoma and Homabay counties. Inadequate knowledge on storage and lack of storage facilities and infrastructure were major challenges cited by the respondents. Sweetpotato varieties differ significantly in their physichochemical properties and hence can have diverse uses in both food and non-food applications. Washing, packaging and storage conditions significantly affect the physicochemical properties of sweetpotato roots during storage. The findings of this study will inform actors on postharvest handling and management of sweetpotato in order to tap in to the unexploited commercial opportunities in the sweetpotato value chain. A comprehensive

sweetpotato policy in Kenya is required to address identified challenges on sweetpotato handling practies along the value chain in order to promote utilization and minimize postharvest loses.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Sweetpotato (*Ipomea batatas*) in Kenya is among the major staple crops and ranks fifth after corn, rice, wheat and potato (MoA, 2010) though greatly underexploited (Rees et al., 2003). It is grown in a wide range of Agro Ecological Zones (AEZ) (Mukras et al., 2013) and grows better in areas with well-distributed annual rainfall of 600-1600mm (Wheatley and Loechl, 2008). Growth is optimal at temperature above 25°C; however, when temperatures fall below 12°C or exceed 35°C, growth is retarded (Kivuva et al., 2014). The ability of the crop to grow under marginal conditions and survive when other crops like maize fail due to low rainfall makes it an important food security crop. Sweetpotato nutritional importance is due to their composition of carbohydrates, proteins, minerals, vitamins, phenolic compounds and anthocyanins (Oloo et al., 2014). Among the various cultivars of sweetpotatoes grown in Kenya are improved varieties and local landraces (Kivuva et al., 2014). Farmers' preferences for particular varieties are based on many factors including taste, yield, maturity period, and market preference among others (Were et al., 2013). Production and consumption of sweetpotato in Kenya has been on the rise in the recent years (ERA, 2015) particularly due to the promotion of the biofortified orange fleshed cultivars by CIP (International Potato Centre) and other partners as a food based approach in combating vitamin A deficiency (VAD) that is prevalent in sub-Saharan Africa (SSA) (Low et al., 2007). Production is mainly for subsistence as a food security crop but surplus (about 40%) is sold as need arises to boost family income (Were et al., 2013). Postharvest loss of fresh agricultural produce in Kenya was estimated at 30-40% (MoA, 2010) due to lack of appropriate postharvest handling technologies and practices with regards to storage, transportation, processing and marketing. This contributes to low production, piecemeal harvesting and less commercialization of the commodity (Kivuva et al., 2014). Despite the numerous challenges of production and postharvest handling, the sweetpotato contributes about Kshs. 22.5billion to Kenya's gross domestic product (GDP) (RoK 2015). In order to realize the maximum potential of this crop for food and nutritional security as well as income generation, there is need for studies to understand the postharvest activities by handlers to identify areas of intervention by relevant development stakeholders.

1.2 Problem Statement

Sweetpotato is mainly produced by small scale farmers in rural areas of Kenya and consumption of fresh roots mainly in the boiled state has steadily gained popularity across all the socioeconomic classes of the population. The demand for fresh roots in urban areas often surpasses the seasonal supply since the roots are highly perishable and deteriorate quickly. Despite sweetpotato being an important food security as well as commercial crop in Kenya, there has been little attention given to postharvest practices to ensure prolonged shelf life of the roots to adequately supply and sustain markets for large volumes. As a result of the high perishability nature of the fresh roots, farmers and traders transact in low volumes to avoid incurring huge losses. Little documented information exists on postharvest handling practices of sweetpotato roots in Kenya. Besides, there's scanty information regarding physicochemical and storage requirements for the roots given new development of biofortified varieties. This study therefore seeks to assess the current postharvest handling practices for sweetpotato grown in Kenya, characterize popular varieties for their physicochemical properties, besides establishing the effect of washing, packaging material and storage conditions on the physicochemical properties of the roots.

1.3 Justification of the Study

Commercial potential of sweetpotato roots can be exploited through appropriate handling technologies to minimize both physical and nutritional quality deterioration and loss. Reduction of postharvest loss of roots is a key contribution to food security in Kenya as it will encourage diversification in consumption and hence decrease over-reliance on maize as the main staple food. Characterization of physicochemical properties of the different cultivars grown in Kenya is essential to guide producers, traders and consumers on the market choice and use. Processing of sweetpotato roots is expected to extend shelf-life of the commodities and ensure all-year supply, reduce bulk in transportation and increase the commercial value of the products for the producers and traders.

1.4 Study Aim

This study aimed at contributing to the knowledge base regarding postharvest management and physicochemical properties of sweetpotato roots in Kenya for reduction of losses, encourage commercialization and up-scale diversity in consumption of staple foods.

1.5 Purpose of the study

To establish appropriate sweetpotato postharvest handling practices for improved food and nutritional security.

1.6 Objectives

1.6.1 Main objective

To assess the postharvest practices and the physicochemical properties of roots of popular sweetpotato varieties in Kenya.

1.6.2 Specific objectives

1. To assess the current postharvest practices on sweetpotato roots in major producing counties of Homabay and Bungoma, Kenya.
2. To determine the physicochemical properties and flour pasting profiles of eight popular sweetpotato varieties.
3. To establish the effect of washing, packaging material and storage conditions on the physicochemical properties of sweetpotato roots of two popular varieties.

1.7 Hypotheses

1. Sweetpotato Postharvest practices in Bungoma and Homabay counties, Kenya are not appropriate.
2. Physicochemical properties of sweetpotato roots do not differ significantly with variety.
3. Washing, packaging material and storage conditions do not significantly affect the physicochemical properties of sweetpotato roots during storage.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The sweetpotato is a starchy tuberous perennial crop (Adeyemi and Salaam, 2015) though usually grown as an annual crop (Smith, 2012). Scientists believe that it originated in the Central America then introduced to Europe by the Spaniards, from where it spread throughout the world (Padda, 2006). It is believed to have arrived around the 20th century in Africa (Adeyemi and Salaam, 2015). It is currently grown more than any other root crop in developing countries (Andrade et al., 2009).

2.1.1 Distribution of sweetpotato in the world

Sweetpotato is grown in more than 110 countries of the world (Grüneberg et al., 2012). In developing countries, it is the 7th most important food crop (Oloo et al., 2014) based on total production and the fifth in economic value (Monjero, 2013). FAOSTAT data 2012 indicates that about 80% of the world's total production is from the Asian continent and about 18% from Africa. The major producing countries include China, Uganda, Indonesia, India and Japan (Sohail, 2013; FAO, 2010). In Africa, Uganda is the leading producer followed by Rwanda and Burundi (Ingabire and Vasanthakaalam, 2011).

2.1.2 Sweetpotato production in Kenya

Sweetpotato is cultivated in 43 of the 47 counties in Kenya. Figure 2.1 shows the five-year production trends (in tonnes) for sweetpotato in Kenya. Major production counties in the year 2014 in descending order were Bungoma, Homabay, Busia and Migori at 133,037 tons, 127,725 tons, 119,970 tons and 69,641.5 tons, respectively.

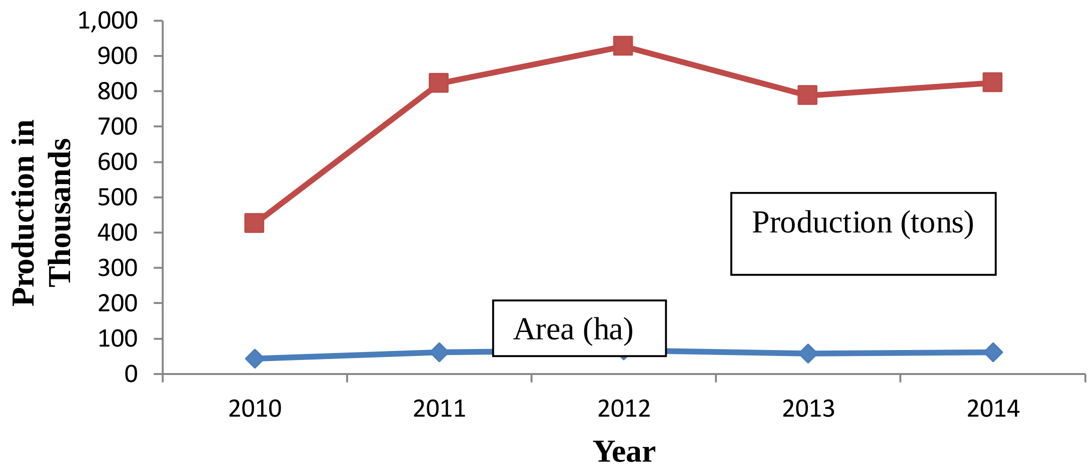


Figure 2.1: Sweetpotato 5year Production trends in Kenya

(Source: RoK, 2015; SDA 2014)

2.1.3 Sweetpotato economic value

The economic value of sweetpotatoes produced in Kenya for a period of five consecutive years is shown in Figure 2.2.

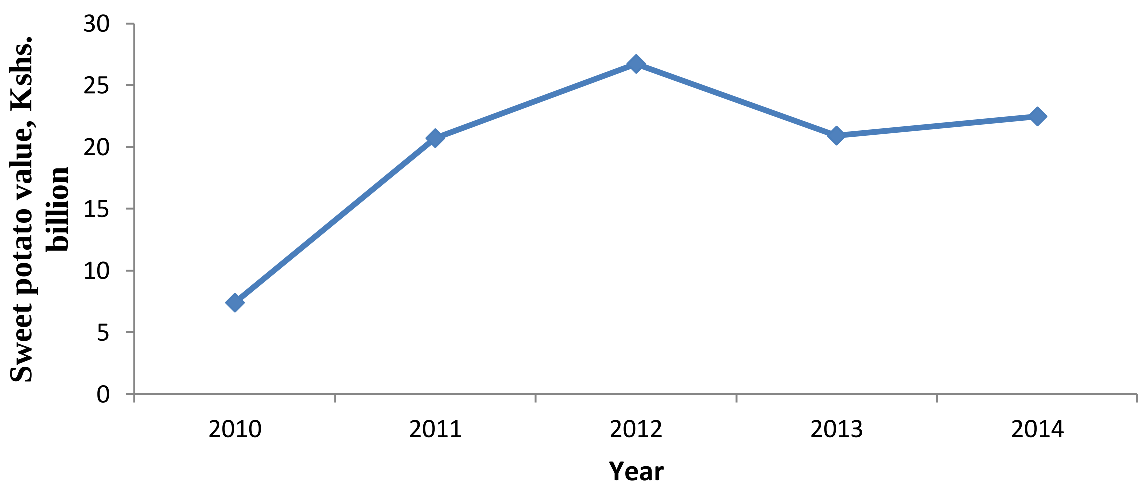


Figure 2.2: Sweetpotato 5year Economic Value Trends, Kenya

(Source: RoK, 2015; SDA 2014)

2.2.1 Harvesting sweetpotatoes

Harvesting usually begins 3-6 months after planting depending on variety (Kivuva et al., 2014). Many farmers in Kenya practice piecemeal harvesting (Kivuva et al., 2014) to allow for continuous longtime harvest, preserve vines for next planting and because of lack of ready market and unavailable modern facilities for storage of roots (Were et al., 2013). SP are however harvested once in large farms, sliced into chips and dried to prevent deterioration (Were et al., 2013). Harvesting of SP in Kenya has traditionally been done using blunt wooden sticks specially carved so as to minimize physical injury to the roots, especially for piecemeal harvesting. The roots are also dug up using hoes in wholesale harvesting for commercial purposes (Nyambok et al., 2011) or when there's need to plant a different crop or season (Were et al., 2013). It is difficult to collect data on piecemeal harvested sweetpotato (Wheatley and Loechl, 2008) hence not easy to quantify yields from the particular farms.

2.2.2 Postharvest losses

Post-harvest losses of fruits and vegetables before they reach the consumer are estimated to be between 30% and 40% (MoA, 2012). Quality and physical losses are usually a result of improper management of temperature, using packages with low quality, rough handling, and generally lack of knowledge on how to observe safety and quality of these roots by farmers, wholesalers and retailers (Kitinoja et al., 2010). The losses eventually lead to decreased market value, lower incomes for farmers and food safety worries (Kitinoja et al., 2010). Insufficient and poorly maintained transport and market infrastructure for handling food products in urban and rural areas has frequently resulted in high level of waste and spoilage (MoA, 2007). It could be more sustainable to reduce postharvest losses of mature produce than to increase production for compensation of the losses (Kitinoja et al., 2010). Losses occurring after harvest of sweetpotato are costly and impact negatively on food security and economic value. There is therefore need to establish the sources of these losses in Kenya for intervention measures.

2.2.3 Postharvest handling

2.2.3.1 Packaging

Sweetpotato is perishable and bulky to transport. Due to the fact that piecemeal harvesting is common in Kenya, most of the sweetpotato is packaged in baskets or sacks depending on the volume and distance of transportation. There have not been developed specific packaging technologies for sweetpotato in Kenya. Traders commonly pack the commodity in gunny bags / sacks which are susceptible to physical damage, attack from pests and microorganisms and to unfavorable environmental conditions especially during transport to longer destinations.

Use of poor-quality packages and rough handling are known to result in physical and quality losses (Kitinoja et al., 2010) at the producer, wholesaler, and retailer levels. In Uganda, the roots were roughly forced into excessively filled sacks with an extension so that a 100kg bag holds 120kg and brokers make extra profit at the farm gate price (Wheatley and Loechl, 2008; Hall et al., 1998). Appropriate packaging sacks and containers are required not only to facilitate safe transport of SP but also for storage of low volume produce and for product presentation at the markets. The role of packaging in SP is to protect the roots from undesirable weather conditions, facilitate other processes of storage, supply of the roots, marketing and safety in transportation.

2.2.3.2 Curing

Curing of the roots facilitates the healing of their harvest-incurred wounds and prolongs the postharvest life of the roots as well as reduces moisture loss and microbial decay during long-term storage (Padda, 2006; Picha, 1986).Curing also reduces shrinkage and minimizes weight loss during storage (Smith, 2012) as well as enhancing the eating quality by decreasing the starch content and increasing the sugar content.Cured, sweetpotatoes can be stored for several months and white fleshed varieties for as long as ten months (Hall et al., 1998). Traditional curing involved stacking potatoes in the field or garden, covering them with sand and leaving them for several weeks. Heat has been used in curing of sweetpotatoes in a constructed sweetpotato cellar where a smoky fire was made every day for three to four weeks (Cooley, 1951).

Curing sweetpotato can be done using several methods e.g. open air-sun, greenhouse solar, hot air cross flow, shade drying, vacuum-freeze drying, osmotic dehydration (Bechoff et al., 2008). Sub-Saharan Africa is known for high ambient temperatures (Hall and Devereau, 2000) thus, roots can possibly be left in the field after de-vining and before harvest in the hot, humid times of the year which is similar to the curing room environment (Smith, 2012). Prior pruning for wholesale harvesting can be done by removing sweetpotato canopy 14 days before harvesting (Nyambok et al., 2011). This Pre-harvest curing has been carried out in Tanzania by the Natural Research Institute (NRI) and resulted in reduction of postharvest losses by up to 40% (Wheatley and Loechl, 2008; RIU,2007). In Uganda and Tanzania, sun drying has been used to dry sweetpotato to extend shelf- life for up to six months (Hall et al., 1998).

Different curing regimes are applied in commercial production; sweetpotatoes can be cured in rooms with humidity of 75 – 80% and temperatures between 27^{O}C and 30^{O}C for a week to ten days (Cooley, 1951) or conducted at 29^{o}C with high humidity for 4-7 days prior to storing at 12-14^{o}C in the U.S. (Kembie, 2004). The roots can be put into storage at 30-32°C and 90-95% relative humidity for 4 to 10 days (Smith, 2012) after which the temperature is dropped to 15.6°C for long term storage, keeping the same relative humidity.

There currently exist no documented information on curing of sweetpotato if practiced in Kenya, the extent/scale and conditions are not known hence the proposed study.

2.2.3.3 Storage

Storage of fresh sweetpotato roots for more than 3 months is difficult (Tomlins et al., 2007). The roots are highly perishable when not stored in favourable conditions because of their high moisture content, especially the orange fleshed cultivars (Wheatley and Loechl, 2008). Sweetpotatoes need to be stored for up to a year in order to sustainably supply and maintain their markets (Tomlins et al., 2007); however, with limited resources and sweetpotato being a crop of marginal value, storage is uncommon practice in developing countries (Tomlins et al., 2007).

Origin of storage of sweetpotato can be traced to the Maoris of New Zealand who used well constructed underground houses dug in the side of a hill. The sweetpotatoes were then stored and the houses tightly closed. Due to the respiratory activity of the potatoes themselves, high relative humidity and a comparatively high temperature would soon develop (Cooley, 1951).

Use of good quality roots free of damage, and disease, not lining the stores with grass and avoiding temperature build-up in the stores are the main factors that improve storability of fresh sweetpotato under tropical conditions (Tomlins et al., 2007; Oirschot et al., 2007). Roots can be left in mounts and harvested piecemeal or can be harvested and stored in a pit or clamp stores on a bed of dry grass (Nyambok et al., 2011). Sweetpotatoes can be stored in pits, saw dust or dark rooms (Tumuhimbise et al., 2010). In Tanzania, low cost storage pits and clamps with thatched roofs can store roots up to four months (Wheatley and Loechl, 2008; RIV 2007). Information on Sweetpotato storage in Kenya is not easily available. Between 68% and 90% of farmers in western Kenya districts did not know how to store surplus of sweetpotato roots (Were et al., 2013). Lack of commodity stores for sweetpotato also hinders production and value chain sustainability.

Storage under tropical conditions has been shown not to affect the overall quality in OFSP (Quirien et al, 2002). The pVAC retention of staple crops during storage reached levels as low as 20% after

1-4 months of storage and was highly dependent on genotype (De Moura et. al, 2013). Starch is usually broken down into sugars by the endogenous enzymes in sweetpotatoes during storage (Nabubuya et al., 2012). An experimental study by Tumuhimbise et al., (2010) in Uganda showed that storage of roots of Ejumula and SPK004/6/6 in a pit at (17-21^{o}C, RH 90) exhibited higher levels of retention of beta carotene compared to those stored in a dark room, saw dust and at ambient conditions, though generally SPK004/6/6 had lower beta carotene levels than Ejumula.

2.2.3.4 Utilization of sweetpotato

Fresh sweetpotato roots need to be consumed within afew weeks once harvested otherwise be processed into various products(Akissoe*et al*., 2003)since they are very sensitive to microbial spoilage, even at refrigerated conditions (Xiao *etal*., 2009)because of their high moisture content.Utilization has for a long time been limited to their traditional uses (Sohail et al., 2013), yet there's tremendous potential of being utilized as food, animal feed and for industrial products (Thottappilly and Loebenstein 2009; Gregory, 1992).They are mainly used as human food; roots are mainly consumed boiled or sometimes fried (Ingabire and Vasanthakaalam, 2011). According to the country's Economic Survey 2015 report by the Kenya National Bureau of Statistics (KNBS), 90% of sweetpotato roots in Kenya are utilized domestically as human food.

2.2.3.5 Consumption of sweetpotatoes

The world average per capita consumption of sweetpotato was recorded as 7.97kg, 8.01kg, and 8.22kg for the years 2011, 2010 and 2009 respectively (FAOSTAT, 2014). Per capita consumption is 90 – 100kg in Uganda and 100 – 300kg in Rwanda (Ingabire and Vasanthakaalam, 2011; Ewell, P.T., 1991) while Kenya has an average of 24kg per year (Were et al., 2013; Scott and Ewell, 1992). There has been increasing consumption of sweetpotato in Kenya, consumption in 2014 being placed at 1,035,000 tons (RoK, 2015).

2.2.3.6 Processing sweetpotatoes

Development of low and intermediate technologies that will process sweetpotato into value added products at the household and village factory levels would promote its production and consumption and increase its economic value (Sohail et al., 2013).Sweetpotatoes have been used in brewing of alcoholic beverages and the roots have the potential to be processed commercially into various products including fried chips, snacks (crisps, potato flakes, potato granules) and starch (Adeyemi and Salaam, 2015). Low level Sweetpotato processing in rural areas of Kenya is mainly done by women/ community group members who have been trained on the simple processing techniques by the home economics officers and make products like flour, porridge, breads, crisps, cakes,Juice, chips and 'Bhajia' (Were et al., 2013).In general the production volume of SP in Kenya is too low to support sustained supply of raw sweetpotatoes for use in industrial large scale processing (FAOSTAT, 2009; MoA, 2012), thus processing by community groups is limited to seasons (3 months in a year) when sweetpotatoes are available (Were et al., 2013). There are however, scanty national data on the level of processing, number of processors of sweetpotato, sweetpotato volumes processed and profit margins for the processors (Were et al., 2013). This study thus seeks to establish the levels of processing, products, frequency and suitability of sweetpotato varieties for processing.

2.2.3.7 Marketing of sweetpotatoes

Practically, below 20% of sweetpotato produced is traded and accessed by both rural and urban markets (Andrade et al., 2014) since sweetpotato is mainly produced by smallholders (the majority of whom are women) who do it primarily on subsistence level such that market supply will depend on the availability of the surplus within the households (MoA, 2010; Wheatley and Loechl, 2008). About 40% - 60% of the sweetpotato produce in some parts of western Kenya is marketed (Were et al., 2013). Kenyan grown sweetpotatoes are usually in the domestic markets from late September to

February (USAID- KHCP, 2012). Locally processed products from community groups are sold to local market shops and supermarkets (Were et al., 2013). There is therefore need to establish how marketing of sweetpotato products is carried out in Kenya and the challenges encountered.

There are no recorded exports of sweetpotato and its products by Kenya according to the Economic survey report of 2015 by the KNBS. However, Sweetpotato roots are usually imported into Kenya from Tanzania by wholesalers between June and August, periods of scarcity (USAID- KHCP, 2012).

2.3 Physicochemical and Nutritional Traits of SweetpotatoVarieties

2.3.1 Physical traits of sweetpotatoes

Sweetpotato roots vary enormously in size, shape, weight and color, although all are smooth-skinned. Shapes vary from spindle to oval (Aina et al., 2009). Sweetpotato flesh can be white, orange, yellow, purple, red, pink and violet (Thottappilly and Loebenstein, 2009) while skin color varies among white, yellow, red, orange and purple (Ingabire and Vasanthakaalam, 2011).

2.3.2 Nutritional aspects of sweetpotatoes

Sweetpotato (SP) is best known for its carbohydrate content, predominantly being starch (Adeyemi and Salaam, 2015) and is a good source of dietary fiber (Vimala et al., 2011). SP is a good source of vitamin C (ascorbic acid) and proteins (Kivuva et al., 2014). They contain assorted phytochemicals like carotenoids (Adeyemi and Salaam, 2015; Downey 2002).Roots have also been reported to contain antioxidants (Burri, 2011; Teow et al., 2007) and minerals (sodium, zinc, calcium,iron,potassium, manganese and magnesium) (Burri 2011; Antia et al., 2006).The orange fleshed and yellow fleshed cultivars have shown high carotenoids content (Adeyemi and Salaam, 2015; FAO 2002) particularly important in combating VAD in SSA (Low et al., 2007).White flesh and pale yellow varieties have very little or no beta-carotene compared to those with orange,pink or redflesh (Thottappilly and Loebenstein,2009).The purple sweetpotato color is a rich source of acetylated anthocyanins which have been demonstrated to quench free production of radicals and hence offer for galactosemia therapy (Timson, 2014).

2.3.3 Proximate composition of sweetpotatoes

2.3.3.1 Dry matter

Sweetpotato roots are known to have relatively low dry matter (DM) contents between 13.8% to 48.3% (Wheatley and Loechl, 2008), which widely vary due to factors like location, cultivar, climate, soil and cultivation practices (Ingabire and Vasanthakaalam, 2011; Woolfe, A. J., 1992).The acceptable level of storage root DM is lower in Southern than in East Africa; about 27% versus 30% respectively (Wheatley and Loechl, 2008).Low DM of most of orange fleshed SP varieties is a challenge towards their adoption and production by farmers (Rukundo et al., 2013; Mwanga et al., 2010; Flores et al., 2010).Higher DM levels are reported in pale yellow and white fleshed varieties meaning that they stay firmer when cooked and their textures are drier and mealier than those with pink,red and orange flesh (Thottappilly and Loebenstein, 2009).

2.3.3.2 Carbohydrates

Sweetpotato roots are said to contain about 10-30% carbohydrates (Nyambok et al., 2011) which constitute 80 – 90% of the dry weight with starch being the most abundant constituent of the roots dry matter content constituting 50-80% (Nabubuya et al., 2012). Carbohydrate contents have ranged from 23.91 to 41.46g/100g (dwb) in six SP varieties in Tanzania (Lyimo et al., 2010) and 26.84% for Jewel variety (OFSP) in Nigeria (Adepoju and Adejumo, 2015).

2.3.3.3 Crude protein

Average total protein of SP roots is usually low at 1.5% (fwb) and 5% dry weight basis (Ingabire and Vasanthakaalam, 2011; Woolfe, A. J., 1992) with most varieties ranging 1-3% (Nyambok et al., 2011). Some varieties have yielded high protein contents of sweetpotato roots ranging from1.0% to 9.0%, respectively (Bovell-Benjamin, 2007). A study on Rwandan four varieties showed protein content of less than 1% (Ingabire and Vasanthakaalam, 2011); Six Tanzanian SP varieties had protein contents ranging 1.44 – 2.50g/100g dry weight basis (Lyimo et al., 2010) while deep OFSP in Kenya were found to contain about 3.5% - 9.5% DM protein (Kivuva et al., 2014).

2.3.3.4 Crude fibre

Dietary fibre is said to be important in reducing the incidences of colon cancer, diabetes, cardiovascular diseases and certain digestive diseases. SP usually contain 2-3% crude fibre (Nyambok et al., 2007). Total fibre content in roots of eighteen varieties of SP in Hawaii were found to be in the range 2.01 to 3.87g/100g fresh weight basis (Ingabire and Vasanthakaalam, 2011; Huang et al., 1999). Jewel OFSP variety in Nigeria showed 1% fibre content (Adepoju and Adejumo, 2015). Three OFSP varieties studied in Kenya (Oloo et al., 2014) had dietary fibre contents of 2.56%, 3.54% and 3.52% for Zappallo, Nyathiodiewo and SPK004/6 respectively.

2.3.3.5 Crude fat

Sweetpotato roots contain minimal fat (0- 1%) (Nyambok et al., 2011). A study on six Tanzanian SP varieties showed a range of 0.03 – 0.95g/100g (Lyimo et al., 2010) while three OFSP varieties Zapallo, Nyathiodiewo and SPK004/6 in Kenya showed fat contents of 2.10%, 3.21% and 3.16% respectively (Oloo et al., 2014). Crude fat is thus very minimal in both SP roots.

2.3.3.6 Minerals

Sweetpotato roots contain various mineral elements whose concentration depends on cultivar, location and agronomical conditions. A study on roots of four Rwandan varieties showed the content of minerals range from 0.4% to 0.44% (Ingabire and Vasanthakaalam, 2011).Deep OFSP were found rich in Fe (50ppm DM) and Zn (40ppm DM) (Kivuva et al., 2014).Cultivars grown in Vihiga county Kenya showed Iron content ranges of 1.10- 1.30mg/100g, 1.28 – 1.30mg/100g, 1.03 – 1.28mg/100g and 1.28 – 1.40mg/100g for white, purple, yellow and orange flesh cultivars respectively and calcium ranges of 25.30 – 26.0mg/100g, 18.50 – 24.43mg/100g, 24.75 – 27.35mg/100g and 21.28 – 24.31mg/100g for white, purple, yellow and orange flesh cultivars respectively (Aywa et al., 2013). Potassium 200 to 300mg/100g, calcium 11mg/100g and 0.8mg/100g iron contents have also been reported (Kivuva 2014; Stathers et al., 2005; Califikan et al., 2007).

2.3.4 Non-Proximate properties of sweetpotatoes

2.3.4.1 Reducing sugars

Sucrose is the most abundant sugar in raw SP roots with smaller amounts of glucose and fructose (Ingabire and Vasanthakaalam, 2011; Bouwkamp, 1985). Some starch usually gets converted to reducing sugars during storage of roots (Ingabire and Vasanthakaalam, 2011; Salunke and Kadam, 1998). During processing, maillard's reactions occur at high temperature frying between reducing sugars and amino acids resulting in dark-colored products with bitter tastes (Pedreschi et al., 2007). Besides, during long time frying at high temperature, acrylamide formation is inevitable due to the reducing sugars and asparagines concentration in the roots (Taiwo et al., 2007). The south Pacific region cultivars have exhibited total sugars ranging from 0.38% - 5.64% (fresh weight basis) while the American cultivars from 2.9% - 5.5%(fresh weight basis) depending on harvest time (Ingabire and Vasanthakaalam, 2011; Woolfe, 1992).A study on four varieties of SP in Rwanda showed the content of reducing sugars to range from 1.74% to 2.5% (Ingabire and Vasanthakaalam, 2011).It is suggested that the acceptable upper limit of reducing sugars content to obtain acceptable processing color is 0.25-0.5% of fresh weight (Pedreschi et al., 2007).Roots are still considered acceptable for processing if the reducing sugars do not exceed 2% on dry weight basis (Truong and Avula, 2010; van Hal, 2000).

2.3.4.2 Carotenoids

Carotenoids have several health-promoting effects: enhancing immunity and reducing the risk of developing degenerative diseases like cataract,cancer, mascular degeneration and cardiovascular diseases (Carvalho et al., 2012).The orange-and red-fleshed cultivars of sweetpotato are particularly high in beta-carotene, the vitamin A precursor (Low et al., 2007).Some studies on raw peeled roots of Kenyan OFSP varieties have yielded beta carotene content between 1240 and 10,800µg/100g fresh weight (Kidmose et al., 2007).Beta carotene content has been known to vary depending on cultivar and environmental conditions of the location where they are grown (Niringiye et al., 2014).

2.3.4.3 Vitamin C

Vitamin C, also referred to as ascorbic acid is a very essential nutrient required daily in the human body for antioxidant activites and has been found to be vital in enhancing of the bioavailability of non-haeme iron in the body (Abong' et al., 2011). Sweetpotatoes have shown to harbor some considerable amounts of this Vitamin. Some studies (Oloo et al., 2014), have reported vitamin C levels ranging from 0.28m/100g to 0.34mg/100g in three varieties of sweetpotato in Kenya. Two varieties in Sudan recorded 60.08mg/100g and 65.70mg/100g of Vitamin C levels (Abdel G. and Abdel R. (2012). Degradation of this vitamin can however, occur rapidly during storage (Sapei and Hwa, 2014). For instance, the reduction seen in an experiment after 5months from harvest in sweetpotato roots (Dandago et al., 2014). During food processing and storage, ascorbic acid is generally used as an indicator of nutrient quality such that its retention gives an indication of retention of other nutrients too (Sapei and Hwa, 2014).

2.3.4.4 Sweetpotato starch

Starch is a useful ingredient in both food and non-food applications (pharmaceutical, paper, plastic and textile industries) (Oladebeye et al., 2009). As a major food ingredient, both in native or modified forms (Adebowale et al., 2011), starch is widely used as a thickener, a gelling agent, a bulking agent and a water retention agent (Li et al., 2014). Sweetpotato roots are rich in starch 6.9 – 30% wet basis or 50 – 80% dry basis (Lase et al., 2013; Chen et al., 2003; Aprianita et al., 2009; Zhu et al., 2011). Starch from sweetpotato is more free swelling and non-congealing besides, it exhibits a Type A Brabender amylograph characterized by a high pasting peak followed by rapid and major thinning on cooling (Lase et al., 2013; Collado et al., 2001). It is therefore not suitable for utilization in products like starch noodles requiring starches with faster retrogredation rates (Lase et al., 2013). OFSP flours have exhibited high pasting peaks and rapid thinning (Nabubuya et al., 2012). High starch viscosity indicates good quality starch while low viscosity could imply some degree of degradation of starch during processing (Dzogbefia et al., 2008).

2.3.4.5 Pasting characteristics of flour from different SP varieties

Pasting properties of SP flour indicate the extent of molecular degradation / changes and degree of paste viscosity and stability of starch (Avula, 2005). These properties include peak viscosity (PV), hot paste viscosity (HPV), cold paste viscosity (CPV), breakdown viscosity (BD) and setback viscosity (SB) (Avula, 2005).

Pasting profiles of flours of 10 sweetpotato varieties ranged as follows: Pasting time (min) 3.7$\pm$ 0.27 to 4.7$\pm$ 0.25, Pasting temperature (^{o}C) 70.4+ 0.19 to 84.2+ 2.52, PV (RVU) 826+ 5.51 to 3039+ 3.06, Trough viscosity (RVU) 1.59+ 3.00 to 1064+ 34.0, final viscosity (RVU) 179+ 4.51 to 1656+ 3.5, breakdown viscosity (RVU) 579+ 2.89 to 2072 + 4.62 and Setback viscosity (RVU) 62 + 1.54 to 865 + 24.79 (Nabubuya et al., 2012). Some varieties have shown higher values like

PV 13408 + 74.95, Trough viscosity 3284 + 648.42, final viscosity 4933, breakdown viscosity 16123.50± 30.89 and SB 1649±579.83 (Eke-Ejiofor, 2015).

There is a great likelihood that the many cultivars of SP produced by farmers in Kenya could be inherently different in their physicochemical and resultant functional properties, thus the need for their characterization.

2.4 Knowledge gaps

There exists insufficient data on postharvest practices like curing, storage, processing and market information on sweetpotato roots in Kenya. There have not yet been enough studies on characterization of the chemical properties of the several Kenyan cultivars of sweetpotato roots for maximum utilization and functionality in food processing. Besides, there is lack of knowledge on conditions suitable for storage of sweetpotatoes in Kenya.

CHAPTER THREE:

POSTHARVEST HANDLING PRACTICES OF SWEETPOTATO IN KENYA: A CASE OF BUNGOMA AND HOMABAY COUNTIES

3.1 Abstract

Postharvest losses in sweetpotato can occur due to poor handling practices and inadequate knowledge on maintaining quality and safety of the roots by handlers across the value chain. This study involved assessment of postharvest handling practices of sweetpotato in Bungoma and Homabay Counties, Kenya. A survey was carried out between November 2015 and February 2016, structured questionnaires were administered to a total of 165 respondents comprising 96farmers, 64 traders and 5 processors drawn from two constituencies of each of the Counties. Four key informants were also interviewed. Results showed that 68%, 87% and 40% of sweetpotato farmers, traders and processors respectively, were women. Iron bars and wooden sticks were used in piecemeal harvesting while hoes ('jembes') and ox-ploughs were used in wholesale harvesting of roots. Informal marketing systems that quantified roots using bags, buckets and heaps were prevalent. Motorcycles, donkeys, bicycles, public service vehicles, foot and cart were used by 26%, 21%, 11%, 8%, 7% and 6% respectively to transport roots to the markets. Storage was rarely practiced by 43% of farmers and 45% of traders. Root curing was not common. Processed products included flour, puree and dried chips. High perishability and unreliable supply of roots were major challenges indicated. Establishment of storage facilities, promotion of processing opportunities as well as formulation and enactment of a comprehensive sweetpotato policy could move this industry to commercial level. There is need for collective action by policy makers and other stakeholders to address the challenges noted to ensure reduction of postharvest losses for food security and better incomes.

Key words: Sweetpotato, postharvest, Homabay, Bungoma, farmers, traders, processors

3.2 Introduction

Sweetpotato (*Ipomea batatas*) ranks fifth in Kenya among the major staple crops, though its commercial potential is underexploited. The crop has been shown to be adaptable to various Agro Ecological Zones (AEZ) (Mukras et al., 2013). Sweetpotato cultivation happens in 43 of the 47 Kenyan Counties with leading counties in production for year 2014 being Bungoma, Homabay, Busia and Migori in that order at 133037, 127725, 119970 and 69642tonnes, respectively (RoK, 2015). Production occurs mainly on subsistence level for food security though the surplus of 40% to 60% is sold on need basis to supplement income for the family (Were at al., 2013). Typically, sweetpotato is cultivated mainly by smallholder farmers, women being the majority (MoA, 2010; Andrade et al., 2009). Kenyan grown sweetpotatoes are normally in plenty supply within the local markets towards end of September to February. Importation of the roots by wholesalers does occur from Tanzania from June to August, during the period when they are scarce in Kenya (Mohammed, 2013). Kenya has various sweetpotato marketing systems that are dominated by women (Mukras et al., 2013; Rono et al., 2006), running parallel with forward linkages from the villages. Village retail markets sell small quantities in heaps usually supplied from small surpluses of farmers (Mukras et al., 2013; FAOSTAT 2009). Postharvest losses in sweetpotato roots are largely caused by improper handling and lack of knowledge generally regarding proper handling of these perishables at the farmer, wholesale and retailing levels (Kitinoja et al., 2010). In a study in Uganda, the roots were noted overfilled in sacks meant for 100kg extended to hold 120kg such that middlemen would benefit at the expense of farmers (Andrade et al., 2009; Hall et al., 1998). Poor handling, storage and transportation can result in roots with a shorter shelf life (3 weeks) and poor quality characteristics (Chang et al., 2008). Losses while transporting to distant markets can be high and have resulted in about 30-50% of roots being unsalable on arrival at the markets in Papua New Guinea due to rots and/or physical damage (Chang et al., 2008).

Fresh agricultural produce loss in Kenya estimates fall between 30 and 40% (MoA 2010) and is mainly attributed to inappropriate postharvest handling technology and practices where the critical loss points are at harvest, transportation and storage. Besides, both rural and urban areas experience insufficient and very poorly maintained transport and market infrastructure for handling food commodities resulting in high level of wastage and spoilage (MoA 2012). These factors widely contribute to lower production, harvesting at piecemeal and low commercial value of the sweetpotato (Kivuva et al., 2014). Though the challenges from production to postharvest handling are numerous, sweetpotato still contributed about USD 23 billion to Kenya's gross domestic product (GDP) (RoK 2015). In order to understand the unexploited potential of this crop for food and nutritional security and for generating income, it is needful that an assessment be carried out on postharvest practices by handlers to identify the challenges for intervention by relevant stakeholders. Losses that occur after the harvesting of sweetpotato can be costly and negatively impact food security as well as on economic status. Reducing postharvest losses of these roots can be more sustainable than increasing production to counter the losses (Kitinoja et al., 2010). Lack of information on the sweetpotato market structure and performance is a constraint to the development of the sweetpotato industry (Mukras et al., 2013). There was therefore a need to establish and document information on sweetpotato handling in Kenya as a guide to address the weak areas in the forward and backward linkages.

3.3 Materials and Methods

3.3.1 Study area

The current study was carried out in Bungoma and Homabay counties between November 2015 and February 2016. Homabay lies within latitudes 0º15'S and 0º52'S and longitudes: 34°E-35°E with an elevation of about 1225m above sea level (Jaetzold et al., 2006). The county covers an approximate area of 4,267.1km^2 with a population of about 963,794 within 206,255 households (Fernandez-Stark et al., 2011). Arable land area is approximately 89.3% (Jaetzold et al., 2006). The area experiences rainfall between March and April for long rains and from September to December for short rains averaging between 1000 to 1250 mm annualy (Jaetzold et al., 2006). Semi-subsistence farming is a common practice amongst many of the farmers. Main crops grown in the county are maize, beans, sweetpotatoes, sorghum, peas, millet, kales, sugar cane, sunflower and pineapples as reported in the Homabay county government Integrated Development Plan of 2013-2017.The county has eight administrative constituencies.

Bungoma lies within 0º35'N and 34º34'E with an elevation of between 1300 and 2073 m above sea level. The County has an approximate area of 3000km^2 and a population of 1,361,390 persons within 260,628 households (Fernandez-Stark et al., 2011). Land with agricultural potential is estimated at 88.8% (183,800 ha) (Jaetzold et al., 2006). The county receives bimodal adequately distributed annual rainfall in the range of 1000 to 1800mm (Jaetzold et al., 2006). Long rains fall from March to July while short rains fall from August to October. Semi-subsistence agriculture is common too with main crops being Maize, beans, Sunflower, potatoes, Sugarcane, Coffee, Tobacco and cotton. The county has nine administrative constituencies.

3.3.2 Sampling procedure and data collection

Purposive sampling was used to select Bungoma and Homabay counties. Bumula and Kanduyi constituencies (Bungoma) as well as Kasipul and Kabondo/Kasipiul constituencies (Homabay) were purposively sampled as the leading constituencies in sweetpotato production (RoK 2015). Sweetpotato farmers were identified from these four constituencies but spread across the villages with the help of the field guides who resided in the localities. Sweetpotato traders were identified and interviewed at the main markets, trading centers and along the main roads. Sweetpotato processors were exhaustively identified by snowball sampling technique. Structured questionnaires were prepared and pre-tested before they were administered to the respondents by the research team which comprised the principal researcher together with trained research assistants who included the field guides. In case of language barrier, the research team members who understood the local languages were asked to interview the specific respondents. Individual farmers were interviewed. A Focused Group Discussion (FGD) of at least12 farmers was also conducted in each county. One key informant from the agriculture extension department in each constituency was also interviewed. Data on socio-demographics, sweetpotato varieties, harvesting, postharvest practices (sorting and grading, curing, drying, consumption, transportation, storage, processing and marketing) and general challenges were obtained. A total of 169 respondents comprising 96 farmers, 64 traders, 5 processors and 4 key informants were interviewed in addition to two focused group discussions with farmers. The numbers of farmers and traders were derived using the Fisher's (1981) formula, **n** (sample size) = $\mathbf{Z^2pq/e^2}$ (Z^2(confidence Interval) = 1.96^2, P (the probability of finding sweetpotato farmers and traders) =0.9, q (1-p) = 0.1 and e^2(the margin of error) = 0.05^2. Processors were exhaustively sampled. Key informants were purposively sampled from among the agriculture extension officers. Observations on postharvest practices by the handlers were also made by the researcher.

3.3.3 Data Analysis

The data collected were analyzed using the statistical Package for Social Scientists (IBM SPSS Statistics version 20). Frequencies were displayed as percentages comparing the two counties studied as shown in the results section.

3.4 Results and Discussion

The findings of the current study are displayed in bar graphs, tables and figures. Error bars on the bar graphs in the results indicate the standard error of means.

3.4.1 Socio-demographic characteristics of respondents in Bungoma and Homabay counties

3.4.1.1 Gender distribution

Majority (68%) of the farmers interviewed were women (Figure 3.1) out of which 75% of the total interviewed were married and living with their spouses. It can be assumed that either some of the men were employed elsewhere, the reason they were not available for interview or sweetpotato was perceived as a woman's crop especially in Bungoma County. It has been cited elsewhere (Andrade et al., 2009) that non-commercial production of sweetpotato was mainly under the control of women.

Majority of the traders (87%) interviewed were also women (Figure 3.2). The dominance of women may be a possible indicator of the low income returns from the crop and cultural perceptions towards the sweetpotato being viewed as a feminine crop as explained by the agricultural extension officers.

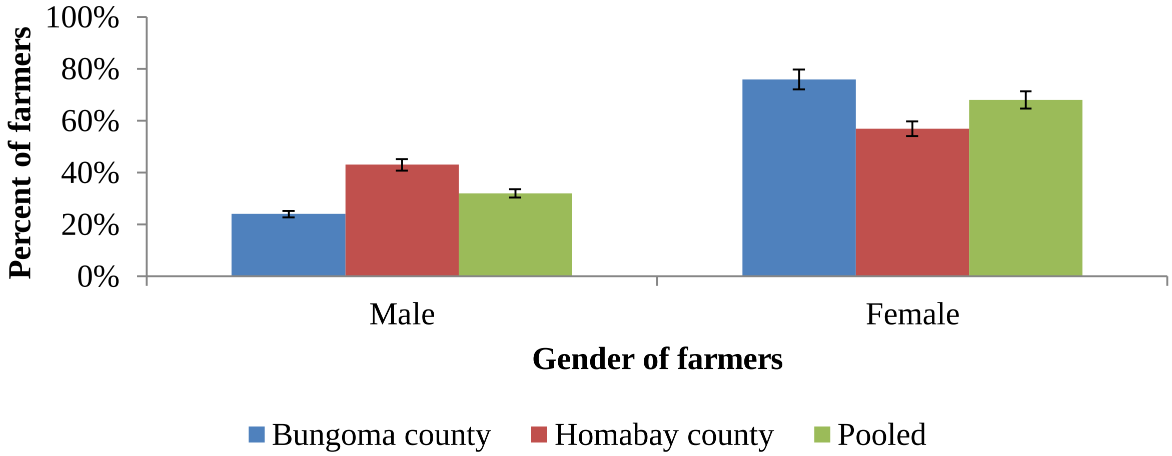


Figure 3. 1: Gender of sweetpotato farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means.

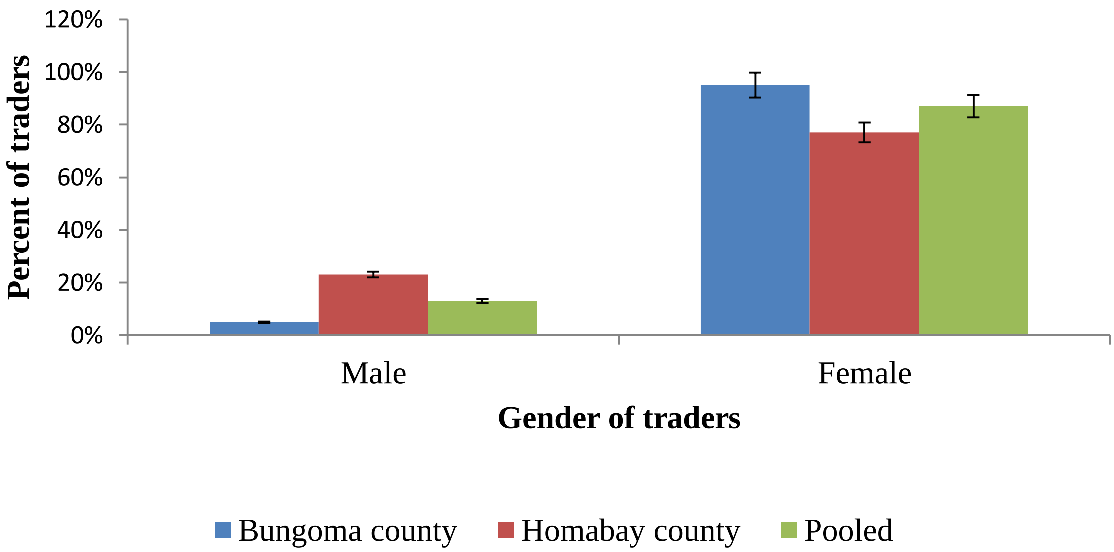


Figure 3. 2: Gender of sweetpotato traders in Bungoma and Homabay Counties. The bars indicate the standard error of means.

A total of five processors were interviewed. The numbers of processors were very few probably because sweetpotato processing is less developed in Kenya. Probably lack of knowledge and skills in sweetpotato processing could be one of the reasons for low processing. The involvement of women (67%) in sweetpotato processing was higher than men (33%) in Bungoma County while only men (100%) were involved in the same in Homabay County (Figure 3.3). This can be attributed to the scale of processing and nature of products. A previous study noted that sweetpotato processing in the villages in western Kenya was mainly carried out by members of women groups after being trained on value addition by home economics officers of the Ministry of Agriculture (Were et al., 2013). The role of women in the sweetpotato value chain should therefore not be underestimated since they are actively involved in all the areas along the value chain. This is similar to an earlier study finding that women were dominantly involved in the sweetpotato marketing systems (Mukras et al., 2013).

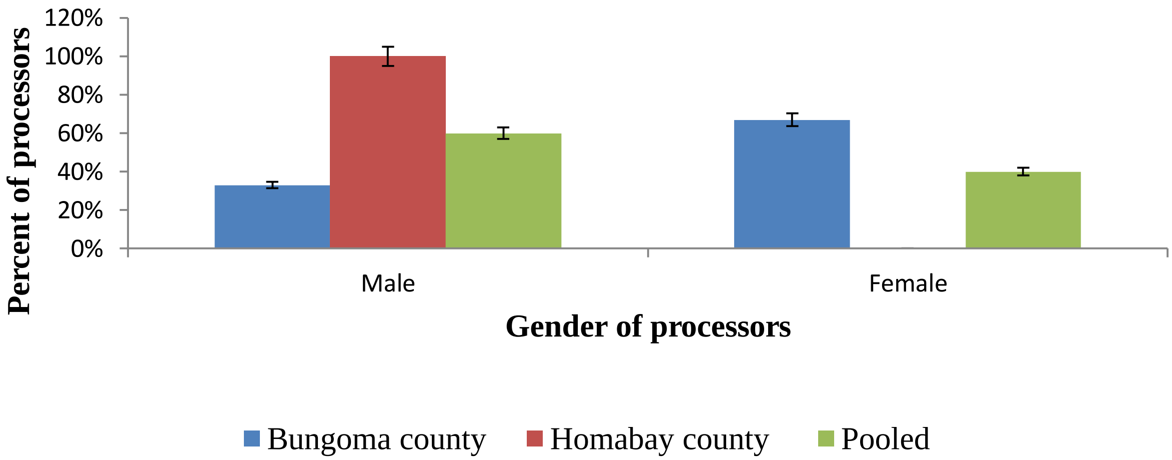


Figure 3.3: Gender of sweetpotato processors in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.1.2 Age distribution

Figures 3.4, 3.5 and 3.6 show the age distribution of the study farmers, traders and processors respectively. There was more youth (18-35 years) involvement in trading (37%) compared to farming (24%) and processing (20%). It is common knowledge in Kenya that most of the youth do not own land since family lands especially in rural areas are ancestral thus the discretion of being apportioned ownership usually lies with the parents. This has also been reported in a different study, that many of the farmers used family land which is usually not yet subdivided to persons aged between 15 and 35 years (Were at al., 2013). At ages 36-45years there was peak involvement in farming, trading and processing sweetpotato and this diminished as age increased from 46 years. This indicates that sweetpotato has the potential to offer employment opportunities to the most productive age groups of the population especially in rural areas.

All sweetpotato processors were aged above 30years (Figure 3.6), at which point most people in Kenya have completed tertiary education and have had some work experience hence have high possibility of possessing skills and some capital for starting up business ventures.

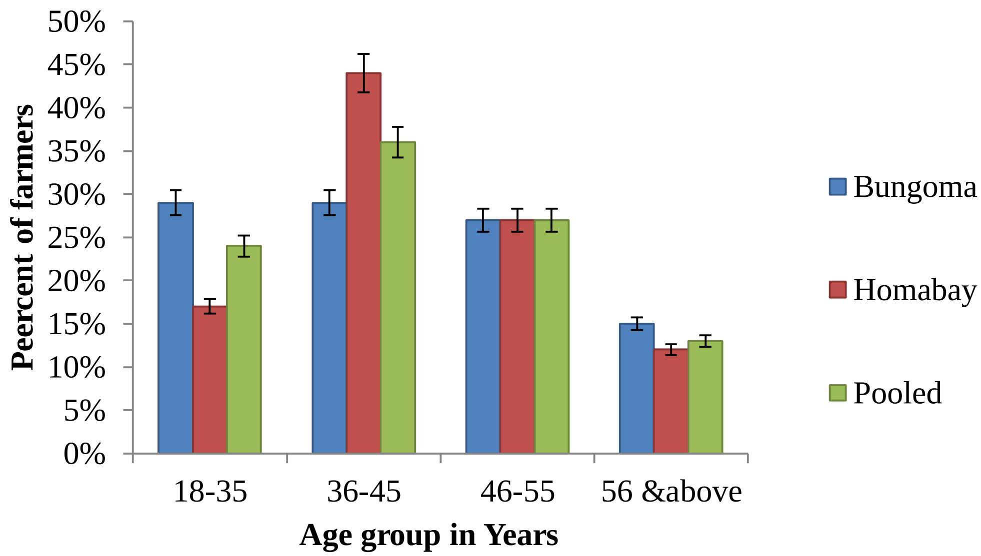


Figure 3. 4: Age group (years) of sweetpotato farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means.

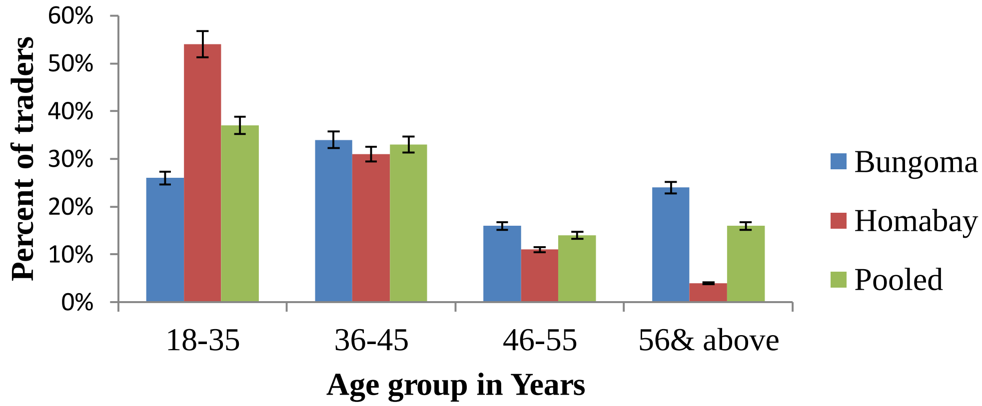


Figure 3. 5: Age group (years) of sweetpotato traders in Bungoma and Homabay Counties. The bars indicate the standard error of means.

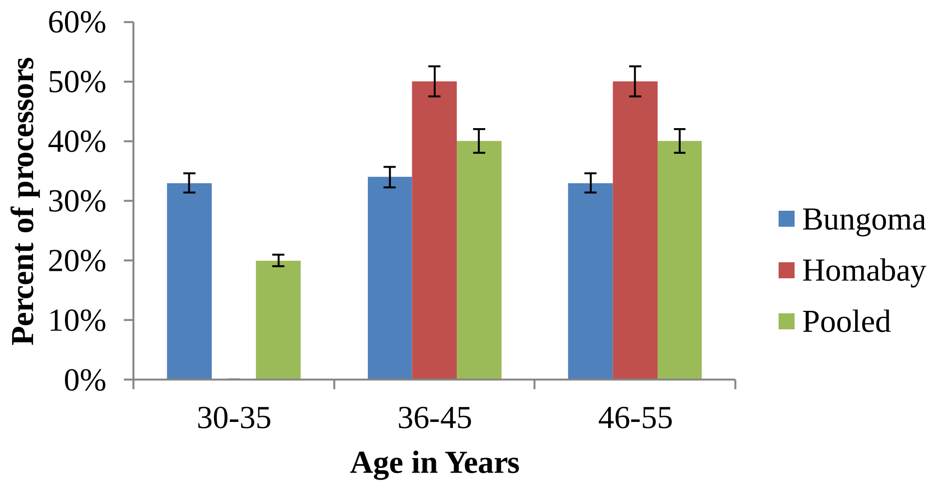


Figure 3. 6: Age group (years) of sweetpotato processors in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.1.3 Education

Literacy levels were generally high among the farmers, traders and processors (Figures 3.7, 3.8 and 3.9 respectively) implying that there was ease of comprehension of ideas during the interviews thus saving on time that would have been used for translation. It is highly unlikely that college graduates will be involved in sweetpotato farming and trading in the rural areas as noted by the status of 89% of farmers who were of primary and secondary school level while 67% and 23% of traders were holders of primary and secondary school education, respectively. This may be perceived to mean that the crop gives minimal returns thus college graduates would opt to be employed elsewhere in urban towns. Processing was likely to be undertaken by people with tertiary education since advanced skills are required. This agrees with the observations of other authors (Mukhtar et al., 2010).

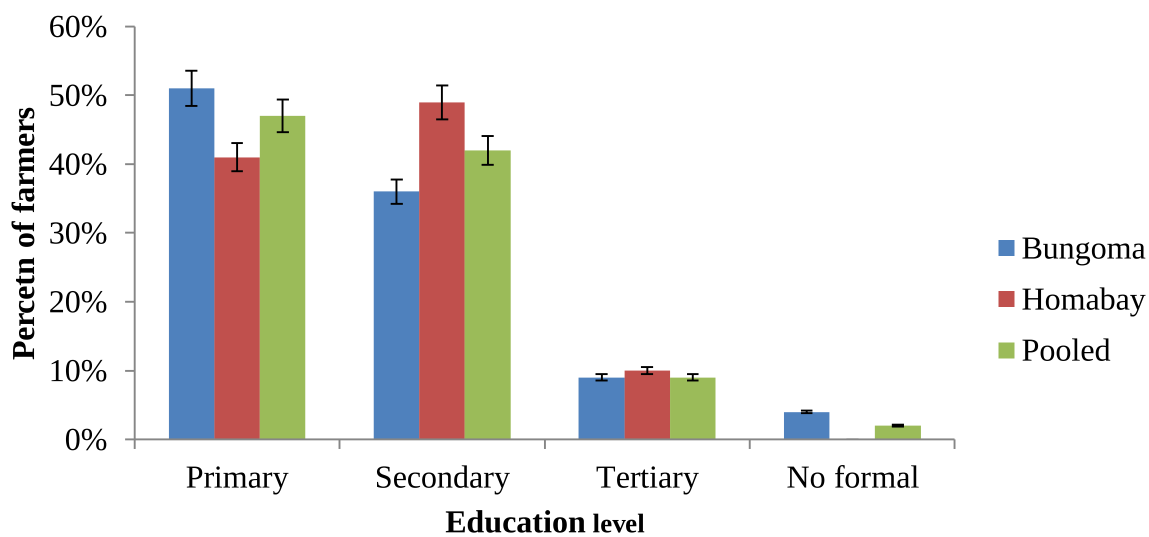


Figure 3. 7: Education level of sweetpotato farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

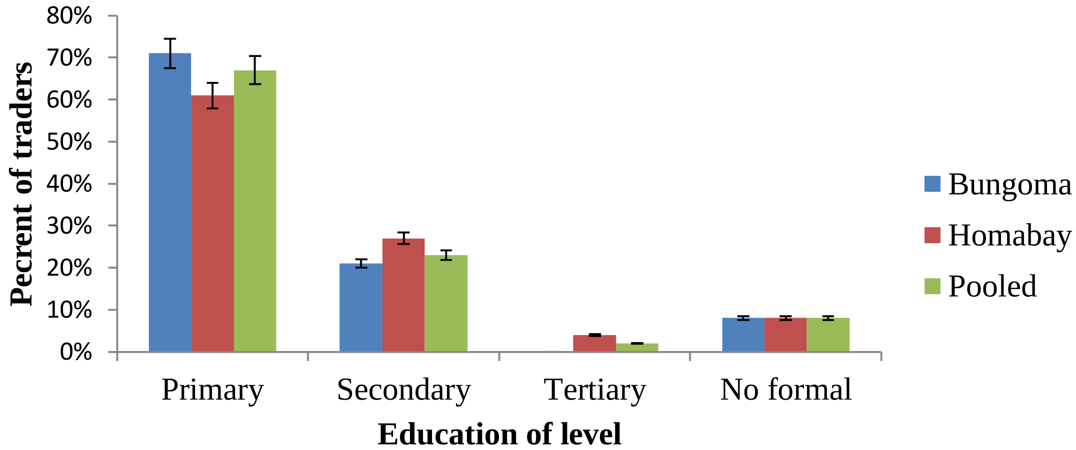


Figure 3. 8: Education level of sweetpotato traders in Bungoma and Homabay Counties. The bars indicate the standard error of means.

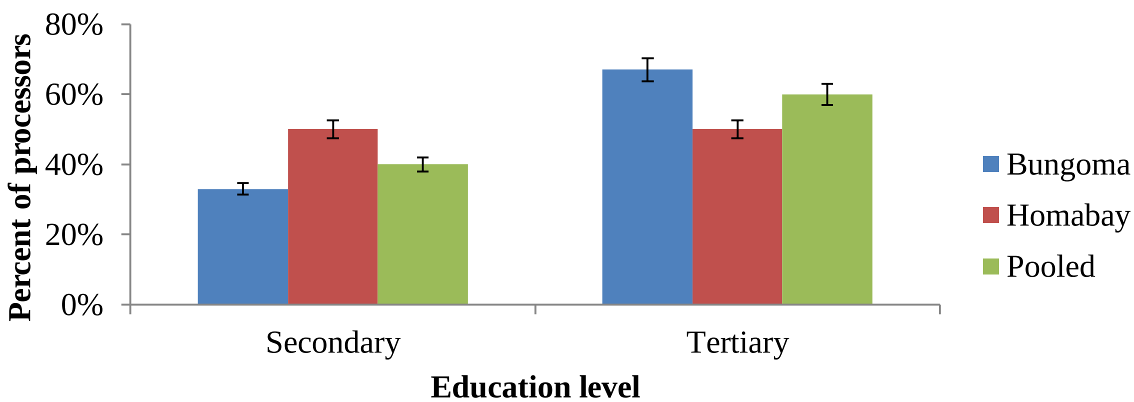


Figure 3. 9: Education level of sweetpotato processors in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.1.4 Marital status of farmers

Figure 3.10 shows that 75% of farmers were married and living with their spouses while 10% had their spouses away and 11% were widowed. Figure 3.11 shows that 59% of the farmers interviewed were spouses and 37% were heads of households. Males are usually heads of households and in most cases regarded as decision makers in Kenyan context. Culturally, the women usually have little say on farm use since most rural farms are inherited from parents. This phenomenon was also observed in other studies (Kivuva et al., 2014; Tedesco and Stathers, 2015).

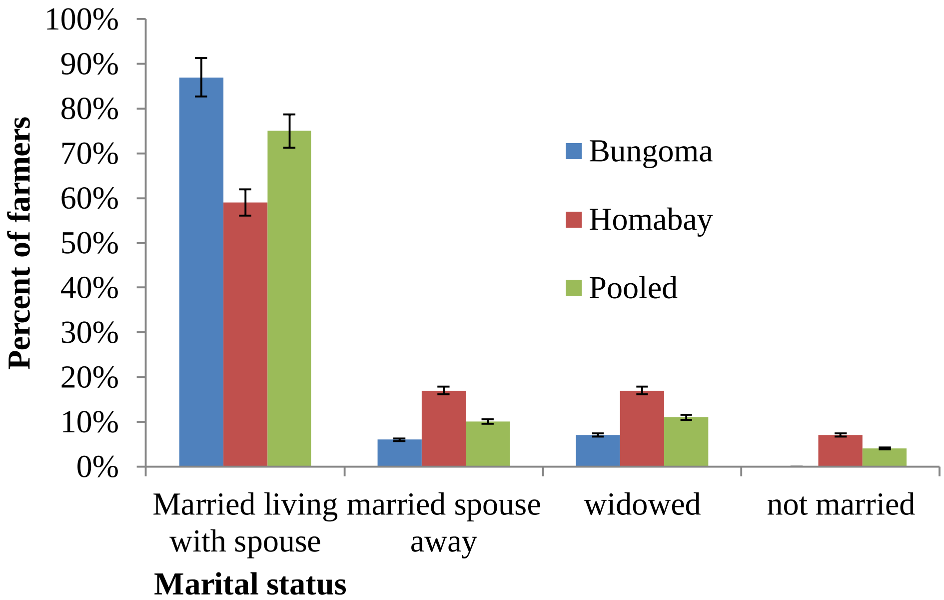


Figure 3. 10: Marital status of sweetpotato farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

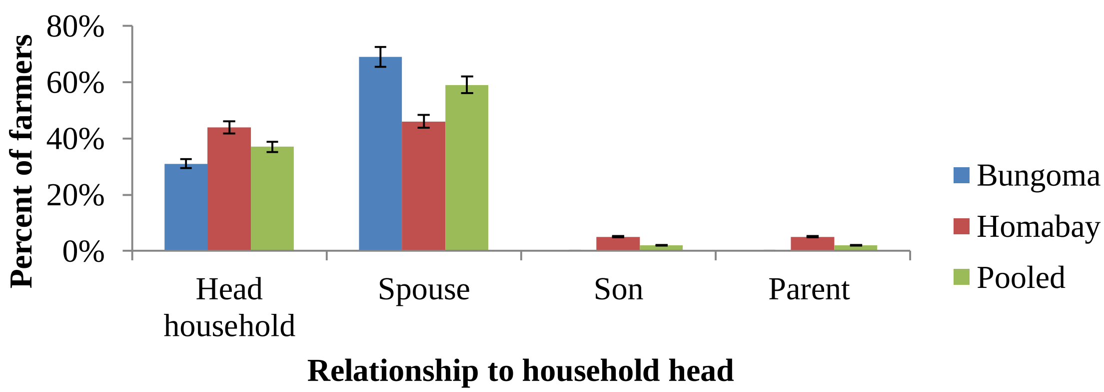


Figure 3. 11: Relationship of respondent to household head in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.1.5 Occupation of households

It is evident that farming is a main livelihood source for the majority (79%) of the rural households (Figure 3.12) implying the need for sweetpotato farming to be carried out as a commercial activity to sustain rural livelihoods as well as improve incomes.

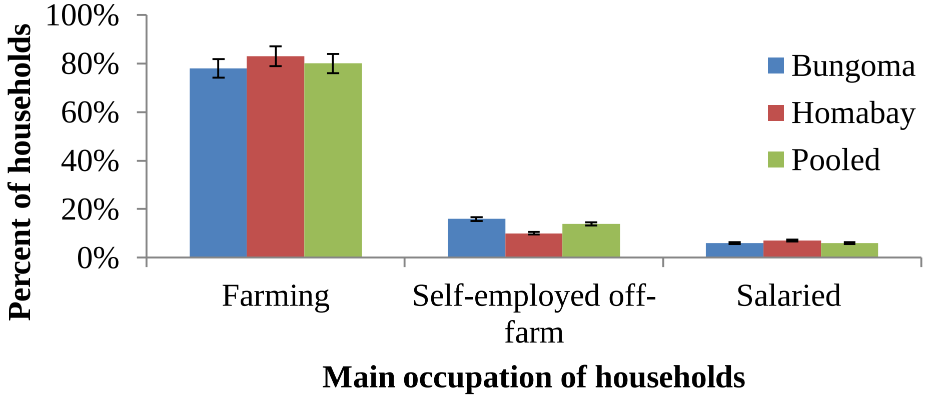


Figure 3. 12: Main occupation of farming households in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.1.6 Family sizes

The most prevalent family size (Figure 3.13) was 3-5 persons (43%) followed by 6 -8 persons (26%).Traditionally in the African societies, large families were cherished because they would provide readily available labour for the farms.

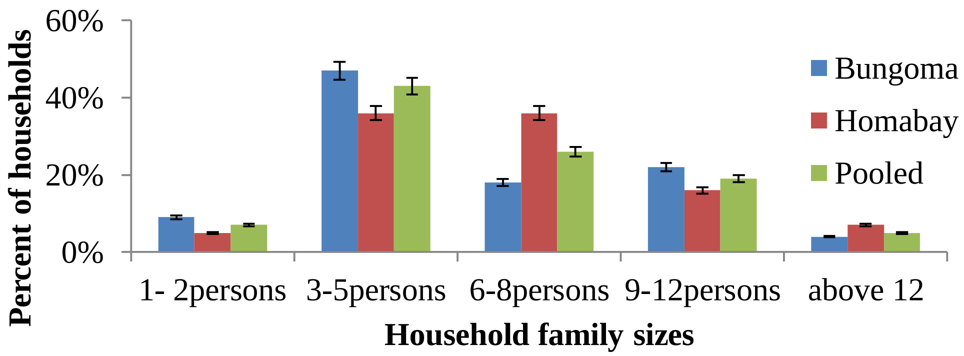


Figure 3. 13: Household family sizes in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.2 Scale of involvement in sweetpotato value chain

3.4.2.1 Land size and sweetpotato acreage

Sweetpotato is dominantly a small scale farmers' crop as noted by 73% of farmers in the current study (Figure 3.14) who owned not more than four acres of total land size. This finding agrees with a previous study by Ewell (2011). Land sizes in Kenya continue to diminish due to subdivisions occasioned by ever increasing population and this can result in over-use and reduced soil fertility. Sweetpotato is therefore a potential crop which can survive under such marginal conditions.Production of sweetpotato was on a low scale as observed by 89% of farmers who had sweetpotato on not more than two acres of their land (Figure 3.15). The finding could be an indication that farmers also have other priority crops planted on their farms and the sweetpotato could be primarily for domestic consumption. Sweetpotato was grown on 0.5acres or less by most households in Kenya (Kivuva et al., 2014; Were et al., 2013).

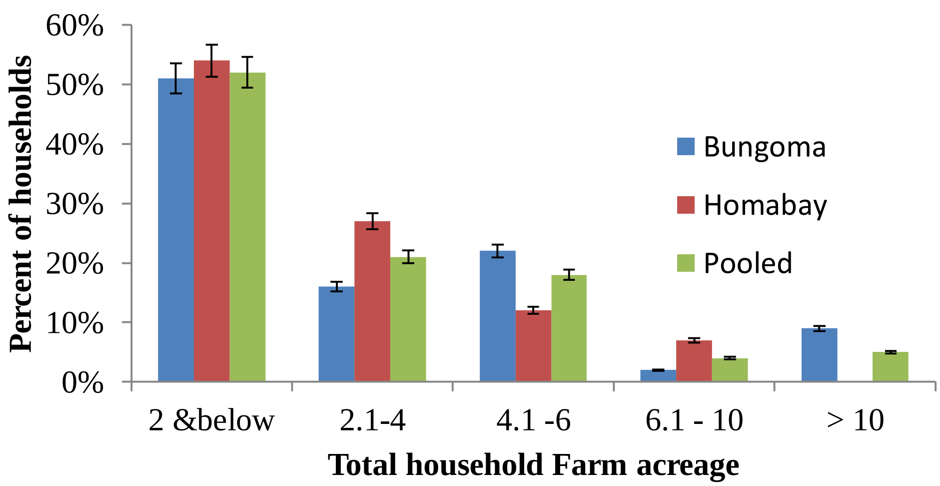


Figure 3. 14: Households' farm sizes in Bungoma and Homabay Counties. The bars indicate the standard error of means.

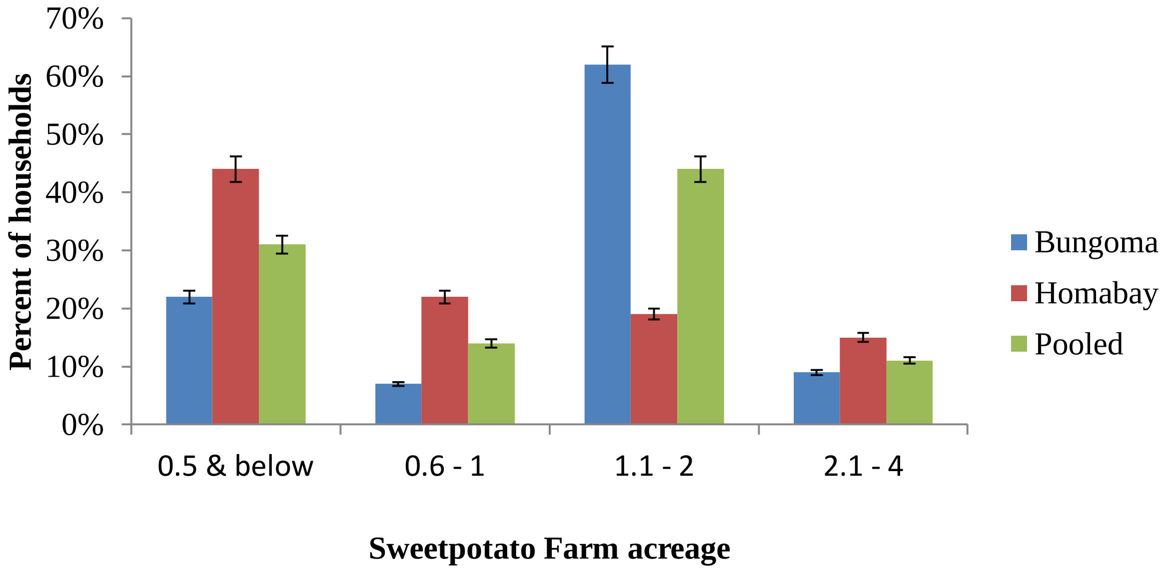


Figure 3. 15: Household sweetpotato acreage in Bungoma and Homabay Counties. The bars indicate the standard error of means

3.4.2.2 Source of farm labour

In the current study 87% (family source only plus family & unskilled labour) of households utilized their family members for farm labour (Figure 3.16). This is in line with low acreagae under the crop that would not require hired labour and hence a possible indicator of low income from the crop hence the use of familiy members as a cheaper source of labour. The use of family members for farm labour could also be due to the inability of the households to fully hire farm labour since their main occupation (79%) was farming.

Figure 3. 16: Source of farm labour for households in Bungoma and Homabay Counties. The bars indicate the standard error of means

3.4.2.3 Traders

Figure 3.17 shows that 77% of sweetpotato traders were retail traders and 23% were middlemen.

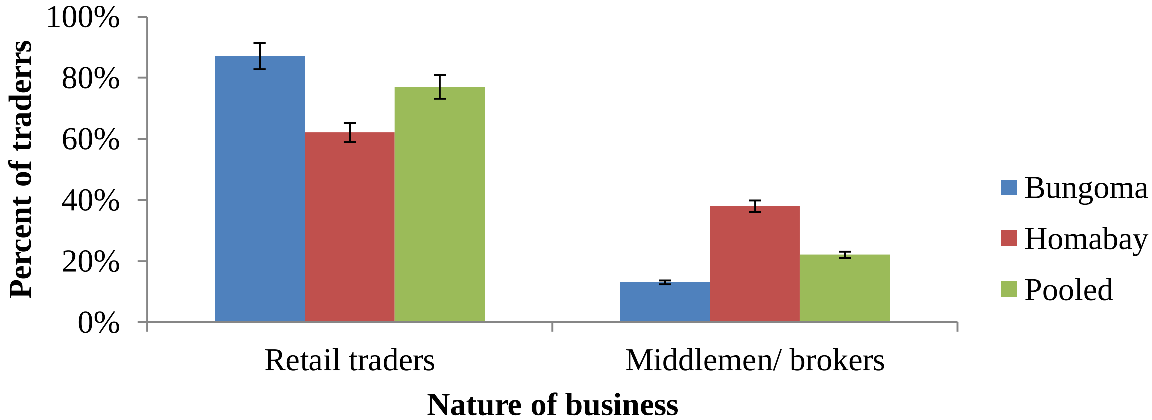


Figure 3. 17: Nature of traders' business in Bungoma and Homabay Counties. The bars indicate the standard error of means.

The retail traders sold products within the local markets while middlemen sold to urban markets. Middlemen become particularly important when they have to access the farmers in the furthest remote places to buy their sweetpotatoes since farmers themselves may lack knowledge of markets and means to transport their produce.

3.4.2.4 Processors

Of the five processors interviewed, there were two sole entrepreneurs, a cooperative society, local NGO company and a group business having been in existence mainly between one and five years. Their operations were on a small scale ranging between 4kg and 400kg of daily production depending on demand for the products and the availability of the raw sweetpotatoes. Processing sweetpotato seemed a new venture since the local population has been used to consumption of boiled roots for much of the time they have known the sweetpotato.

3.4.3 General Food crops production by households

Farmers practiced mixed crop farming systems with the main crops being maize, sweetpotato, beans, bananas, cassava and local vegetables among others. The practice of mixed crop farming is common among small scale farmers who grow crops firstly for subsistence and secondly for income generation when there was surplus.This phenomenon was also observed in another study(Kivuva et al., 2014). This could be attributed to the small size of farms which required maximum utilization since the main occupation of more than half of the farmers interviewed was farming.Sweetpotato ranking second among crops grown and first among roots and tubers is an indication that it has high potential whose value should not be underestimated.Sweetpotato varieties commonly planted were Kabode, Vitaa, and Ejumula in both counties, Nyathiodiewo (in Homabay), Bungoma and Kenspot 4 (Fundukusia) (in Bungoma) being most popular (Table 3.1). Kabode and Vitaa (orange fleshed varieties) had been adopted because of readily available markets and sensitization efforts on nutritional value by various stakeholders. In Bungoma, KSP 4 (Fundukusia) and nyathiodiewo were preferred because of their favourable starch content, high yield and prolonged continous harvesting time.

Table 3. 1: Most popular sweetpotato varieties grown by farmers in Bungoma and Homabay Counties

Sweetpotato variety	% of farmers growing in Bungoma	% of farmers growing in Homabay	Pooled (total % of farmers growing)
Kabode	64%	83%	72%
Vitaa	16%	46%	29%
Bungoma	40%	-	23%
Kenspot4(fundukusia)	36%	-	21%
Nyathiodiewo /nyawoo	-	41%	18%
Ejumula	5%	2%	4%
Miezitatu	5%	-	3%
Miezimbili	5%	-	3%
Namaki	4%	-	2%

New varieties of sweetpotato will always be adopted cautiously by farmers while still holding on to the local familiar varieties (Kivuva et al., 2014). Varieties with consumer-desired attributes are most likely to be adopted since they will have ready markets. There is need for breeders to develop varieties which encompass all the desired attributes.

3.4.4 Harvesting sweetpotato roots

A majority of farmers (59%) practiced piecemeal harvesting while 41% practiced wholesale harvesting. Ox-plough, Iron bar (old file), ‘Jembe’ and wooden stick were tools used by 27%, 31%, 21% and 21% of farmers respectively for harvesting (Figure 3.18). Piecemeal harvesting was practised mainly to extend the crop’s season since the crop served both roles of food security and income generation. Besides, the farmers harvested the exact amounts for sale as per the demand hence the use of wooden sticks and iron bars.Wholesale harvesting was mainly practised when land was required for establishment of a new crop hence use of ‘*jembes*’ and ox-ploughs.Piecemeal harvesting can be time consuming and tricky to plan since it is dependent on the availability of unpredictable market.

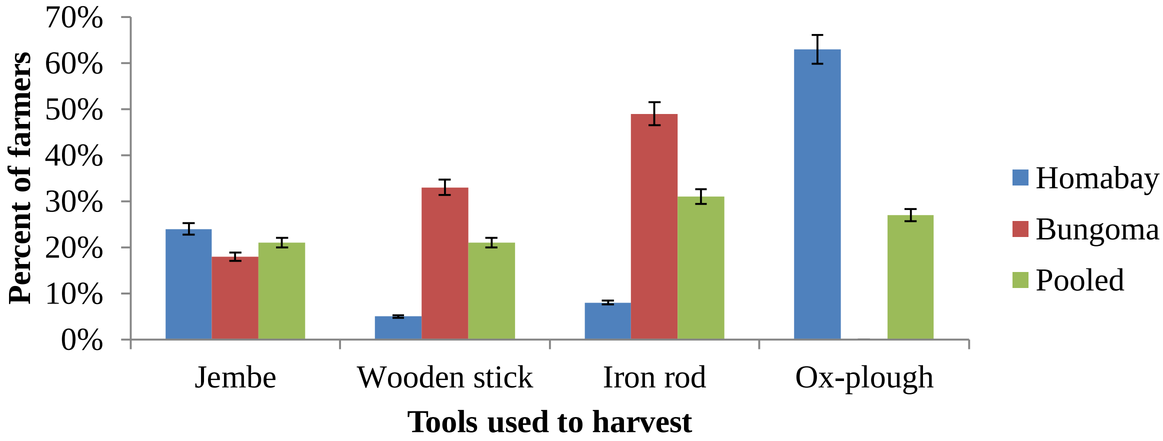


Figure 3. 18: Tools used in sweetpotato harvesting by farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

Wholesale harvesting can be economical in terms of labour and time requirements.Sweetpotato roots are susceptible to mechanical injuries due to the tools used in harvesting. A lot of care is thus required during harvesting to ensure minimal injuries occur.

3.4.5 Sorting and grading of sweetpotato roots

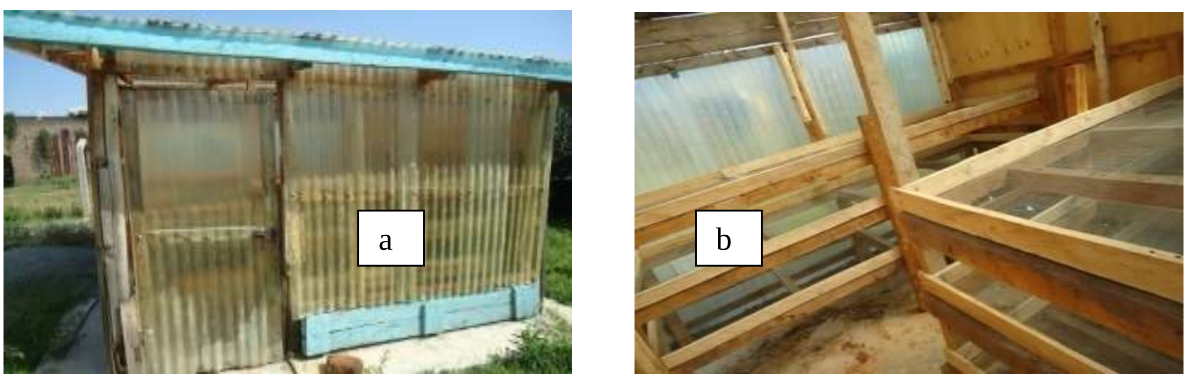
An overwhelming 93% of farmers carried out sorting and grading of roots mainly according to size, damage and colour. Five percent did not find it necessary to grade while two percent delivered all roots to cooperative society which did the sorting. These two practices are important in marketing and value addition. It was observed that traders in Homabay county sorted roots according to variety while those in Bungoma sold sweetpotato in heaps of mixed varieties as per their customer demand. It is common knowledge that most of the times consumer behaviour dictates the market practices.

3.4.6 Curing sweetpotatoes

Curing was limited and practiced by 20% of farmers. About 59% had no idea on curing while 21% did not find it a necessary practice. Curing was not a common practice among the farmers (80%)

because they harvested the roots to sell immediately for readily available market. Curing may be necessary for large scale farmers who practice wholesale harvesting and probably for storage when the market for the roots is not immediately available. Cured roots are able to maintain their desired market quality attributes like insignificant loss of weight, no rotting and absence of sprouting (Wheatley and Loechl 2008).

None of the traders interviewed practiced curing of sweetpotatoes. This can be attributed to either lack of knowledge or storage facilities for the roots or both. About 40% of the processors had access to curing chambers but rarely used them. This was because they received lower volume of roots then processed them immediately. Poor linkages between farmers and processors may be the cause of inadequate supply of the roots. Since the processors had curing chambers which were rarely used (Figure 3.19), perhaps the facilities could be utilized for curing roots for the farmers to encourage storage. There is need to establish the behavior of different sweetpotato varieties when subjected to curing conditions.



(a) External and (b) interior of curing chambers by a processor in Bungoma county

(c) External and (d) interior of curing chambers by a processor in Homabay County

Figure 3. 19: Sweetpotato curing chambers in Bungoma and Homabay Counties

3.4.7 Storage of sweetpotato roots

3.4.7.1 Storage by farmers

About 57% of the farmers did not practice storage of roots at all because they reported that they either did not know how to store (43%) or they did not find it necessary since they harvested for immediate sale and had no surplus left (57%).Storage of sweetpotatoes was occasionally practiced by 43% of farmers especially after wholesale harvesting to clear the farm for the next planting. Figure 3.20 shows storage methods used by those who stored (n=43). Periods of storage varied as follows: 1-14 days (71%), 3weeks to a month (18%), 2-3months (9%) and 5-6months (2%).From the current findings, storage by farmers seemed an afterthought since it would happen especially after wholesale harvesting in clearing the farm for the next planting and storage would take place in the houses and not designated stores. Lack of knowledge and appropriate facilities could be the main hindrance to storage hence farmers did piecemeal harvesting to avoid incurring huge losses after harvesting. Besides, the roots are also bulky and would consume a lot of space in the houses where they were most likely to be stored. There was no standardized way of treating the roots before storage (Figure 3.21); whether to wash or not, sun-dry or not. This was probably the reason why most farmers would not risk trying it.

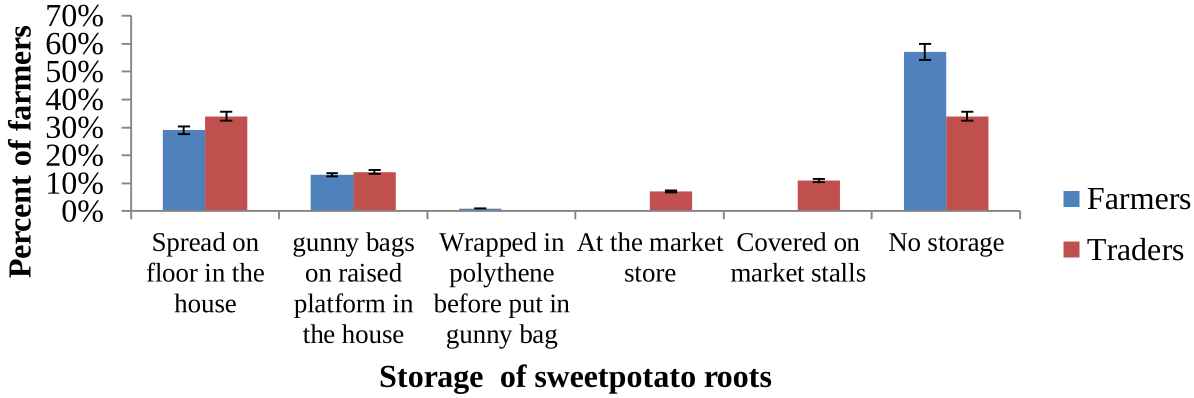


Figure 3. 20: Storage of sweetpotato roots by farmers and traders in Bungoma and Homabay Counties. The bars indicate the standard error of means

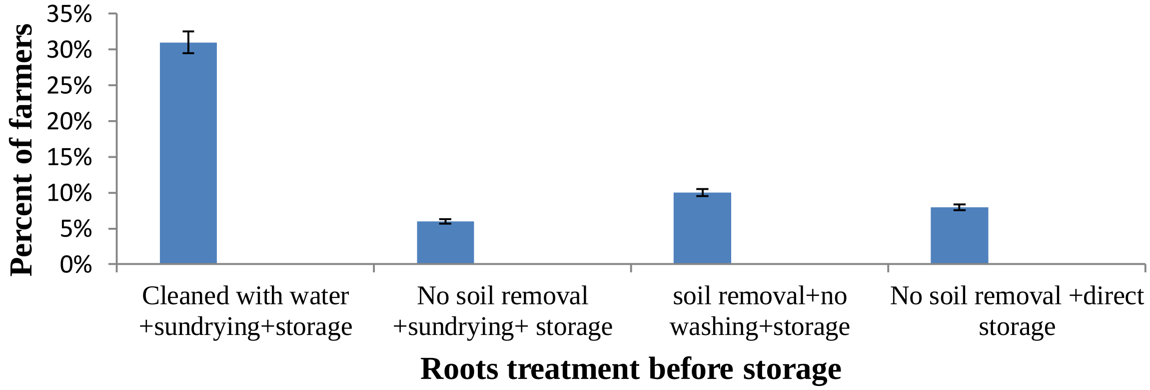


Figure 3. 21: Treatment of sweetpotato roots before storage by farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.7.2 Storage by traders

The roots were mainly stored at the prevailing room temperature or left on the market stalls. Gunny bags were the most commonly used containers (53%) for storage followed by polyethylene bags (21%). About 19% of those who stored did not use any container. There is a high likelihood that the market centers do not have enough storage space for sweetpotato roots such that many traders had limited options to either leave them on the stalls or carry them back home. This could be really cumbersome since the roots are bulky to transport and also highly perishable. This situation could be one of the main reasons why traders would purchase roots several times in a week in small manageable volumes.

3.4.7.3 Storage by processors

Processors did not store raw sweetpotato roots with 20% fearing possible rotting (spoilage) but storage of processed products took place. Puree was stored for a maximum of one day in frozen conditions prior to transportation to prevent spoilage since the product did not have any preservatives. Dried chips were stored for a maximum of six months on shelves within the business premises. Crisps, crackies and flours were usually stored for a period between one week and one month while bread/scones were stored for two to three days at most on shelves within the business premises at room temperature. Processing of roots can be a way of ensuring longer shelf life for supply throughout the year (Wheatley and Loechl, 2008). It is clear that the processors require training on how to preserve sweetpotato products for a longer period so that they can be able to process in large volumes.

3.4.8 Household consumption of sweetpotato roots

Majority (68%) of the households consumed roots twice per week (Figure 3.22.) Frequency of consumption was likely increased when the roots were in season. This finding is similar to what has been reported by another study that the frequency could be due to the sweetpotato being a second staple crop (Wheatley and Loechl, 2008). Estimated consumption per household was as follows: 1-5kg (71%), 6-10kg (21%), 11-15kg (2%), 16-20kg (3%) and 25-30kg(3%). The quantity consumed was influenced by the family size and seasonality of sweetpotato roots, among other factors. All households reported that they consumed the roots mainly boiled with or without skin and also mashed with other food. About 15% of respondents occassionally consumed fried slices/crisps/chips, roasted roots, sweetpotato flour or composite flour. It was evident that boiling was still the main form of preparation and consumption. This could be due to the fact that boiling was the easiest and less costly cooking method as it requires only water while frying would incur extra cost for cooking oil. Flour from the orange-fleshed roots was used in porridges especially for children. Sweetpotato consumption in the study areas was still low probably because it was consumed as an accompaniment to tea and mainly as boiled. Average per capita consumption of sweetpotato for both counties combined stood at about 55.9kg per year (Bungoma County 54.8kg and Homabay 57.29kg) which is about twice the country's figure. Kenya has an average per capita consumption reported as 24kg per year (Were et al., 2013; Ingabire and Vasanthakaalam, 2011) while Uganda has 90 – 100kg, and Rwanda has 100 – 300kg (Mmasa and Musuya, 2012; Ingabire and Vasanthakaalam, 2011).

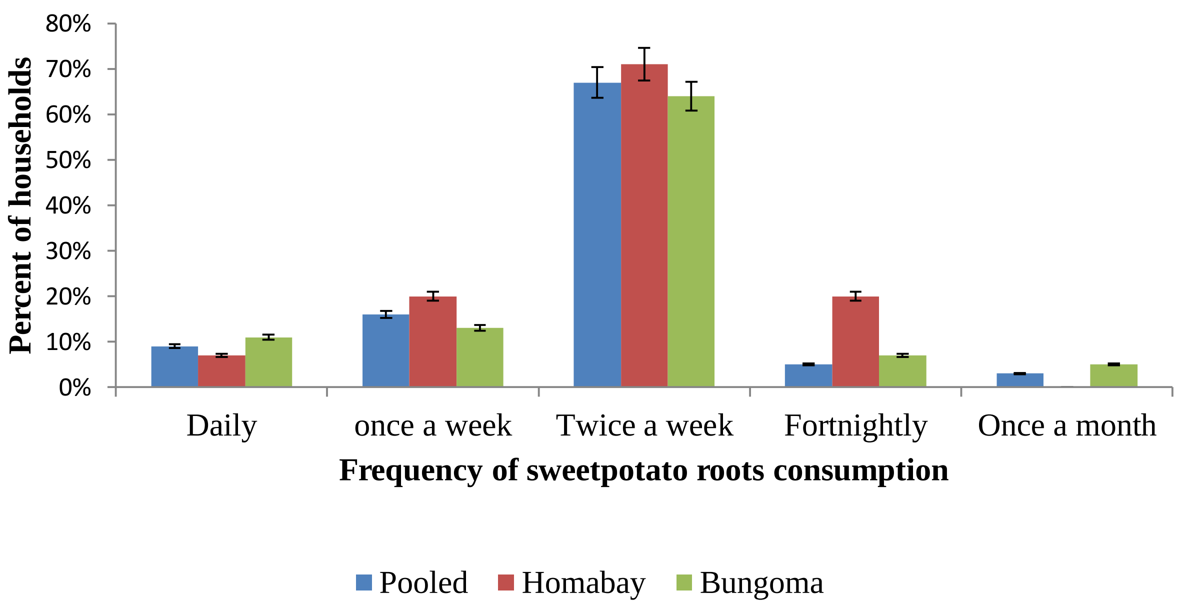


Figure 3. 22: Frequency of sweetpotato roots consumption by households in Bungoma and Homabay Counties. The bars indicate the standard error of means.

Kenya's national per capita consumption is lower than those for Homabay and Bungoma counties probably because consumption by other counties with less or no sweetpotato production could be presumably very low. Consumption in Kenya could probably be increased if the sweetpotato can be prepared in different ways or processed into various products.

3.4. 9 Processing of roots

3.4.9.1 Sweetpotato roots processing by farmers

About 56% of farmers did not practise any form of processing of sweetpotato roots because of lack of knowledge (63%), lack of processing equipment (7%), low sweetpotato production (10%) or simply lack of interest (20%).Forty four percent of farmers did minimal processing due to the availability of the roots to fetch some income or for household consumption. Among those who processed, itwas done within 24hours (by 46%), within 49-72hours (by 34%) or 1-2 weeks (by 4%). Processing took place in a room/kitchen in the house or at ayard outside the house.

Kabode, vitaa, Bungoma, 'mwezi moja', kanduyi, 'namaki'and nyathiodiewo/Nyawoo sweetpotato varieties were used in processing by 36%, 15%, 3%, 1%, 1%, 1% and 7% of farmers respectively because of their nutritional value (orange-fleshed varieties), sweet taste and color. Various products (Figure 3.23) that farmers processed from sweetpotato roots included dried chips and flour (by 36%), juice (by 2%), fried chips (2%) and doughnuts (2%). There was reported evidence of limited processing of roots into dry chips for flour for various uses or fried chips. This on-farm processing was perhaps occasioned by the availability of roots during the harvesting season.

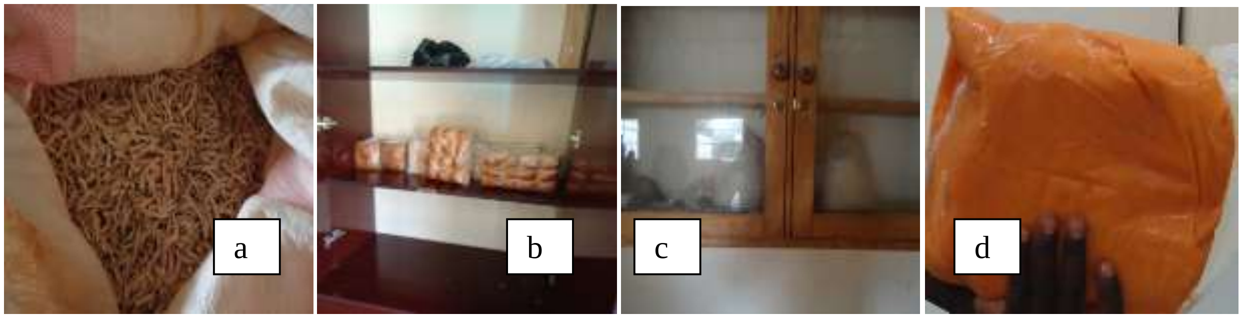


Figure 3. 23: Some sweetpotato processed products in Bungoma and Homabay Counties (a) Dried chips (b) scones and bread (c) flour (d) sweetpotato puree

The level of processing by farmers in the current study is informal and subsistence since most of the farmers were secondary school leavers with little knowledge on processing probably acquired informally through friends. Domestic or small scale /equipment used in processing included knives, chippers, graters, blenders, pounding mortar and grinding mill. The simplicity of tools/equipment used, processing at home and products show a desperate desire by farmers to process sweetpotato to reduce waste and increase consumption especially in seasons of plenty. Major challenges cited by farmers in processing sweetpotato roots were lack of appropriate processing equipment/tools, high cost of processing equipment and inadequate knowledge on processing as rated by 64%, 63% and 53% of farmers, respectively.The challenges of lack of processing skills and equipment could be the main hinderance to processing of sweetpotato roots and subsequent low production of roots due to lack of market to absorb them.

3.4.9.2 Sweetpotato roots processing by processors

Table 3.2 shows the products, volumes and frequency of production by processors in both counties of study. About 60% of the respondents processed the roots within 24 hours after harvest while 20% processed within 4days at the maximum. The frequency of processing would vary from daily to seasonal depending on type of products and customers. About 20% did processing at the home yard, 20% rented a room at the market centre, 60% processed from designated premises though 20% of these rented the premises.

Table 3. 2: Sweetpotato products, volume and frequency of processing

Nature of business		Dried chips	Flour	Composite flour	Crisps	Crackies	Bread and scones	Puree	Animal feed
Sole proprietor	Volume	4kg	-	-	50kg	-	-	-	-
	Frequency	daily	-	-	monthly	-	-	-	-
Sole proprietor	volume	4kg	8kg	40kg	-	-	-	-	-
	Frequency	weekly	Weekly	weekly	-	-	-	-	-
NGO company	volume	100kg	-		-	100kg	24kg	-	-
	Frequency	daily	-	-	-	weekly	weekly	-	-
Group business	volume	-	-	-	-	-	-	300kg	-
	Frequency	-	-	-	-	-	-	Daily	-
Marketing cooperative society	volume	-	300kg	200kg	-	-	-	-	200-400kg
	Frequency	-	fortnightly	Daily	-	-	-	-	Daily; fortnightly

Assorted processing equipment were used by the processors includingwashers, slicers, manual extruder for crackers, electric sealers, baking equipment, graters, grinding mill, Chippers, solar dryer, ‘pangas’, knives, Puree machine and steam boiler (Figure 3.24).

Figure 3. 24: The photos indicate the Some equipment used in sweetpotato processing in Bungoma and Homabay Counties

(a) sweetpotato washer, (b) flour miller, (c) assorted equipment at the puree processing plant in Homabay, (d) baking chambers in Bungoma

As evidenced by the results, several products can be processed from sweetpotato roots.The demand within localities was already abovethe volume of production. This calls on the processors to up-scale production so as to reach even wider markets.Perhaps up-scaling production could provide market for the volumes of roots supplied by farmers. Low production by procesors was attributed to inadequate supply of roots or low capacity processing equipment.Setting up processing facilities is a big investment which may require efforts from organized groups or good source of funding.

3.4.10 Marketing of sweetpotato products

3.4.10.1 Marketing by farmers

Only 10% of the interviewed farmers did not sell sweetpotato roots compared to 90% who did. About 29% of the respondents did not package their products when selling. Gunny bags were used by 60% of farmers to package the roots while polyethylene bags were used to package products for sale by 11% of farmers (Figure 3.25).About 15% of respondents sold the roots at the farm gate, 63% sold to the local market, 6% took to the urban markets while 6% took to the marketing cooperative society (Figure 3.26).

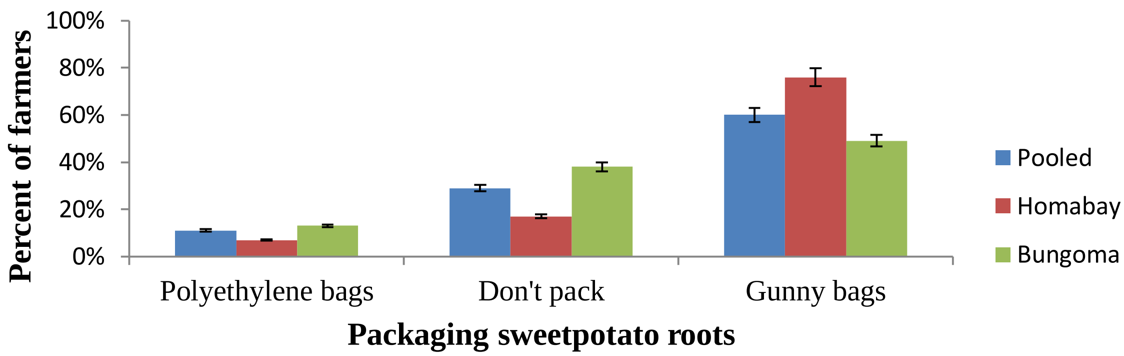


Figure 3. 25: Packaging of sweetpotato roots for sale by farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

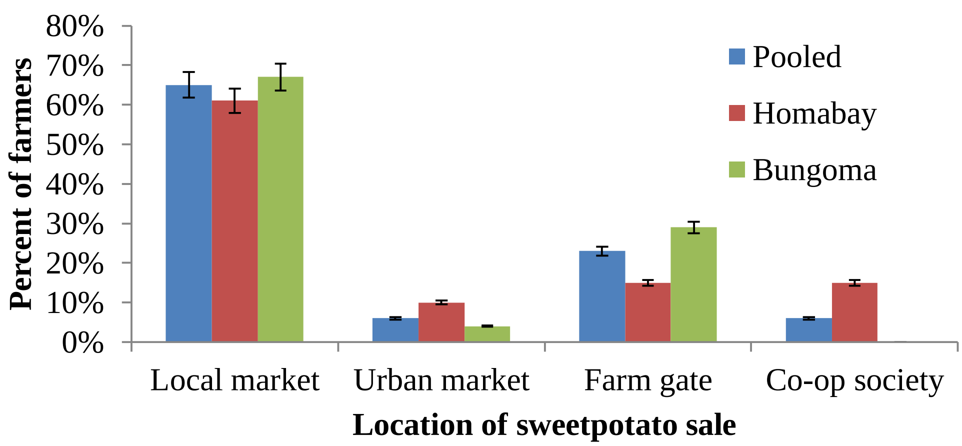


Figure 3. 26: Location of sale of sweetpotato roots by farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

The buyers of the roots and other processed products were final consumers (24%), traders (25%), brokers (24%) and processors (20%). Instead of using weighing scales, the roots were sold using bags or buckets to determine quantity. In most cases, the buyers came with their gunny bags which were notably bigger than the normal gunny bags used by the farmers. Farmers are thus vulnerable to exploitation by buyers due to the existing informal marketing systems.Challenges experienced in marketing included low prices of products (53%), unstable prices (36%), high perishability of sweetpotato roots (21%), middlemen interference (25%) and poor road network (19%). Several coping strategies used by farmers for the challenges they faced included selling at farm gates (27%), selling through marketing cooperative society (35%), preserving for later sale (18%) and direct selling to consumers without passing through brokers (2%). Some farmers (11%) had no idea what to do about their challenges. Most of the challenges experienced in marketing could be as a result of farmers operating as individuals. If they organized themselves in marketing groups they would stand better chances of benefiting more due to greater bargaining power.

3.4.10.2 Marketing by traders

About 97% of the traders sold raw roots while 13% (at the main markets) sold already boiled roots. The main target consumers for boiled roots were the traders in the market since it's where they spent many hours of the day. This seemed to be a new venture whose adoption is yet to be observed. Majority (78%) of the traders sourced their sweetpotato roots for sale directly from farmers, 14% sourced solely from the open markets while eight percent sourced from brokers /middlemen. This implies that the main marketing channel is farmers selling the roots directly to retailers who sell directly to consumers as was also observed in an earlier study (Mukundi et al., 2013). On average the raw sweetpotato roots were bought two to three times per week by a majority (59%) of the traders, followed by daily with 33% of the traders and weekly by 8% of the traders. The frequency of purchase was influenced by the local market days and seasonality of availability of sweetpotato roots. The traders said that they bought to sell immediately during the market days since they did not have storage facilities. Most markets did not have storage facilities thus traders had to transact in small volumes to avoid incurring huge losses of roots. This means that it can be very costly to transport roots several times in a week depending on how far the source of the roots is and / or the state of the road network. Perhaps availability of storage facilities would encourage traders to buy roots in larger consignments which would be economical to transport.

3.4.10.2.1 Unit of purchase and sale of roots

Figures 3.27, 3.28 and 3.29 show the units of purchase and sale for sweetpotato roots by traders. The main unit of sale in Bungoma was heaps/piles at about 94% while in Homabay it was predominant at 42%. The main buyers of the roots were final consumers who constituted 63% in Bungoma County and 46% in Homabay County while 15% of traders sold roots to processors/millers.

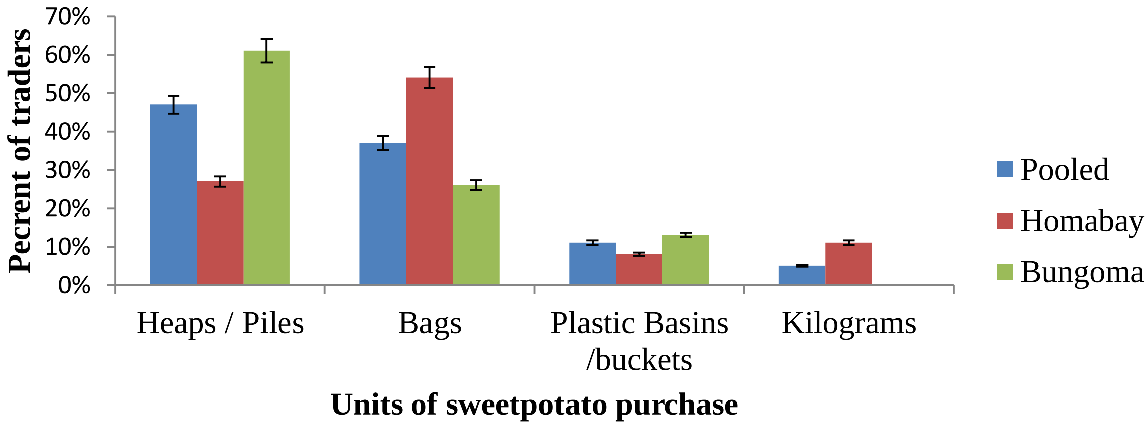


Figure 3. 27: Units of sweetpotato purchase by traders in Bungoma and Homabay Counties. The bars indicate the standard error of means.

It is evident that the most commonly used measurement units of purchasing and sale of sweetpotato roots by traders were non-standardized. Maybe the traders earned more by selling in heaps after buying in bags. These traditional (non-standardized) practices could be happening due to lack of weighing scales among farmers and traders. These informal units of measurement are therefore subjective and pose a great risk of exploitation for both the seller and the buyer since the objects and containers used are not standardized. The use of informal measurements can make it difficult to quantify actual economic value or losses in the sweetpotato trade.

Figure 3. 28: The bars indicate the Units of sweetpotato roots sale by traders in Bungoma and Homabay Counties. The bars indicate the standard error of means

Figure 3. 29: The photos indicate the Units of trade for sweetpotato in Bungoma and Homabay counties.

(a) traders at the market selling in heaps, (b) trader along the highway selling in buckets, (c) a trader selling in bags at a collection centre, (d) a farmer selling to a processor in kilograms

A different research showed that over 70% of sweetpotato produced in Kenya were sold in unorganized and informal markets where farmers fetched low prices (Tedesco and Stathers, 2015). In Homabay County, however, the use of weights for purchasing roots was gradually being adopted because of the cooperative society and the puree processing plant which paid the farmers according to weights. Formal measurements should therefore be encouraged and gradually adopted by all in order to realize the maximum commercial potential of the sweetpotato and ensure fairness in trade.

3.4.10.3 Marketing by processors

Flours, dried chips, puree and animal feeds were sold by weights. Loaves of bread were sold in pieces (numbers), scones were sold in packets of a dozen pieces, crackies and crisps were sold in satchets of 100g. Processed sweetpotato products were sold to both final consumers and retailers a majority of who were within the counties. Sweetpotato puree was transported daily to Nairobi City for use in bread making. Flour was sold locally and consumers blended the flours for use in making porridge, bread and cakes for home consumption or sold for household income generation. Crackies and crisps were mainly sold to school pupils. Dried chips were sold to consumers who mixed them with other grains like millet, maize before milling.

No marketing promotion was done for products like puree, crackies and bread. Puree production daily took place in a newly established company in Homa Bay County, which operated below its design capacity. Dried chips, flour, crisps and animal feeds, however, required sales promotion. Processed products had higher demands than supply and this is probably the reason why sales promotion was never done. There is need for sales promotion and increased production in order to tap in to the unexploited markets outside the localities. It is likely that the processed products will get acceptance even in new regions.

3.4.11 Transportation of sweetpotato roots

3.4.11.1 Transportation of roots by farmers

From the farm sweetpotato roots were either transported directly to the local trading centers / open air markets (40%) or to the marketing cooperative society (14%) or to the homestead first (39%)

or sold directly to buyers on the farm (6%). The roots were carried in gunny bags (88%) or buckets (9%) or baskets (3%). Modes of transport are shown in Figures 3.30 and 3.31.

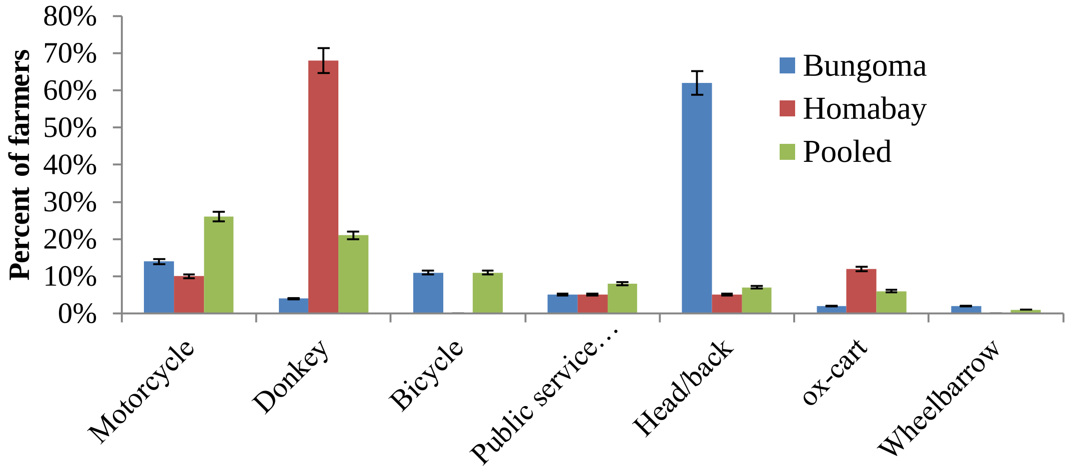


Figure 3. 30: Mode of transport for sweetpotato roots by farmers in Bungoma and Homabay Counties. The bars indicate the standard error of means

Figure 3. 31: The photos indicate the Donkey and ox-cart used to transport roots to the markets in Bungoma and Homabay Counties

Distance from households to the markets ranged from 20metres to 20km. About 66% of respondents covered 1-5km to deliver roots to the markets, 16% covered not more than 500metres, 2% covered 6-10km while 3% covered 11-20km to the markets.

3.4.11.2 Transportation of roots by traders

Ox-cart usage was high in Homabay County at 31% while bicycle and back/head usage were common in Bungoma at 26% each (Figure 3.32). Transporting roots can be costly depending on the distance to the local markets and state of the roads. The use of carts, donkeys, motorcycle, walking and wheelbarrow to transport sweetpotato roots from the farm could be an indication that local markets were not far from the homesteads.

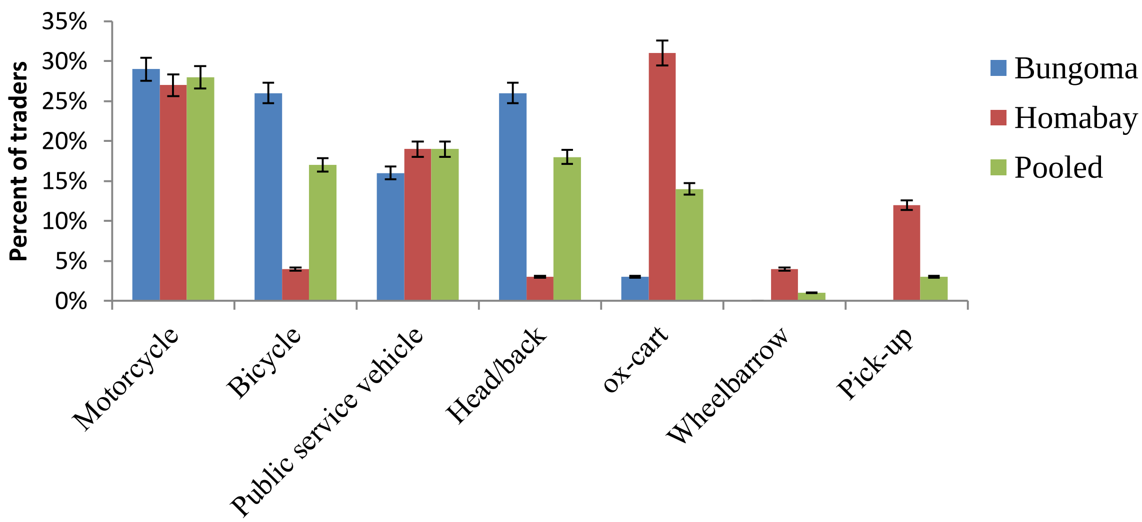


Figure 3. 32: Transport mode for sweetpotato for sweetpotato roots by traders in Bungoma and Homabay Counties. The bars indicate the standard error of means

Besides, it can portray the low demand and hence use of cheaper means of transport may be because farmers aren’t sure of the income from the sales. The choice of transport mode could also be probably influenced by volume of product, cost and distance to the market. In remote areas without proper roads, motorcycles, bicycles, back/head and ox-cart would be the most appropriate means of transport. It can therefore be costly to transact in small volumes. The use of motorcycles and donkeys in transportation is common (Tedesco and Stathers, 2015).

3.4.12 Sweetpotato Losses

3.4.12.1 Farmers' sweetpotato losses

Table 3.3 shows estimated percentage of losses by famers at different stages of handling. Losses occuring during harvesting were mainly due to mechanical injuries. Mechanical injuries on roots during harvest are likely due to the tools like metal bars or carved sticks used in harvest since the roots are usually burried in the soil. Losses of roots during transport were due to dropping off, bruises and tearing of the bags.

Table 3. 3: Causes of sweetpotato losses as incurred by farmers

	Percent of farmers		
Causes of loss (%) during harvest	**Pooled (overall)**	**Bungoma**	**Homabay**
Mechanical injury/bruising	61	59	65
Theft	5	6	3
Pests damage	30	25	35
Rotting	31	31	32
Causes of loss (%) during transport			
Bruises	24	36	-
Theft	`16	16	17
Falling off	72	59	96
Estimated loss (%) at storage			
Theft	12	17	-
Rotting	67	57	92
Pests	38	43	25

3.4.12.2 Traders' sweetpotato losses

Nearly half of the traders (44%) experienced some losses during transportation of the roots, about 45% experienced losses at storage, while 31% experienced losses at the market. The causes of losses experienced are also indicated in Table 3.4. Losses during transporting as a result of dropping off and tearing of bags could be due to the mode of transport. Packaging excess roots in gunny bags can result in tearing. Rough roads can result in injuries to roots due to abrasion during transport. Injured roots need to be utilized immediately since they become more susceptible to rotting and pest attack. If the mechanically damaged roots are to be stored they need to undergo curing to minimize rapid spoilage. Rotting and molding of roots maybe exacerbated by bruising caused during transport since the roots are never cured. Rough handling, poor packaging, lack of curing, poor product ventilation and delays in transit contribute to large losses that occur from farm to the market and up to 40% loss can occur due to rotting during shipping (Chang et al., 2008). Since the traders notably had gunny bags of extended sizes, it was likely that the roots were closely packed resulting in poor ventilation. The longer the distance to the markets therefore, the greater the expected damage and loss.

Table 3. 4: Causes of sweetpotato losses as incurred by traders

	Percent of respondents		
Causes of loss(%) during transport	**Pooled (overall)**	**Bungoma**	**Homabay**
Mechanical damage	57	59	9
Theft	21	23	18
Package tearing /Falling off	22	18	18
Causes of loss(%) during storage			
Theft	23	29	13
Rotting	45	29	74
Pests/molds	23	28	13
Causes of loss(%) at the market			
Theft	44	36	60
Withering	50	55	40

3.4.12.3 Processors' sweetpotato losses

Crisps and sweetpotato flour losses of 10-20% were experienced during storage by 40% of the processors while sweetpotato puree, flour and composite flour losses of less than 10% were experienced by 60% of the respondents (Figure 3.33). According to some processors, crisps losses happened mainly when schools were closed because the main consumers were school children. Sweetpotato flour losses could be due to the fact that the flour was not widely used by the consumers. Moreover, the flour had no additional preservatives to prolong shelflife. The minimal (less than 10%) loss experienced by 60% of processors could be because the production volumes were based on the readily available market in most cases.

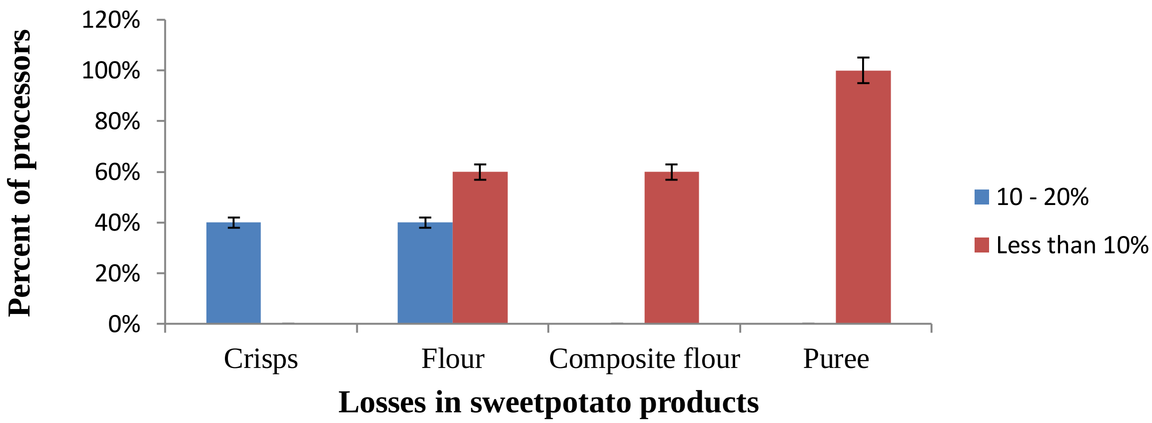


Figure 3. 33: Losses in products processed from sweetpotato roots in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.13 Challenges encountered in the sweetpotato trade

The major challenge cited by all the processors was the seasonal supply of roots. Minor challenges were lack of appropriate packaging, low demand by consumers, high perishability of roots and non-uniform quality of materials. Figures 3.34 and 3.35 show the challenges experienced in sweetpotato trade by farmers and traders respectively. Seasonal availability of sweetpotato roots could be a major determinant of prevailing prices. Use of non-standardized measurements like bags, heaps and buckets by the seller perpetuates unfairness in trade as there is no objectivity. Middlemen are essential in sweetpotato trade even though they are always viewed negatively. This segment of the value chain actors are risk taking entrepreneurs who help even the remote inaccessible farmers to sell their roots. It is an advantage to the middlemen when farmers sell individually without belonging to the cooperative or trade association. High perishability of roots compounded with lack of appropriate storage facilities perhaps limited the ability of the traders to purchase roots in large volumes due to the fear of incurring losses in case they are not sold in time.

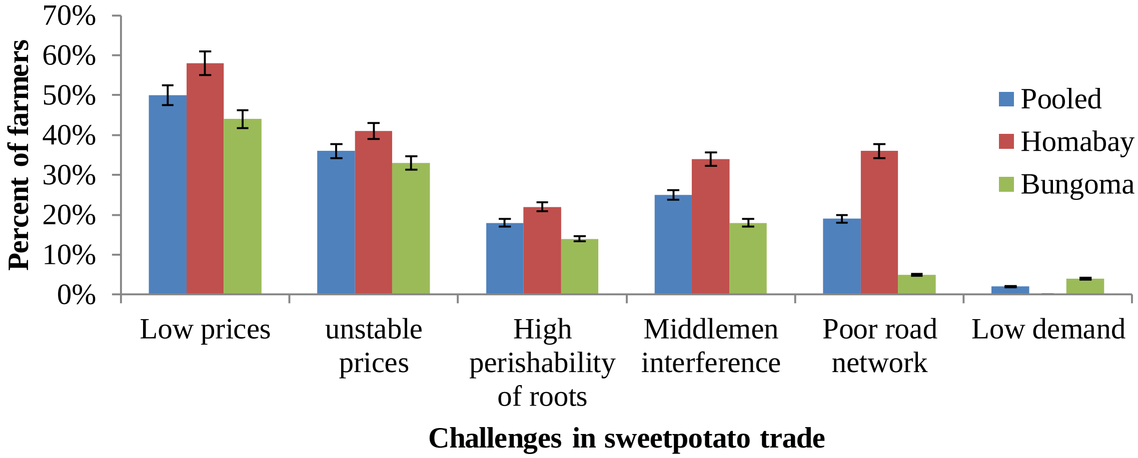


Figure 3. 34: Challenges experienced by farmers in sweetpotato trade in Bungoma and Homabay Counties. The bars indicate the standard error of means

Unreliable supply of roots could be due to low harvests in the off-season, among other factors. If storage facilities were available, the traders would ensure enough stock even when the roots are out of season. Poor road network can lead to high transport costs, delayed delivery of roots to the markets and hence low profitability. Mechanical injuries, variation in quality, low demand by consumers and lack of appropriate packaging were viewed as minor challenges. This may imply that buyers did not mind the presence of mechanical injuries nor the variability in quality of tubers. The market for roots seemed always readily available. Packaging was probably viewed as a minor challenge since buyers came with their packages. Profitability of sweetpotato trade could possibly be dependent upon the various challenges earlier mentioned that were specific to each farmer or trader.

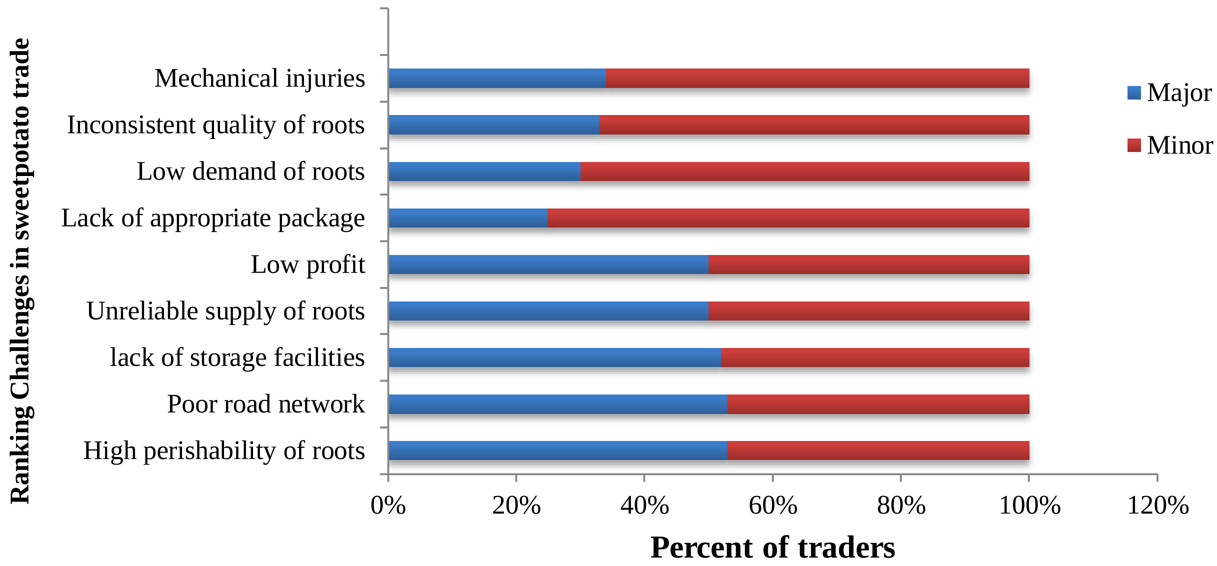


Figure 3. 35: Ranking of challenges in sweetpotato trade in Bungoma and Homabay counties by traders. The bars indicate the standard error of means

3.4.14 Suggestions on improving postharvest handling of sweetpotato roots

3.4.14.1 Farmers' suggestions

Figure 3.36 shows farmers' suggested areas of assistance**.** Training of farmers on storage, preservation, curing and processing technologies is vital because for a longtime in Kenya farming has been done as a social activity where knowledge and skills have informally been passed on from one generation to the next. To commercialize sweetpotato farming, farmers need to be informed on appropriate postharvest handling practices for improved incomes.Marketing cooperative societies for farmers can help minimize exploitation from brokers since they can be able to fetch better prices through use of standard weights.

Establishment of collection centers can ease the burden of transport especially to those farmers who reside far from the markets.Community storage facilities would go along way in prolonging the shelf-life of sweetpotato roots thus reducing losses.There's need for increased processing of sweetpotato roots in order to absorb the roots from farmers for increased production.Poor road network can be a hindrance to movement of sweetpotato roots from the rural farms to the markets because of time wastage and high cost of transport. The Government of Kenya has a responsibility to protect farmers from exploitation by middlemen in terms of pricing and size of gunny bags as well as encourage consumption of sweetpotato in Kenya through enactment of relevant laws and formulation of appropriate policy.

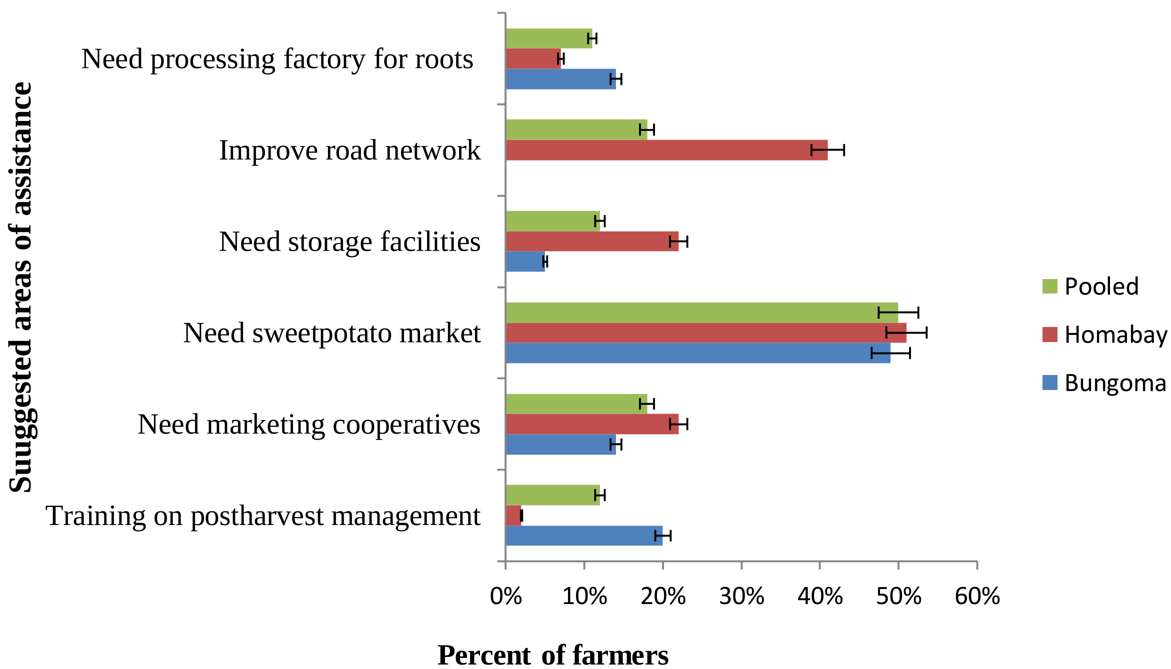


Figure 3. 36: Farmers' suggested areas for assistance in Bungoma and Homabay Counties. The bars indicate the standard error of means.

3.4.14.2 Traders' suggestions

Traders who failed to sell the whole stock of roots would often require storage facilities to sustain their stock in good condition until sold since sweetpotatoes are generally perishable and bulky to transport. The need for modern market facilities is real since the open market facilities offer limited or no shelter thus exposing the sweetpotato roots to the sun and rain (Chang et al., 2008). Traders' suggestions are shown in Figure 3.37.

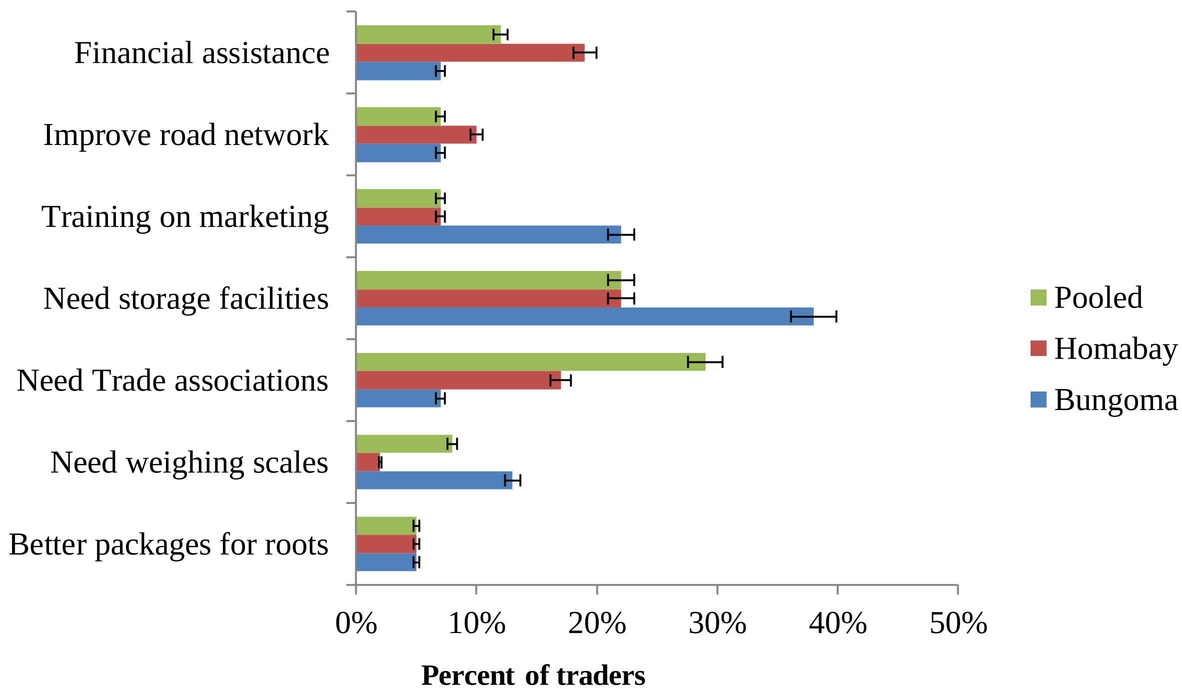


Figure 3. 37: Traders' suggestions for assistance in Bungoma and Homabay Counties. The bars indicate the standard error of means

3.4.14.3 Processors' suggestions

Processors' suggestions (Figure 3.38) varied from financial assistance to purchasing large scale processing equipment (40%), more training on processing skills (40%), need for sweetpotato policy to encourage consumption (20%) and storage facilities for sweetpotato when in season (40%). Large scale processing equipment seemed too expensive to be afforded by processors and there is therefore need for subsidies to enable them acquire these vital items. Inadequate skills capacity of processors can negatively impact the quality of processed sweetpotato products in the ever competitive market. A government policy on sweetpotato is one sure way of encouraing consumption thus unlocking the commercial potential.

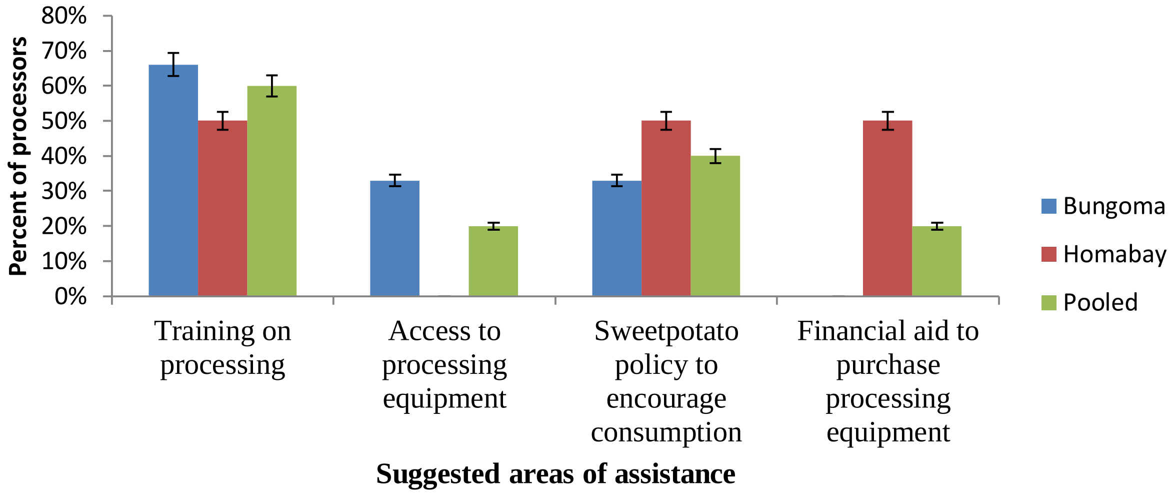


Figure 3. 38: Processors' suggested areas of assistance in Bungoma and Homabay Counties. The bars indicate the standard error of means

3.5 Conclusion and Recommendation

The Postharvest practices and challenges are similar in both Bungoma and Homabay counties. The sweetpotato value chain faces several challenges right from farmers, traders to processors and at every stage of handling. Lack of storage facilities and knowledge of appropriate storage conditions seems to be critical and determine transaction volumes since the handlers are cautious about incurring huge losses. Sweepotato roots storage and processing could be sure ways of accommodating the glut when the roots are in season while ensuring continuous supply when the roots are out of season. The Government of Kenya should intervene in the sweetpotato industry by formulating and enacting a comprehensive sweetpotato policy that will ensure increased consumption of sweetpotato and its products, increased utilisation of processing opportunities and minimal exploitation of farmers.

CHAPTER FOUR

PHYSICOCHEMICAL PROPERTIES AND FLOUR PASTING PROFILES OF POPULAR SWEETPOTATO VARIETIES FROM KENYA AND UGANDA

4.1 Abstract

Sweetpotato varies in physicochemical properties as a result of inherent varietal make up and agroecological zones where grown. Although pasting profiles of sweetpotato flour can be used to determine their end use in food processing, information on systematic evaluation of popular varieties in Kenya and Uganda are limited. Four orange fleshed sweetpotato varieties from Kenya and four common varieties from Uganda were evaluated for their physicochemical properties and for the pasting profiles of their flours. Results indicated significant variations ($p < 0.01$) in the attributes of the eight varieties. Orange fleshed varieties (OFV) had comparatively higher moisture, beta carotene, fat and mineral contents but lower pasting profiles than the non-orange fleshed varieties (NOFV). Sodium/Potassium ratio of the eight varieties ranged from 0.16 to 0.5 and within <1 that is recommended. Calcium/magnesium ratios ranged from 1.11 to 2.09 and were above the required value of 1. OFV had calcium/phosphorous values above 2.00 while NOFV had values below 0.1 against the required >0.5. OFV had lower Peak viscosities (124-590cP) and cold paste viscosities (89.5-319cP) compared to 677-1060cP (peak viscosities) and 438-800cP (cold paste viscosities) for NOFV. Positive correlations were recorded between flour pasting profiles and carbohydrates ($r = 0.71 – 0.88$), starch ($r = 0.26 - 0.52$), phosphorous ($r = 0.05 – 0.37$), protein ($r = 0.07 – 0.30$) and fiber ($r = 0.54 – 0.79$). Sweetpotato consumption can combat hidden hunger since it contains various minerals. Shelf life of sweetpotato can be prolonged through processing into flour which can be blended with other flours appropriately according to their varying pasting profiles for production of high-quality food products.

4.2 Introduction

Sweetpotato ranks fifth in Kenya among the major staple crops after maize, wheat, rice and Irish potato (MoA, 2010). It is found grown in different Agro Ecological Zones (AEZ) (Kivuva et al., 2014) and performance is better where annual rainfall ranges from 600 to 1600 mm and is distributed well. The sweetpotato as an important food security crop has the ability to survive under marginal conditions unlike other staple crops like maize which get severely affected when rainfall is below expectation (Wheatley and Loechl, 2008). Both improved varieties and local landraces of sweetpotato are grown in Kenya (Kivuva et al., 2014). Farmers prefer particular varieties based on different factors like yields, period to maturity and consumers' choice (Rukundo et al., 2013). Production volumes and consumption status of sweetpotato in Kenya has been increasing in recent years (RoK, 2015) especially following the promotion of the biofortified orange-fleshed cultivars by CIP (International Potato Centre) and various other related organizations as a food-based intervention in combating vitamin A deficiency (VAD) which has been common in sub-Saharan Africa (SSA) (Low et al., 2007).

Sweetpotato nutritional composition includes carbohydrates, proteins, vitamins and minerals (Oloo et al., 2014). The physicochemical properties of sweetpotato roots have wide variations depending on factors such as the cultivar, area grown, climatic condition, soil profile and cultivation practices (Ingabire and Vasanthakaalam, 2011; Woolfe, 1992). Dry matter (DM) contents in the roots range between 13.8% and 48.3% (Wheatley and Loechl, 2008). Higher dry matter contents are reported in varieties with white and pale-yellow flesh varieties noted by their ability to stay firm when cooked in addition to their textures which are drier and mealier compared to those of the pink, red and orange flesh (Thottappilly and Loebenstein, 2009). Low DM content in most orange fleshed SP varieties does not make it easy for farmers to adopt and produce them (Rukundo et al., 2013; Mwanga et al., 2011).

Carbohydrate contents in sweetpotato roots usually range between 10 and 30% (Nyambok et al., 2011) constituting 80 – 90% on dry weight; where starch is the abundant constituent (50-80%) of the dry matter in the roots (Nabubuya et al., 2012). Starch is a very key ingredient in commercial food and non-food applications (Oladebeye et al., 2009). Sweetpotato roots have starch content of 6.9 to 30% wet basis or 50 to 80% dry weight basis (Zhu and Corke 2011; Chen et al., 2003; Aprianita et al., 2009). There is therefore need to exploit the starch potential in popular sweetpotato varieties.

Protein content is usually minimal thus roots of some sweetpotato varieties have yielded protein contents ranging from1.0% to 9.0% (Bovell-Benjamin, 2007), while some deep OFSP contained dry matter protein of about 3.5% to 9.5% (Kivuva et al., 2014). Dietary fiber is said to be important in reducing the incidences of non-communicable diseases like cancer of the colon, diabetes, diseases of the cardiovascular system and some digestive disorders. Sweetpotato roots usually contain about 2-3% crude fiber (Nyambok et al., 2011). A study on three OFSP varieties in Kenya (Oloo et al., 2014) revealed dietary fiber with contents of 2.56% to 3.54%. Fat is essential in the diet for enhanced bio efficacy of beta carotene, thus lack of fat has been linked to deficiency of vitamin A in the body (Oloo et al., 2014). Minimal fat (0- 1%) content is however found in sweetpotato roots (Nyambok et al., 2011). A study on three Kenyan varieties of OFSP; Zapallo, SPK004/6 and Nyathiodiewo, revealed fat contents ranging from 2.10% to 3.21% (Oloo et al., 2014). Ash (mineral) content of roots of some varieties have ranged between 0.4% and 0.44% (Ingabire and Vasanthakaalam, 2011). Deep OFSP were discovered richer in potassium, calcium, iron and Zinc (Kivuva et al., 2014). Regular study of the protein, fibre, fat and ash content among other physicochemical properties is essential in determining the nutritional value of the different popular sweetpotato varieties as determined by location of cultivation and genetic properties.

Carotenoids possess several effects that promote good health: they enhance immunity and reduce the risk of developing degenerative diseases like cataract, many cancers, muscle degeneration and diseases of the cardiovascular system (Carvalho et al., 2012).The orange flesh cultivars of sweetpotato have high levels of beta-carotene, the precursor to Vitamin A (Low et al., 2007).Some raw roots of Kenyan OFSP varieties have recorded between 1240 and 10800µg/100g fresh weight beta carotene content (Kidmose et al., 2007). Beta carotene content normally varies depending on cultivar and the environmental conditions where sweetpotato were grown (Niringiye et al., 2014), thus the need to assess different varieties.

Sweetpotato roots can be processed into flour to increase their postharvest shelf life for extended use in processing various food products (Olatunde et al., 2016). A study of the pasting profiles of these flours from different varieties is an important guide in determining end use in food applications (Li et al., 2014). Pasting properties (peak viscosity (PV), hot paste viscosity (HPV), cold paste viscosity (CPV), final viscosity (FV) breakdown viscosity (BD) and setback viscosity (SBV) of flour may indicate the extent to which molecular degradation has occured and paste viscosity degree as well as stability of starch (Olatunde et al., 2016). Starch from sweetpotato has been found to have high free swelling ability (Tsakama et al., 2011). Starch of good quality usually has high viscosity while low viscosity could be an indication that some degree of degradation occured during processing (Tsakama et al., 2011). Although pasting profiles of sweetpotato flour can be used to determine their end use in food processing, information on systematic evaluation of popular varieties in Kenya and Uganda is limited. The current study was carried out to evaluate the physicochemical properties and flour pasting profiles of eight selected sweetpotato varieties to determine their suitability for extended use in food processing.

4.3 Materials and Methods

4.3.1 Materials acquisition

Fresh sweetpotato roots of four varieties, Kenspot 4, Kabode, Vitaa and Sallyboro were obtained from the Kenya Agricultural and Livestock Research Organization (KALRO) farm in Kitale in March 2016 at four months' maturity, while the roots of Kawogo, Zidamukooti, Kyebadula and Dimbuka varieties were obtained from the Uganda National Agricultural Research Organization (NARO) farm in Kampala in April 2016 after harvesting at five months' maturity (Table 4.1 and figure 4.1). These were wrapped in polyethylene bags and sealed in carton boxes then transported within 24hours to the University of Nairobi for analyses at the Food Science, Nutrition and Technology laboratories.

Table 4. 1: Physical characteristics of eight sweetpotato varieties from Kenya and Uganda

Variety name	Site collected from	Skin color	Flesh color
Kenspot – 4	KALRO Kitale, Kenya	Purple	Light orange
Kabode	KALRO Kitale, Kenya	Purple	Deep orange
Vitaa	KALRO Kitale, Kenya	Purple	Orange
Sallyboro	KALRO Kitale, Kenya	Cream pink	Orange
Kawogo	Kampala, Uganda	Purple	Very light yellow
Zidamukooti	Kampala, Uganda	Light brown	White
Dimbuka	Kampala, Uganda	Light brown	Pale yellow
Kyebadula	Kampala, Uganda	Purple	White

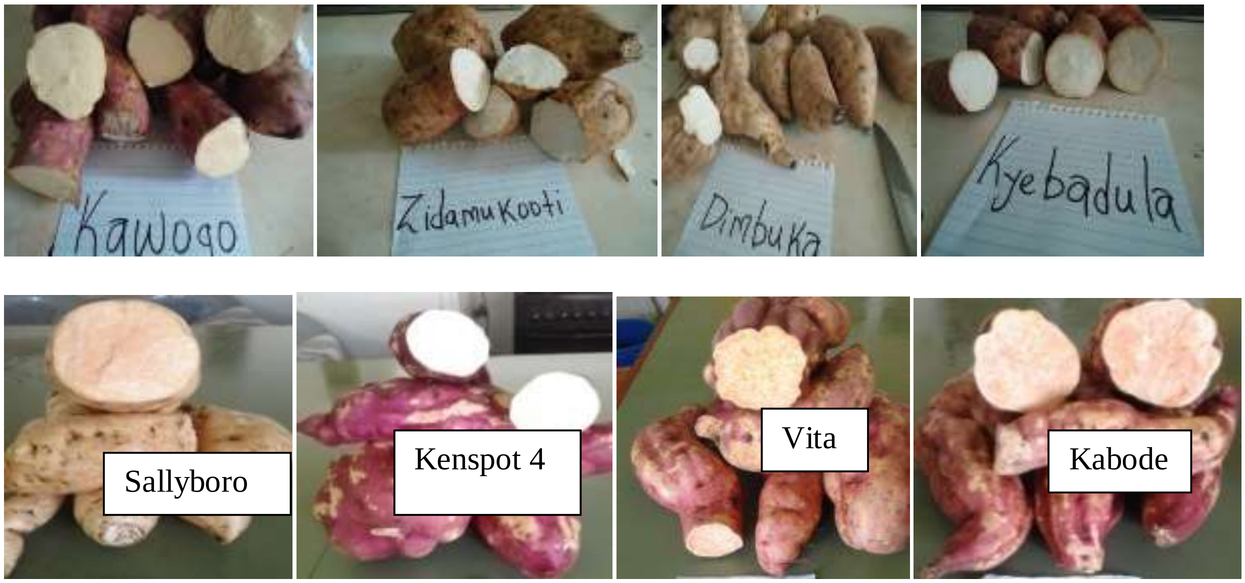


Figure 4. 1: Physical appearance of eight sweetpotato varieties from Kenya and Uganda

4.3.2 Experimental design

The experimental design applied in this section was a complete randomized design of the three replication effect. Each of the eight varieties of sweetpotato were analyzed for beta carotene, reducing sugars, starch content, flour pasting profiles and for proximate composition.

4.3.3 Samples preparation for analyses

Sweetpotato roots from each variety were peeled and finely grated to obtain composite samples of each variety. These were used to analyze moisture content, beta carotene, reducing sugars and starch content accordingly. Grated sweetpotato samples were oven dried at 45^{o}C for 16hours then milled into flour. The flour was then kept in air tight polyethylene bags ready for analysis. These were used for proximate analyses and to test pasting profiles.

4.3.4 Reagents used

All the reagents used were of analytical grade and were obtained from Sigma-Aldrich chemical company.

4.3.5 Analytical methods

4.3.5.1 Determination of moisture content

Moisture content of raw sweetpotato was determined as per the procedure of AOAC 2005 method number 925.09B. About 2 grams of composite sample of each variety was dried in the air oven set at a temperature of 105ºC for about 5hours, cooled in a desicator and weighed again until a constant weight was attained. Moisture content was calculated as the weight loss due to evaporated water.

4.3.5.2 Determination of crude protein content

Crude protein content was determined by the micro-Kjeldahl distillation technique as per the procedure of method number 955.04 of AOAC 2000. 0.5g sample were weighed, folded in nitrogen-free filter paper and put in to the Kjeldahl flask. A catalyst tablet was added. Sulphric acid was added carefully for sample digestion to release nitrogen. NaOH was added for neutralization. Back titration was done using 40% NaOH against 0.1N NaOH solution. Phenolphthalein indicator was used to determine end point. Crude protein content was then calculated from the nitrogen content of sample using the coversion factor of 6.25. Figure 4.2B shows the titration stage to pink end point in protein determination process.

4.3.5.3 Determination of crude fiber content

Crude fiber was determined using sulphuric acid and potassium hydroxide as per AOAC 2000 standard method number 962.09.

4.3.5.4 Determination of crude fat content

Crude fat content was determined by Soxhlet extraction, using the AOAC 2000 standard method no. 954.02 of. Approximately 5g composite samples in a thimble per variety were used to extract crude fat using analytical grade petroleum ether (boiling point 40-60ºC) in soxhlet extraction apparatus for 16 hours (Figure 4.2C). A rotary vacuum evaporator was used to evaporate the petroleum ether and the residual oil dried in an air-oven set at 105°C for 1hour. The weight of the residue was calculated as percent fat content.

4.3.5.5 Determination of ash content

Ash content was determined as per the AOAC 1990 official methods number 923.03. About 20g of sweetpotato composite root samples were weighed into previously weighed crucibles and placed in the muffle furnace (600°C) for 2h. The crucibles were cooled and reweighed. The remaining weight was taken as the ash content and the percent ash content calculated.

4.3.5.6 Determination of total carbohydrates content

The total carbohydrate was determined by difference; Total carbohydrate = 100 - (%fat + % protein + % moisture + % ash + % fiber) (Oladebeye et al., 2009).

4.3.5.7 Determination of starch content

Starch from fresh roots was obtained as per the method of Ikegwu et al., (2009). Roots were washed, manually peeled, grated then processed in a laboratory blender, sieved using muslin cloth, sedimented, decanted and dried. Starch content were then calculated as a percentage of the sample weight.

4.3.5.8 Determination of beta carotene content

Approximately 2g composite sample of roots of each sweetpotato variety were used to estimate the β-carotene content using the UV spectrophotometric method based on the procedure of Luff-schoorl method No. 44 of the IFFJP (1972).

4.3.5.9 Determination of mineral content

In determining Mineral content, Copper (Cu), Zinc (Zn), Calcium (Ca) and Iron (Fe) were measured by the Atomic Absorption spectrophotometer (AAS) while Flame photometry was used for analysis of Sodium (Na), Potassium (K), Phosphorous (P) and Magnesium (Mg) after samples undergoing acid digestion as per the AOAC 2003 official methods (Aywa et al., 2013).

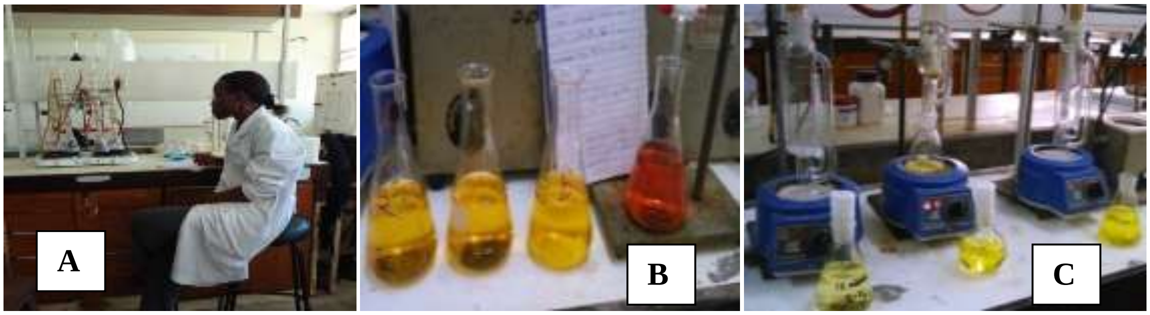


Figure 4. 2: Photos of some laboratory processes in the proximate analyses

A-Reflux condensing stage in reducing sugars content determination; B- Titration stage from pink to golden yellow in crude protein content determination; C-Soxhlet extraction apparatus in crude fat content determination.

4.3.5.10 Reducing Sugars determination

Reducing sugars content were established from 10g of sample by theLuff-schoorl method No. 4 of the IFFJP (1968). Figure 4.2A shows some steps in the reducing sugars determination of the composition of sweetpotato samples.

4.3.6 Sweetpotato flour pasting profiles determination

Pasting profiles were determined using the Brabender® (Duisburg Nr. 175508, type 800101, West Germany). About 50g flour suspension in 450 ml of distilled water in aluminium can were subjected to heating from 30 to 95^{o}C in 3.5minutes and held at 95^{o}C for 2.5minutes with constant stirring at 160rpm speed, cooled back to 50^{o}C in 4minutes and held at 50^{o}C for 2minutes. Gelatinization time(minutes), gelatinization temperature (^{o}C), peak viscosity(PV), peak viscosity temperature, peak viscosity time, hot paste viscosity(HPV), breakdown viscosity (BDV) and cold paste viscosity(CPV) were recorded. Viscosity was recorded as centipoises (cP).

4.3.7 Statistical analysis

All statistical analyses were performed using Genstat software 15th Edition. Data were subjected to analysis of variance (ANOVA) to determine means and standard deviation for significant differences at $p<0.05$. Duncan's multiple range test was performed to establish significant differences in means of the physicochemical properties of the eight sweetpotato varieties. Correlations between the physicochemical properties and pasting properties were also established.

4.4Results and Discussion

4.4.1 Physicochemical properties of sweetpotato varieties

4.4.1.1 Moisture content

Table 4.2 shows the physico-chemical properties of the eight sweetpotato varieties on dry weight basis. Moisture contents among the varieties differed significantly ($p<0.001$) and ranged from 60.3±0.42% to 72.50±0.71%.The non-orange fleshed varieties (Kawogo, Dimbuka, Kyebadula and zidamukooti) in the current study recorded significantly ($p<0.001$) lower moisture content values (60% - 62%) than the orange fleshed varieties (Kenspot 4, Kabode, Vitaa and Sallyboro) which showed moisture content of 65% to 72%.These differences can be attributed to the agronomic practices, environmental factors and inherent variety differences (Nabubuya et al., 2012).These values are within ranges reported in another study (Wheatley and Loechl, 2008). Lower dry matter (<25%) of the orange fleshed varieties can negatively influence their acceptability and production by farmers (Rukundo et al., 2013). Higher dry matter content in the white fleshed and pale yellow varieties is responsible for the roots staying firmer with drier and mealier textures if cooked than the roots with orange flesh (Thottappilly and Loebenstein, 2009). The acceptable levels of root DM by consumers is lower in South African countries than in Eastern Africa; about 27% and 30% respectively (Wheatley and Loechl, 2008).

Table 4. 2: Physicochemical properties of eight sweetpotato varieties from Kenya and Uganda

Variety	Moisture %	Protein %	Fat %	Fiber %	Ash %	Carbohydrates %	Starch (% DM)	β carotene (mg/100g)
Kenspot – 4	65.50±0.71^{c}	2.01±0.04^{a}	4.95±0.21^{b}	4.03±0.04^{b}	3.10±0.14^{c}	59.20±1.05^{cd}	49.57±0.42^{d}	2.12±0.01^{c}
Kabode	72.50±0.71^{e}	3.18±0.11^{b}	3.8±0.14^{b}	4.33±0.25^{bc}	3.90±0.28^{d}	44.70±0.78^{a}	54.55±0.42^{bc}	12.76±0.00^{e}
Vitaa	72.00±0.00^{e}	2.15±0.35^{ab}	3.45±0.21^{b}	3.60±0.14^{a}	3.88±0.32^{d}	53.30±0.39^{ab}	50.85±0.21^{ab}	15.82±0.01^{f}
Sallyboro	68.50±0.71^{d}	2.75±0.21^{ab}	3.50±0.14^{b}	3.55±0.21^{a}	3.60±0.14^{cd}	57.50±0.00^{bc}	41.43±0.21^{a}	6.00±0.01^{d}
Kawogo	67.70±0.42^{d}	3.00±0.21^{ab}	0.73±0.21^{a}	4.18±0.13^{b}	1.25±0.08^{b}	71.70±0.42^{d}	43.34±0.71^{ab}	0.34±0.00^{b}
Zidamukooti	60.30±0.42^{a}	4.59±0.82^{c}	0.65±0.46^{a}	4.70±0.14^{d}	0.60±0.06^{b}	73.50±087^{e}	41.44±0.21^{cd}	0.83±0.01^{a}
Dimbuka	62.05±0.35^{b}	2.16±0.17^{ab}	0.35±0.21^{a}	6.45±0.15^{e}	0.93±0.77^{ab}	73.97±0.95^{e}	38.70±0.04^{b}	0.29±0.01^{b}
Kyebadula	60.60±0.28^{a}	2.74±0.74^{ab}	0.58±0.28^{a}	4.63±0.08^{cd}	0.23±0.06^{a}	79.26±1.44^{e}	51.73±0.18^{e}	0.18±0.01^{a}
% CV	0.8	15	11.2	3.5	14.7	3.8	2.3	0.7
Grand mean	66.14	2.82	2.25	4.43	2.18	22.17	15.62	1.36
S.E	0.51	0.42	0.25	0.16	0.32	0.85	0.36	0.01
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Results are means of duplicates ±SD. Values in the same column followed by different alphabetical letter superscript are significantly different at p≤0.05

4.4.1.2 Protein content

Protein contents of the eight varieties significantly ($p<0.05$) differed from 2.01±0.04to 4.59±0.82% (dwb) irrespective of the flesh colour. The differences can be attributed to variety of sweetpotato and environment where the roots were grown (Kivuva et al., 2014). The results reveal that these eight varieties are poor sources of dietary protein thus, need for other sources to supplement sweetpotato in the diet. Though low, the protein in sweetpotato is considered of high biological value due to its high lysine content (Sgroppo et al., 2010). These values are within those reported in other studies, 3.5-9.5% (Kivuva et al., 2014).

4.4.1.3 Fat content

Fat content (dwb) among varieties were significantly ($p<0.001$) different ranging from 0.35±0.21% to 4.95±0.21%. The orange fleshed varieties recorded significantly ($p<0.001$) higher fat contents (3.45 – 4.95%) while the yellow and white fleshed varieties recorded fat contents of less than one percent. The differences can thus be linked to variety. This shows that the varieties used in the present study are also poor sources of dietary fat. Dietary fat is essential for enhancing the bio-efficacy of beta carotene in the body (Oloo et al., 2014). Perhaps the roots can be prepared with methods that require additional fat in cooking. Fat content of the orange-fleshed varieties in the current study are higher than values recorded in another study of three varieties (Oloo et al., 2014) but the values for the white and yellow fleshed are within ranges recorded for Tanzanian six varieties (Lyimo et al., 2010).

4.4.1.4 Fiber content

Fiber content (dwb) ranged from 3.55±0.21% (Sallyboro) to 6.45±0.15% (Dimbuka). The white and yellow fleshed varieties in the current study recorded significantly ($p<0.01$) higher fiber contents than the orange fleshed varieties. The orange fleshed sweetpotatoes are improved varieties with less fiber which is a desirable characteristic by consumers. This implies that the eight varieties are good sources of dietary fiber especially the white and yellow fleshed ones and can provide sufficient daily requirements. Fiber is essential in the body for the well-functioning of the digestive system. Adequate intake of dietary fiber has been associated with low risk of developing digestive disorders, colon cancer, diabetes and coronary heart conditions among others (Oladebeye et al., 2009). The fiber contents in this study were however, higher than those of four china varieties (Ji et al., 2015) and three Kenyan varieties (Oloo et al., 2014).

4.4.1.5 Ash content

Ash content (dwb) varied significantly ($p<0.01$) from 0.23±0.06% (Kyebadula) to 3.90±0.28% (Kabode). White fleshed varieties had the least ash content, followed by yellow fleshed varieties. Orange fleshed varieties had, significantly ($p<0.01$), the highest ash content. The difference was significant ($p<0.01$) between Kenyan varieties and Ugandan varieties. There was no significant difference ($p>0.05$) among the four Kenyan varieties likewise among the Ugandan varieties. The differences reported are probably due to different geographical locations where the roots were grown and differences of variety. The ash content values were within findings reported on three Kenyan varieties (Oloo et al., 2014), six varieties in Tanzania (Lyimo et al., 2010) and four varieties in China (Ji et al., 2015). The ash content usually indicates the presence of mineral elements deposited in the roots (Antia et al., 2006). This possibly explains why the orange fleshed varieties are a better source of minerals than the white and yellow varieties. Minerals are very essential for the proper functioning of the nerves and heart, for building strong bones and maintenance of the composition of the body fluid (Sanoussi et al., 2016; Chaney 2006). A deficiency of micronutrients (hidden hunger) namely vitamins and minerals is a global problem affecting about three billion people (Sanoussi et al., 2016; FAOSTAT 2017) and this can be well combated through dietary means.

4.4.1.6 Carbohydrates content

Carbohydrate contents (dwb) were in the ranges of 44.70±0.78% (Kabode) to 79.26 ±0.87% (Kyebadula) with significant ($p<0.001$) differences among the varieties. On fresh weight basis, these were 12.30% to 31.23% which is in agreement with a general observation (Nyambok et al., 2011). Carbohydrates contents of Orange fleshed varieties were comparably lower than the yellow and white fleshed varieties (Table 4.2). Carbohydrates are the main constituents of the dry matter in sweetpotato (Nabubuya et al., 2012) and these particular carbohydrates in sweetpotato are found to be of low glycemic index (Fetuga et al., 2014). Carbohydrates are a rich source of energy hence the white and yellow flesh varieties in this study can be preferred over the orange fleshed in cases where high carbohydrates are required.

4.4.1.7 Starch content

Starch content (dwb) in the varieties in the current study differed significantly ($p<0.001$), ranging from 41.43±0.21% in Sallyboro to 54.55±0.18% in Kabode (Table 4.2). Kabode, kyebadula, vitaa and kenspot 4 had high starch contents, in descending order. Dimbuka variety had the least starch content; it requires about 1.4 times the given quantity of Kabode variety to get the same amount of starch from Dimbuka variety. Starch values in the current study are however lower than those reported by another research (Nabubuya et al., 2012). Starch is important in industrial use for both food and non-food applications (Tsakama et al., 2011). Nearly 9% of the world's starch production is derived from sweetpotato, and this comes third after cereals and cassava (Mais et al., 2014). It is therefore important that high starch yielding sweetpotato varieties are selected since twice as much sweetpotato is required to produce same amount of starch as cassava (Mais et al., 2014).

4.4.1.8 Beta carotene content

Beta carotene content (dwb) in the study ranged from 0.18±0.01mg/100g (Kyebadula) to15.82±0.01mg/100g (Vitaa) with significant ($p<0.001$) differences among the varieties. The non-orange fleshed varieties had less than 1mg/100g beta carotene. The differences are inherent in the varieties. The ranges are within the beta carotene levels (0.43mg/100g to 18.37mg/100g on dry weight basis) found in nine varieties in Uganda (Niringiye et al., 2014). The current results imply that orange fleshed varieties (Kabode, vita, kenspot 4 and sallyboro) are a more reliable source than white and yellow fleshed for dietary supply of beta carotene thus their consumption should be greatly encouraged. Beta carotene is an important pro-Vitamin A carotenoid (pVAC) found richly in orange fleshed sweetpotato varieties (Burri, 2011) and converts to Vitamin A in the body once absorbed (Kidmose et al., 2007). Vitamin A is an essential micronutrient required in the body for prevention of poor night vision, growth, development, genes expression and some immune functions (De Moura et al., 2015; Rando, 1990; West et al., 1991). Unfortunately, this vitamin's deficiency is very prevalent in the sub-Saharan Africa (Low et al., 2007). It has been reported that over 80% of Vitamin A intake in developing countries is from plant sources (Kidmose et al., 2007; Burri, 2011; van den Berg et al., 2000; WHO, 2017). The consumption of orange fleshed varieties with higher beta carotene levels like vita, Kabode and sallyboro should therefore be promoted since they are a cheaper and easily accessible source of pro-Vitamin A carotenoids unlike meat and fish (Kidmose et al., 2007; van den Berg et al., 2000).

4.4.1.9 Reducing sugars content

Reducing sugars content (Figure 4.3) varied significantly ($p<0.01$) from 0.85% (Dimbuka) to 4.45% (Vitaa). Orange fleshed varieties had higher reducing sugar contents of 1.75% and above. The differences in sugar levels could be due to the growth environment and the genetic makeup of the varieties. Reducing sugars influence the color, texture and other functional properties of sweetpotato flour and starches (Nabubuya et al., 2012). High Reducing sugars and low starch contents in roots favour oxidation reactions during frying or drying yielding darker brown products with some bitter tastes (Rukundo et al., 2013). Higher levels of reducing sugars increase the intensity of brown color of fried and baked sweetpotato products due to the Maillard's reaction with the amino acids in the sweetpotato (Nabubuya et al., 2012). Kyebadula and kenspot 4 can offer better quality fried or baked products since they possess a combination of both high starch and low reducing sugars content.

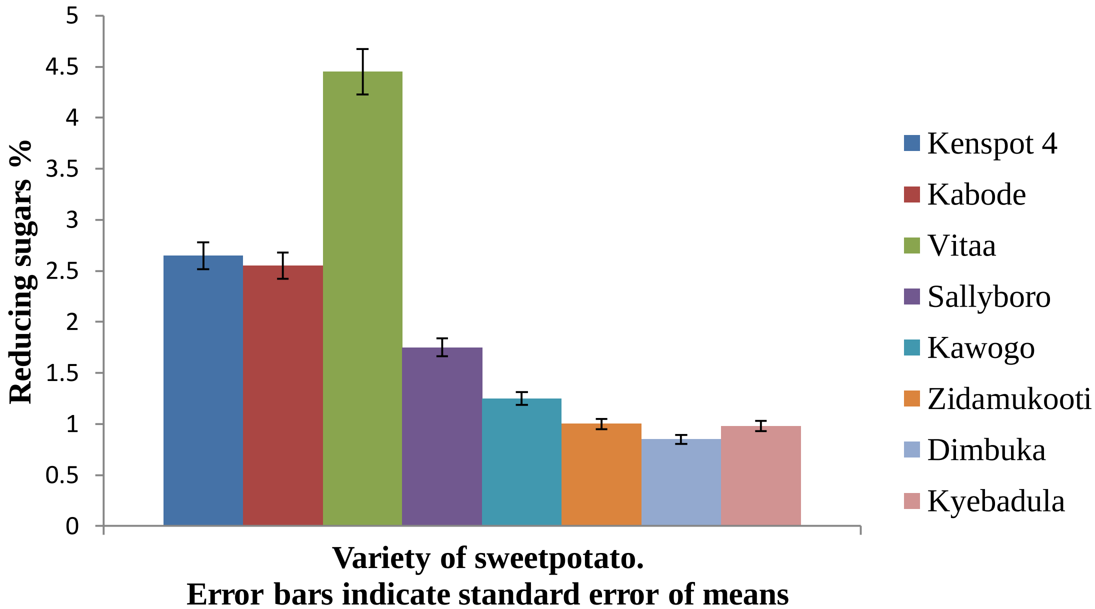


Figure 4. 3: Reducing sugars content of eight sweetpotato varieties

4.4.1.10 Mineral composition

4.4.1.10.1 Potassium content

Table 4.3 displays the mineral composition of the eight sweetpotato varieties used in the current study. Potassium (K) level was the most abundant (ranging from 199.5±2.12 mg/100g in Kyebadula to 657.5±10.61mg/100g in Sallyboro) among all the minerals in all the varieties compared to other minerals. Potassium levels in the orange-fleshed varieties in the current study were significantly ($p<0.001$) higher than in the yellow and white-fleshed varieties. These levels are, however, lower than those reported in one study (Aywa et al., 2013) though the values in the white and yellow fleshed are within results of other researches (Kivuva et al., 2014). Potassium (K) levels were also reported to be the highest (308.67 – 328.67mg/100g) in another study among the minerals in ten elite sweetpotato landraces of Benin (Sanoussi et al, 2016). TheWorld Health Organization recommended daily intake of potassium is 2000mg and 1600mg for adults and chidren respectively. Potassium consumption is important in neurotransmission and heartbeat regulation (Sanoussi et al, 2016; Alinnor and Oze, 2011) and in higher amounts, increases iron utilization in the body (Sanoussi et al, 2016; Nair et al., 2013). Consumption of 100g of the varieties in this study can supply about 13% to 42% of daily requirement.

4.4.1.10.2 Sodium content

Sodium (Na) levels (ranging 61.9±10.82 mg/100g in Zidamukooti to 137.7±0.49mg/100g in Kawogo) were second highest in the mineral composition as shown in table 4.3**.** The differences were significant ($p<0.001$) among the varieties with orange fleshed varieties posting higher values. Differences in sodium levels could be due to variety and soils where they were grown. These values were higher than levels reported in ten varieties (29.0 – 34.0mg/100g) in Benin (Sanoussi et al, 2016). Sodium is one of the major nutrients required by the body for its role in maintaining electrolyte balance of body tissues and regulating of body fluids (Alinnor and Oze, 2011). The World Health Organization recommends daily sodium intake of 400mg for children and 500mg for adults (Adjatin et al., 2013). High consumption of sodium has been associated with high urinary calcium levels and can therefore accelerate osteoporosis for individuals on low-calcium diet. High sodium intake has also been associated with elevated levels of blood pressure which is a potential risk to cardiovascular disease (Mozaffarian et al., 2014). The roots in this study are suitable for consumption even for individuals on low sodium diet.

4.4.1.10.3 Magnesium content

Magnesium (mg) levels were significantly ($p<0.001$) lower in the non-orange fleshed varieties (0.04 – 0.21mg/100g) than in the orange fleshed varieties (47.1 – 59.02mg/100g) as shown in Table 4.3. The huge differences can be attributed to variety and the soils where the roots were grown. The orange fleshed varieties are therefore a better source of magnesium compared to the white and yellow fleshed varieties.

Table 4. 3: Mineral content of eight sweetpotato varieties from Kenya and Uganda

Variety	Na (mg/100g)	Mg (mg/100g)	Ca (mg/100g)	Fe (mg/100g)	P (mg/100g)	K (mg/100g)	Zn (mg/100g)	Cu (mg/100g)
Kenspot 4	107.2±0.49^{c}	51.50±4.95^{b}	95.15±0.21^{b}	0.61±0.06^{c}	36.17±0.11^{a}	526.5±68.59^{a}	0.12±0.01^{a}	0.03±0.00^{ab}
Kabode	106.5±1.34^{c}	59.02±1.73^{c}	96.75±1.06^{c}	0.68±0.00^{c}	34.90±0.14^{a}	598.0±2.83^{d}	0.12±0.00^{a}	0.29±0.02^{c}
Vitaa	112.1±0.57^{c}	47.10±0.57^{b}	97.75±0.35^{d}	0.58±0.00^{c}	42.75±0.35^{b}	576.0±1.41^{bc}	0.13±0.00^{a}	0.02±0.00^{ab}
Sallyboro	107.2±0.71^{c}	50.20±0.42^{b}	104.9±0.14^{e}	0.40±0.03^{b}	45.10±0.14^{b}	657.5±10.61^{e}	0.61±0.71^{a}	0.03±0.00^{ab}
Kawogo	137.7±0.49^{d}	0.21±0.04^{a}	0.30±0.14^{a}	0.17±0.06^{a}	85.25±1.10^{c}	277.1±3.75^{b}	0.14±0.06^{a}	0.03±0.03^{ab}
Zidamukooti	61.9±10.82^{a}	0.37±0.03^{a}	0.41±0.04^{a}	0.24±0.04^{a}	44.75±1.48^{b}	221.4±3.89^{ab}	0.11±0.04^{a}	0.06±0.02^{b}
Dimbuka	69.05±1.06^{ab}	0.27±0.18^{a}	0.40±0.18^{a}	0.22±0.11^{a}	45.05±1.48^{b}	195.6±0.64^{a}	0.13±0.10^{a}	0.00±0.00^{a}
Kyebadula	81.4±3.11^{b}	0.04±0.01^{a}	0.08±0.01^{a}	0.20±0.08^{a}	34.75±1.48^{a}	199.5±2.12^{a}	0.03±0.01^{a}	0.00±0.00^{a}
% CV	4.1	7.2	0.8	15.2	2.2	6.1	149.1	24
Grand mean	97.9	26.09	49.47	0.385	46.09	406.5	0.17	0.06
S.E	4.05	1.87	0.41	0.06	1.0	24.65	0.25	0.01
Fpr	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
RDA for adult (mg/day**)**	500	350	800	15	800	2000	15	
Contribution to RDA for children (%)	15.5 – 34.3	0.02 – 34.7	0.01 -13.1	1.7 – 6.8	4.34 – 10.66	12.2 – 41.1	0.3 – 6.1	
Contribution to RDA for adult (%)	12.4 – 27.4	0.01 – 16.9	0.01 – 13.1	1.13 – 4.53	4.34 – 10.66	9.8 – 32.9	0.2 – 4.1	

Results are means of duplicates ±SD. Values in the same column followed by different alphabetical letter superscript are significantly different at $p \leq 0.05$

Magnesium levels range of 12.20 – 30.40mg/100g has also been reported in other studies elsewhere (Ukom et al., 2009). Magnesium is important in the body for metabolism of calcium and formation of bones (Semassa et al., 2016; Alinnor and Oze., 2011). Magnesium is also known to prevent other several health issues including congetinal malformations, bleeding disorders, impaired spermatogenesis, immunologic dysfunction, retarded growth, degeneration of muscles, atrophy of the gonads and diseases of the circulatory system among others (Andzouanna and Monbouli, 2012). The World Health Organization recommended dietary allowance (RDA) for magnesium is 350mg/100g and 170mg/100g for adults and children respectively (Adjatin et al., 2013). The orange- fleshed varieties in this study can supply upto 17% and 35% of RDA magnesium in adult and children respectively while the non-orange fleshed varieties can supply less than one percent of RDA for both children and adults. The non-orange fleshed varieties are thus poor source of magnesium.

4.4.1.10.4 Iron content

Iron (Fe) contents (Table 4.3) in orange fleshed varieties (0.4- 0.68mg/100g) were significantly ($p<0.001$) lower than in the white and yellow fleshed varieties (0.17-0.24mg/100g). The differences in Fe content could be attributed to variety of sweetpotato and Fe content in soils where they were planted (Aywa et al., 2013). Iron content levels in the white and yellow-fleshed varieties were lower than those reported elsewhere though the orange fleshed values were within the reported range (Sanoussi et al, 2016). RDA for iron is 10mg/day for children and adults while female adults require 15mg/day (Alinnnor and Oze., 2011). The orange fleshed varieties in this study can supply between 4.0 - 6.8% while the non-orange fleshed varieties can supply between 1.7- 2.4% of RDA. Another study found out that the contribution of OFSP varieties was about 7.1% (0.71mg /100 g) and white fleshed sweetpotato varieties about 3% (0.3mg/100g) iron to the diet of children agedfour to eight years (Leighton et al., 2010). Iron is one of the micronutrients whose dietary deficiency is a global health concern (Kivuva et al., 2014; Woolfe 1992). Young children require high iron levels because of their rapid growth stage and it is during these early years that the central nervous system undergoes rapid development (Domello¨f et al., 2014). Iron is required by the body for blood formation to prevent anaemia especially among the vulnerable groups like pregnant women, nursing mothers, infants and the elderly (Alinnor and Oze., 2011). Orange fleshed varieties in this study have the ability to supply higher dietary iron content than the non-orange fleshed varieties though the amounts are far below the daily requirements. To meet the daily requirements of iron, consumption of these roots need to be supplemented by other iron rich foods.

4.4.1.10.5 Zinc content

There were no significant differences ($p>0.05$) among the varieties in values of Zinc (0.03 – 0.61mg/100g). The varieties in this study can supply about 0.2 – 6.1% of RDA Zinc.The findings imply that the sweetpotato varieties were generally very low sources of dietary zinc. Dimitropoulou et al., 2008 reported that the concentration of zinc was found highest in the brain compared to other parts of the body. Zinc is an essential trace mineral whose importance can not be underestimated since it plays an important role in cell division (Yanagisawa, 2004), synthesis of proteins, maturation of cells, sexual functions and general immunity among other roles (Semassa et al., 2016; Sandstead et al., 1998). Zinc also is vital in replication of DNA as well as antioxidant properties (Dimitropoulou et al., 2008). Deficiency of zinc can be characterized by retarded growth and cell development, skin rashes, depression, baldness, delayed wound healing, suppressed immunity, impaired sense of taste and delays in sexual maturation (Lokoruka, 2012). Populations at risk of zinc deficiency include the eldery above 60years, expectant and nursing women, infants and children, strict vegeterians and the sickle cell anaemic (Yanagisawa, 2004). In order for populations to obtain adequate dietary zinc they must therefore obtain it form other sources like seafoods, animal meats, legumes and nuts (Lokoruka, 2012).

4.4.1.10.6 Calcium content

Calcium (Ca) level in non-orange fleshed varieties ranged from 0.08 to 0.41mg/100g while in the orange fleshed varieties it ranged from 95.15 to 104.9mg/100g (dwb). The differences among the non-orange fleshed varieties were insignificant ($p>0.05$) while the differences among the orange-fleshed varieties were significant ($p<0.001$). Differences in calcium content are probably due to variety of sweetpotato. This finding is in agreement with Leighton's observation that orange fleshed varieties were higher in calcium content than white fleshed varieties (Leighton, 2010). Ca content differences may also be due to the level of other nutrients in the soil. For instance, lower level of Ca in sweetpotato has been attributed to high levels of K and Fe in the soil which lower the uptake of Ca by the roots (Aywa et al., 2013). Calcium is needed for teeth and bone formation, blood clotting in addition to its role in muscle contraction among other functions in the body (Senga et al., 2013). The orange fleshed varieties in the current study are therefore better sources of dietary calcium than the non-orange fleshed varieties even though the contribution is between 11.9% - 13.1% of daily calcium requirements. The World Health Organization of the United Nations stipulates a daily calcium intake of 8000mg/kg for both children and adults (Semassa et al., 2016).

4.4.1.10.7 Copper content

Table 4.3 shows that copper was below detectable levels in Dimbuka and Kyebadula varieties. It was significantly higher ($p<0.001$) (0.02 – 0.29mg/100g) in the other six varieties with Kabode variety recording the highest level. These findings are within ranges reported in other studies (Aywa et al., 2013). This could mean that even the soils where the roots were grown could be poor in copper content. Copper (Cu) is nutritionally required in conjunction with iron (Fe) for the red blood cell formation and healthy functioning of the nerves and the immune system (Aywa et al., 2013). The WHO recommended dietary allowance for copper is 3mg per day for adults and 2mg per day for children (Adjatin et al., 2013). These varieties are generally poor sources of copper as they can contribute between 0.7%-10% in adults and 1% - 15% in children of RDA.

4.4.1.10.8 Phosphorous content

There were significant ($p \leq 0.05$) differences in phosphorous content, ranging from 34.75mg/100g (Kyebadula) to 85.25mg/100g (Kawogo) as shown in table 4.3. These levels are relatively low considering their ability to contribute about 4.3-11% of the recommended dietary allowance of 800mg/day phosphorous. Low or high phosphorous content in the sweetpotatoes could be a result of low or high phosphorous in the soil where they were grown due to low or high soil pH (Sanoussi et al, 2016; Laurie et al., 2012).Phosphorous is an essential mineral in the body as it works together with calcium in strengthening of teeth and bones particularly for children and lactating women (Andzouana and Mombouli, 2012).The values in the current study are within those reported in four South African varieties (Leighton et al., 2013).

4.4.1.10.9 Mineral ratios

Table 4.4 shows ratios of selected minerals. The mineral ratio Na/K, Ca/Mg and Ca/P of foods has been used to determine their potential health benefits when consumed. The Na/K ratio ranged from 0.16 to 0.50. The ratio Na/K of less than 1 is essential in control of high blood pressure (Alinnor and Oze, 2011). All the eight varieties are therefore suitable as they have a Na/K ratio of less than 1. Ca / P ratio ranged from 0.00 to 2.77. Ca/P ratio of greater than 1 is best since it fosters calcium absorption in the small intestines (Adjatin et al., 2013). The orange fleshed varieties in this study are therefore the best for posting Ca/P ratio above 2 while the non-orange fleshed had the ratios less than 1. Ca/Mg ratio ranged 1.11 to 2.09. A value of 1 is usually recommended since magnesium is vital in calcium metabolism in bones (Sanoussi et al, 2016). All the eight varieties had Ca/Mg ratios exceeding 1 thus other dietary sources for the two minerals can be utilized to balance the ratio.

Table 4. 4: Mineral ratios of the eight sweetpotato varieities

Variety	Ca/P ratio	Na/K ratio	Ca/Mg ratio
Kenspot 4 (orange fleshed)	2.63	0.20	1.85
Kabode (orange fleshed)	2.77	0.18	1.64
Vitaa (orange fleshed)	2.28	0.19	2.08
Sallyboro (orange fleshed)	2.33	0.16	2.09
Kawogo (pale yellow fleshed)	0.00	0.50	1.43
Zidamukooti (white fleshed)	0.01	0.28	1.11
Dimbuka (pale yellow fleshed)	0.01	0.35	1.48
Kyebadula (white fleshed)	0.00	0.41	2.00
Recommended values	>0.5	< 1	1

4.4.2 Pasting profiles of flour from eight sweetpotato varieties

Pasting profiles of flour from the eight sweetpotato varieties are shown in Tables 4.5 and 4.6. Gelatinization (pasting) temperature of the sweetpotato flour varied from 55.50±3.54°C to 75.50±12.02°C with significant variations ($p \leq 0.05$) among the varieties (table 4.5). Orange fleshed varieties in the current study had significantly lower ($p \leq 0.05$) pasting temperatures than the non-orange fleshed, a finding in agreement with that in an earlier study of 10 sweetpotato varieties (Nabubuya et al., 2012). Pasting temperature is the minimum temperature required to gelatinize or cook the flour (Julianti et al., 2015; Kaur and Singh, 2005) and where viscosity increase at its first detectable level is measured (Julianti et al., 2015; Eniola and Delarosa 1981). Lower gelatinization temperature has been associated with greater water availability (Julianti et al., 2015; White et al., 1989). This is observed in the current study where the orange fleshed varieties had higher moisture contents and subsequently lower gelatinization temperatures. Pasting temperature range of 65 to 72°C has been reported in the literature (Mohd et al., 2014). Sweetpotato flours with lower pasting temperatures are likely to have higher amylose content (Olatunde et al., 2016). Pasting temperature is important during processing as it determines the swelling, gelatinization and gel formation (Eke-Ejiofor, 2015). Higher pasting temperatures could mean that the flour possesses great structural rigidity (Mohd et al., 2014; Aprianita et al., 2009). From the results of the current study, the non-orange fleshed varieties kawogo, kyebadula, zidamukooti and dimbuka are likely to possess lower amylose content and smaller starch granules which require higher temperatures in processing.

Table 4. 5: Pasting profiles of flour of eight sweetpotato varieties

Variety	G_{temp} (°C)	G_{time} (min)	P_{temp}(°C)	P_{time}(min)
Vitaa (OF)	55.50±3.54[a]	8.50±0.71[a]	69.50±0.71[a]	10.42±0.04[a]
Kabode(OF)	59.50±2.12[ab]	8.20±0.28[a]	70.50±0.71[a]	10.40±0.14[a]
Sallyboro (OF)	63.95±1.48[abc]	9.60±0.57[ab]	74.00±1.41[ab]	10.75±0.35[a]
Kenspot 4(OF)	64.50±2.12[abc]	10.65±0.49[ab]	75.00±1.41[ab]	12.59±0.57[ab]
Kawogo(PYF)	65.00±4.24[abc]	11.00±0.00[ab]	76.00±2.83[ab]	13.50±0.71[ab]
Kyebadula (WF)	66.00±5.66[a]	13.00±2.83[bc]	79.00±7.07[b]	15.50±3.54[b]
Zidamukooti(WF)	72.00±5.65[bc]	15.00±1.41[c]	78.00±2.83[ab]	15.00±1.41[b]
Dimbuka (PYF)	75.50±12.02[c]	15.50±2.12[c]	86.50±0.71[c]	20.50±2.12[c]
Mean	65.2	11.43	76.06	13.83
CV%	8.6	12.2	3.9	11.4
Fpr	0.105	0.004	0.009	0.002
SE	5.59	1.398	2.99	1.58

Means±SD in the same column bearing same superscripts are not significantly different (P>0.05). **G_{temp}=Gelatinization temperature, G_{time}=Gelatinization time, P_{temp}–Peak temperature, P_{time}-Peak time, OF –Orange fleshed, WF –White fleshed, PYF –Pale yellow fleshed**

Flour from the eight varieties differed significantly ($p<0.05$) on gelatinization time, peak time and peak viscosity temperature. Gelatinization time ranged from 8.20±0.28 to 15.50±2.12 minutes. Kenspot 4, Kabode, vitaa and sallyboro (orange fleshed) varieties had significantly ($p<0.01$) lower gelatinization time than the white and yellow fleshed varieties. Rate of gelatinization is determined by the size of starch granules in the flour since larger granules swell faster and tend to give higher pasting viscosities (Tsakama et al., 2011). Peak time is determined by the rate of water absorption by the swelling granules of starch in the flour (Nabubuya et al., 2012). In the current study, orange fleshed (OFSP) varieties required lesser time (10.40 – 12.59minutes) than that (13.50 –

20.50minutes) required by the non-orange fleshed varieties to reach peak viscosity. OFSP varieties in this study are therefore likely to possess larger starch granules which absorbed water faster. There were significant variations ($p \leq 0.05$) in the flour peak viscosities (PV), hot paste viscosities (HPV), breakdown viscosities (BDV) and cold paste viscosities (CPV)among varieties with orange fleshed varieties exhibiting significantly ($p<0.05$) lower values compared to non-orange fleshed varieties (table 4.6). When gelatinized starch reaches the maximum viscosity during heating in water, this point is referred to as peak viscosity (Tsakama et al., 2011). Lowest peak viscosities (124-590cP) were recorded in the orange fleshed varieties in the present study. Highest peak viscosity was attained by Dimbuka variety (1060±74cP). Higher peak viscosities indicate higher thickening power of the flour in food processing (Eke-Ejiofor, 2015), thus the flour can be a suitable thickening agent. Dimbuka, Kyebadula and zidamukooti flours could be suitably utilized as thickening agents in sauces and soups due to their high peak viscosities.

Table 4. 6: Pasting profiles of flour of eight sweetpotato varieties continued

Variety	PV (cP)	HPV(cP)	BDV(cP)	CPV(cP)	SBV (cP)
Vitaa (OF)	124 ± 2.83^{a}	67 ± 11.3^{a}	57 ± 84.9^{a}	89.5 ± 2.12^{a}	34.5 ± 0.71^{a}
Kabode(OF)	127 ± 1.41^{a}	69 ± 14.1^{a}	58 ± 12.73^{a}	89.5 ± 3.54^{a}	37.5 ± 2.12^{a}
Sallyboro (OF)	141.8 ± 7.42^{a}	73 ± 15.6^{a}	69 ± 8.13^{a}	97 ± 1.41^{a}	44.8 ± 8.84^{a}
Kenspot 4(OF)	590 ± 2.83^{b}	296 ± 76.4^{b}	294 ± 73.5^{b}	319 ± 17^{b}	271 ± 19.8^{b}
Kawogo(PYF)	677.2 ± 126^{bc}	332 ± 19.8^{b}	345 ± 106.4^{bc}	438 ± 12.7^{c}	239 ± 113.5^{ab}
Kyebadula (WF)	809 ± 104^{c}	312 ± 33.9^{b}	497 ± 70^{c}	481 ± 28.3^{cd}	327 ± 75.7^{b}
Zidamukooti(WF)	747 ± 111^{bc}	419 ± 17^{c}	328 ± 128.7^{bc}	527 ± 25.5^{d}	220 ± 137.2^{ab}
Dimbuka (PYF)	1060.5 ± 74^{d}	759 ± 41^{d}	302 ± 33.2^{b}	800 ± 72.1^{e}	261 ± 146.4^{b}
Mean	534	290.9	244	355.1	179
CV%	14	12.1	28.9	8.4	48
Fpr	<0.001	<0.001	0.002	<0.001	0.038
SE	74.8	35.21	70.4	29.83	86.1

Means±SD in the same column bearing same superscripts are not significantly different ($P>0.05$). **PV-Peak Viscosity, HPV-Hot Paste Viscosity, CPV-Cold Paste Viscosity, SBV –Setback Viscosity, BDV –Breakdown Viscosity, OF –Orange fleshed, WF –White fleshed, PYF –Pale yellow fleshed**

Hot paste Viscosity (HPV) is the lowest viscosity that is achieved when the flour paste is held at 95ºC and can be used to indicate the paste's ability to withstand breakdown during cooling (Nabubuya et al., 2012). Dimbuka had the highest value (759cP) while Kabode, vitaa and sallyboro (OFSP) had lowest values (69, 67 and 73cP respectively) of HPV.

Breakdown viscosity (BDV) is the difference between PV and HPV. BDV is an indication of the ease with which the swollen granules in the paste can be disintegrated (Julianti et al., 2015; Kaur and Singh, 2005). Flours from OFSP varieties (Kabode, vitaa, kenspot 4 and sallyboro) exhibited low BDV values (57-294cP). Flours with high BDV like kyebadula, kawogo and zidamukooti are likely to form weaker gels (Nabubuya et al., 2012) since they possess low ability to withstand the heat and shear stress during cooking (Mohd et al., 2014). Such are useful in making pastries. Cold paste viscosity (CPV) is achieved after cooling the paste to 50ºC resulting in gel/paste formation due to the re-association of starch granules (Nabubuya et al., 2012). CPV values were significantly ($p<0.001$) different among the varieties and the differences could be associated with amylose content differences.CPV for the flours were higher than respective PV. High CPV levels show great potential for high retrogradation hence gel formation (Tsakama et al., 2011).

SBV is the difference between CPV and HPV. Low SBV values show a low tendency to retrogradation (Olatunde et al., 2016). Setback viscosities of the eight varieties did not differ significantly. Values of the pasting profiles of flour from these eight sweetpotato varieties were lower than those reported in other ten varieties (Nabubuya et al., 2012). Flours with high SBV like kyebadula, kenspot 4 and Dimbuka are not suitable for products like pie fillings as high retrogradation is likely to cause syneresis (Nbubuya et al., 2012). Flours with high paste viscosities could be suitably utilized as thickeners and stabilizing agents in some food products while flours with low paste viscosities like Kabode, vitaa, sallyboro could be suitable for food formulations like weaning foods (Olatunde et al., 2016; Wiesenborn et al., 1994). Flours with high peak viscosities like dimbuka could be suitable in food applications where high gel strength and elasticity matter and in baked products where volume of product is a very important quality (Nabubuya et al., 2012).

4.4.2.1 Correlations between physico-chemical properties and pasting properties

Correlations between the physico-chemical properties of the sweetpotato tubers and the pasting properties of their flours are displayed in Table 4.7. Significant ($p<0.001$), strong positive correlations ($r= 0.706$ to 0.882) were noted between carbohydrates content and pasting properties of the flours. Significant ($p< 0.01$) strong positive correlations ($r = 0.543$ to 0.789) were also evident between fiber content and pasting properties. This implies that higher contents of carbohydrates and fiber resulted in higher paste viscosities of the flours. Low but significant ($p<0.05$) positive correlations were observed with starch ($r = 0.267$ to 0.522) and phosphorous ($r = 0.052$ to 0.372). Flours with larger size of starch granules were likely to have higher paste viscosities since the granules swell and break faster. Protein content were also positively correlated though low ($r = 0.069$ to 0.304) and insignificant ($p > 0.05$). Reducing sugars (Rs) were negatively and significantly ($p<0.01$) correlated with the pasting properties ($r = -0.536$ to -0.877). Higher levels of Rs in sweetpotato results in low pasting viscosities since Rs have a higher affinity than starch for available water in the flour-water paste thereby reducing the starch swelling ability (Nabubuya et al., 2012). Strong correlations between pasting properties and the chemical components (fiber, protein, fat, carbohydrates, reducing sugars, ash) could probably be reflective of the high solubility of these chemical components. These outcomes likely imply that carbohydrates, fiber, starch and reducing sugars contents in sweetpotato pose a significant effect on the pasting viscosities of the flours.

Table 4. 7: Pearson correlations (r) between physico-chemical and pasting properties of the flours

Chemical properties	BDV	FV	G_{temp}	G_{time}	PV	SBV	TV	P_{temp}	P_{time}
Moisture content	-0.794***	-0.856***	-0.763***	-0.888***	0.820***	-0.760***	-0.781***	-0.761***	-0.821***
Protein	0.069	0.160	0.304	0.23	0.130	0.146	0.121	0.173	0.166
Fat	-0.484*	-0.759***	-0.47*	-0.643**	-0.632**	-0.353*	-0.598**	-0.561**	-0.685**
Ash	-0.824***	-0.851***	-0.627**	-0.834***	-0.830***	-0.700**	-0.713**	-0.702**	-0.806***
Fiber	0.543**	0.789***	0.636**	0.759***	0.769***	0.606**	0.766***	0.724***	0.777***
Carbohydrates	0.864***	0.882***	0.706**	0.879***	0.859***	0.765***	0.750***	0.764**	0.851***
Reducing sugars	-0.635	-0.877	-0.667	-0.731	-0.760	-0.536	-0.698	-0.723	-0.811
Starch	0.522	0.391*	-0.268	0.42*	0.445*	0.494*	0.362*	0.267	0.374*
Sodium (Na)	-0.289	-0.673**	-0.602**	-0.626**	-0.595**	-0.339*	-0.596**	-0.538***	-0.637***
Phosphorous (P)	0.052	0.356*	0.338*	0.313	0.249	0.097	0.372*	0.298	0.329*
Calcium (Ca)	-0.832***	-0.751***	-0.594**	-0.751***	-0.741***	-0.80***	-0.675**	-0.627**	-0.758***
Copper (Cu)	-0.522**	-0.421*	-0.314	-0.38*	-0.412*	-0.412*	-0.291	-0.471*	-0.426*
Potassium (K)	-0.729***	-0.879***	-0.648**	-0.864***	-0.871***	-0.727***	-0.838***	-0.757***	-0.884***
Magnesium (Mg)	-0.73***	-0.697***	-0.498*	-0.724***	-0.692**	-0.659**	-0.584**	-0.523**	-0.706**
Zinc (Zn)	-0.598**	-0.234*	-0.394*	-0.379*	-0.333*	-0.692**	-0.241	-0.388*	-0.298

*significant at P <0.05; **significant at P < 0.01, ***significant at P < 0.001

BDV – Breakdown Viscosity; FV – Final Viscosity; Gtemp – Gelatinization temperature; Gtime – Gelatinization time; PV – Peak Viscosity; SBV – Setback Viscosity; TV – Trough Viscosity; P temp – Peak temperature; Ptime - Peak time

4.4.2.2 Correlation coefficients between pasting properties of the flours

There were significant (p<0.05, p<0.01) strong positive correlations (r = 0.58 to 0.972) among the various pasting properties of the flours (Table 4.8). Increase in gelatinization time resulted in increase in peak temperature, peak time, PV, SBV and TV of the flour.

Table 4. 8: Pearson correlation coefficients between the various pasting properties of the flours

Parameters	BDV	FV	G_{temp}	G_{time}	PV	SBV	TV	Peak temp
FV	0.711**							
Gtemp	0.699**	0.83***						
Gtime	0.759***	0.933***	0.893***					
PV	0.734***	0.931***	0.775***	0.94***				
SBV	0.887***	0.709**	0.799***	0.832***	0.797***			
TV	0.580*	0.92***	0.799***	0.905***	0.882***	0.730***		
Peak temp	0.727***	0.888***	0.911***	0.881***	0.867***	0.792***	0.850***	
Peak time	0.727***	0.972***	0.874***	0.961***	0.945***	0.795***	0.942***	0.903***

*significant at P <0.05; **significant at P <0.01; ***significant at P < 0.001

The various pasting properties had positive interrelationships implying that flours with high peak viscosities had high SBV and TV.

4.5 Conclusion and Recommendation

Variations in the physico-chemical properties of sweetpotatoes are due to the varietal differences and ecological environment where they are grown. The orange fleshed varieties are richer in mineral content than the non-orange fleshed sweetpotato varieties. Pasting viscosities of flours from the orange fleshed varieties are lower than the white and pale yellow fleshed varieties. Pasting viscosities are negatively correlated with all the minerals except for phosphorous which is positively correlated. Great potential lies in blending of sweetpotato flours which are rich in nutrients with other flours with higher paste viscosities for better quality end products in food processing. This will ensure diversification of sweetpotato utilization and prolonged shelf life when processed into flour. Further studies should be done to establish changes in the pasting profiles of the flours stored over a period of time.

CHAPTER FIVE:
EFFECT OF WASHING, PACKAGING MATERIAL AND STORAGE PERIOD ON THE QUALITY OF SWEETPOTATO ROOTS

5.1 Abstract

Sweetpotato storage is rarely practiced in Kenya since most farmers harvest the roots piecemeal on demand. Moreover, many traders have little knowledge on the appropriate conditions for storage. There exists limited information on stability of nutrients of these roots during storage. Kabode (orange fleshed) and Kenspot 2 (white fleshed) varieties of sweetpotato were harvested and subjected to similar storage conditions for 21days to monitor changes in moisture content, starch, reducing sugars, beta carotene and vitamin C. Half of the samples were washed while the similar half were unwashed before storage. Both samples were stored under prevalent storage room conditions (22-24^{o}C, relative humidity 60-70%) and at recommendation temperature of 12-13^{o}C, relative humidity 80-90%. Moisture loss of up to 82.9%(Kabode) and 53.2%(Kenspot-2); starch loss of up to 29.7%(Kabode) and 23.7%(Kenspot 2); reducing sugars increase of up to 286%(Kenspot 2) and 148.4%(Kabode); beta carotene loss of up to 100%(Kenspot 2) and 79.6%(Kabode) as well as vitamin C loss of up to 56%(Kenspot 2) and 62%(Kabode) were found in the current study at the end of 21days of storage. Significantly ($p \leq 0.05$) higher losses were recorded in samples stored at room temperature (22-24^{o}C) with relative humidity 60-70% compared to samples stored at 12-13^{o}C with relative humidity ranging 80-90%. Sweetpotato storage shelf life can therefore be enhanced by storing the roots at temperature 12-13^{o}C and 80-90% relative humidity. Relevant stakeholders in the sweetpotato value chain should work together towards designing and establishing sweetpotato roots storage facilities to increase the commercial viability of the enterprise.

5.2 Introduction

Postharvest loss reduction in food crops needs to be considered as a critical measure in addressing current and future global food shortage (Maalekuu et al., 2014). Root and tuber crops storage is a challenge that requires concerted efforts from all the value chain actors (Ezeocha and Ironkwe, 2017). Sweetpotato roots, after harvest and storage just like several other fresh vegetables, experience nutrient degradation as a result of cellular respiration and oxidation (Bouzari et al., 2014). Proper storage of sweetpotato roots should therefore result in preserving the nutritional and physiological quality (Ezeocha and Ironkwe, 2017; Takavarasha and Rukovo 1989) since the roots still remain active metabolically after being harvested (Vimala et al., 2011). The high content of moisture in these roots especially the orange-fleshed cultivars, contributes to their high perishability nature when they are stored under unfavourable conditions (Andrade et al., 2009). To supply and maintain markets sustainably, up to a year storage of sweetpotato roots is needed (Tomlins et al., 2007). However, storage of the fresh roots is not a common practice in many parts of the world due to their high vulnerability to damage and high perishability as a result of their thin delicate skin besides the flesh moisture content that is high (Vimala et al., 2011; Woolfe1987). In less developed countries, the challenge is compounded by the marginal value of the crop and inadequate resources (Tomlins et al., 2007).Sweetpotato production and the value chain sustainability are thus hindered by lack of storage facilities (Tumuhimbise et al., 2010).In some African countries, farmers in rural areas use traditional ways of storage like pit storage, in-ground storage and platform storage (Ezeocha and Ironkwe, 2017).Sweetpotato storage is generally very low in Kenya since 68% - 90% of farmers had no idea on how to store surplus sweet potato roots(Were et al., 2013). The roots are mainly temporarily stored in gunny bags or spread on the ground at prevailing room temperature. Another researcher (Sugri et al., 2017) states that up to one year shelf-life extension of sweetpotato roots can be realized if proper pre-storage treatments are applied and storage done at temperatures of 12-15°C and relative humidity 80-90%.This study aimed at finding out the effect of storage conditions on the moisture content, starch, reducing sugars, beta carotene and vitamin C in samples of two varieties of sweetpotato roots grown in Kenya.

5.3 Materials and Methods

5.3.1 Materials acquisition

Fresh sweetpotato roots of two popular varieties, Kenspot 2(white fleshed) and Kabode (orange-fleshed), were obtained from the Kenya Agricultural and Livestock Research Organization (KALRO) farm in Kitale at five months maturity. These were wrapped in polyethene bags then transported in a box within 24hours to the University of Nairobi for analyses at the Food Science, Nutrition and Technology laboratories.

5.3.2 Experimental design

A randomized experiment with factorial arrangement of 2x2x3x2 yielding 24 treatment combinations was applied. The roots of each variety were divided into two batches; one batch washed while the other not washed. Each variety from each batch were packaged in three different ways; gunny bag, jute bag and plastic tray before being subjected to two storage regimes; at room temperature (22ºC- 24ºC), relative humidity 60-70% and in a storage chamber at temperatures of 12ºC-13ºC, relative humidity 80-90%. Analyses of moisture, beta carotene, vitamin C, starch and reducing sugars contents in the 24 samples were determined at day one, day seven, day fourteen and day twenty-one.

5.3.3 Reagents used

All the reagents used were of analytical grade and were obtained from Sigma-Aldrich chemical company, Nairobi Kenya.

5.3.4 Proximate analyses

5.3.4.1 Determination of moisture content

Moisture content in raw sweetpotato was determined as per the AOAC 2005 method number 925.09B. About 2 grams composite sample of each variety were dried in air oven at 105^{o}C for 5hours, cooled in a desiccator and weighed again until a constant weight was reached. Moisture content was calculated as a result of weight loss due to evaporated water.

5.3.4.2 Determination of starch content

Starch from fresh roots was obtained as per the method of another study (Ikegwu et al., 2009). Roots were washed, manually peeled and grated. 100g of sample was processed in a laboratory blender, sieved using a muslin cloth, sedimented, decanted and dried. Starch was weighed and recorded as a percentage of the sample weight.

5.3.4.3 Determination of reducing sugars content

Reducing sugars were extracted from 10g of sample by the procedure of Luff-schoorl, method No. 4 of the IFFJP (1968).

5.3.4.4 Determination of β-carotene content

Approximately 2g composite sample of roots of each sweetpotato variety were used to estimate the β-carotene using the UV Spectrophotometric method based on the procedure of Luff-schoorl method No. 44 of the IFFJP (1972).

5.3.4.5 Determination of Vitamin C content

Vitamin C was determined by the AOAC (2005) official method number 967.21. Vitamin C was extracted from 2g sample using 25ml of 20% TCA solution, 5 ml of 4% KI solution and 3 drops of starch solution were added, the solution was then titrated with N- bromosuccinimide solution. Vitamin C content was then calculated and expressed as mg/100g.

Vitamin C content = $V \times C \times \frac{176}{178}$ (mg), and the answer multiplied by 100 over the sample weight

(Where V is the volume of N bromo titrated; C is the N bromo concentration, 0.1; 176 is molecular weight of N bromo and 178 is the molecular weight of TCA (Trichloroacetic acid) used).

5.3.5 Data Analysis

Data were analyzed using Genstat software 15th edition. Data on physicochemical properties of sweetpotato roots and the effects of treatments on selected properties were subjected to ANOVA to establish variation in means of the variables at LSD $p \leq 0.05$.

5.4Results and Discussion

5.4.1 Moisture Content

Table 5.1 shows the initial moisture content (MC) of Kenspot 2(Ksp) variety, 70±2.83%, was significantly ($p<0.001$) lower than that of Kabode (Kb) variety, 77±0.71%. This difference is likely due to genotypic difference between the two varieties. Orange-fleshed varieties are known to have higher moisture content than white and yellow fleshed varieties (Rukundo et al., 2013). These values are within the range (62.9% - 83.8%) reported in other studies (Aina et al., 2009). Moisture content levels of sweetpotato roots influence their acceptability by consumers and adoption by farmers (Rukundo et al., 2013).

Table 5. 1: Moisture content of two sweetpotato varieties subjected to different packaging and storage conditions

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	70±2.83a	65.50±0.71cdef	57.00±0.00c	44.50±2.12cd
Ksp- UFT	70±2.83a	66.00±2.53cdef	63.50±0.71defg	56.00±1.41efg
Ksp- WFGB	70±2.83a	68.00±0.00def	68.00±0.00ghjk	63.50±0.71ghijklm
Ksp- UFGB	70±2.83a	66.00±1.41cdef	66.00±0.00fghi	60.50±6.40efghijk
Ksp- WFJB	70±2.83a	65.00±1.41cde	59.00±0.00cde	58.00±0.00efghij
Ksp- UFJB	70±2.83a	64.50±0.71cd	61.00±0.00cdef	61.00±0.00efghijk
Ksp- WRTT	70±2.83a	54.00±1.41a	35.00±2.83a	12.00±1.41a
Ksp- URTT	70±2.83a	57.00±1.41ab	44.00±2.83b	21.50±0.71b
Ksp- WRTGB	70±2.83a	61.00±0.00bc	57.50±0.71cd	57.50±0.71efghi
Ksp- URTGB	70±2.83a	61.50±0.71bc	55.00±0.00c	57.00±0.00efgh
Ksp- WRTJB	70±2.83a	64.00±0.00cd	64.00±0.00efg	54.50±0.71ef
Ksp- URTJB	70±2.83a	61.50±0.71bc	59.50±0.71	52.50±3.54de
Kb- WFT	77±0.71b	74.00±1.41ghi	66.50±2.12fghi	65.50±2.12hijklmn
Kb- UFT	77±0.71b	73.50±0.71ghi	67.00±1.41fghij	66.50±0.71jklmn
Kb- WFGB	77±0.71b	76.50±0.71i	68.00±1.41ghijk	71.50±0.71mn
Kb- UFGB	77±0.71b	75.50±0.71hi	73.00±1.41jkl	70.00±1.41lmn
Kb- WFJB	77±0.71b	76.50±0.71i	75.00±1.41l	73.00±1.41n
Kb- UFJB	77±0.71b	74.50±0.71ghi	70.50±0.71hijkl	68.00±1.41klmn
Kb- WRTT	77±0.71b	61.50±2.12bc	43.00±2.83b	36.00±2.83c
Kb- URTT	77±0.71b	64.50±2.12cd	57.50±2.12cd	43.50±2.12c
Kb- WRTGB	77±0.71b	74.00±1.41fgh	71.50±0.71ijkl	67.00±1.41klmn
Kb- URTGB	77±0.71b	73.50±0.71ghi	70.50±0.71hijkl	67.50±0.71klmn
Kb- WRTJB	77±0.71b	70.50±0.71fgh	67.50±2.12ghij	66.00±1.41ijklmn
Kb- URTJB	77±0.71b	70.00±0.00efg	64.50±0.71efgh	62.00±1.41fghijkl
% CV		1.8	2.3	3.5
Grand mean		67.44	62.08	56.46
S.E		1.20	1.43	1.98
P value		<0.001	<0.001	<0.001

NB: means ±SD followed by same alphabetical letter in the same column arenot significantly different at p≤ 0.05.

Ksp- Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Samples that were washed and stored on trays at room temperature (WRTT) recorded lowest moisture content levels with storage time followed by samples that were unwashed and stored on trays at room temperature (URTT) for both varieties. This could be probably because the relatively thin skin of the roots gets much exposure and is vulnerable to moisture loss since manual washing is prone to bruising.From the present study, it is also evident that samples stored at room temperature experienced higher losses in moisture content compared to those under same packaging and stored at 12-13ºC in a closed chamber.This could be attributed to the room's higher temperature (22-24ºC) and lower relative humidity (60-70%)supporting greater moisture loss into the environment.Washing roots before storage especially for those stored on trays (without any packaging) should not be encouraged as it showed the highest and significant loss in moisture content. Lower relative humidity of the external environment facilitates faster loss of moisture from the roots to the environment. Samples stored in gunny bags and jute bags exhibited lower losses in moisture content compared to those stored on trays when subjected to similar storage temperature conditions ($p \leq 0.05$). In the current study there was significant gradual decrease in moisture content of the roots through the 21days of storage regardless of how they were stored. High moisture content in sweetpotato roots and thin skin makes them very perishable and challenging to store for long periods of time (Vimala et al., 2011).

Storage of sweetpotato roots at 12-13ºC, use of gunny bags and/or jute bags should be encouraged to prolong the shelf life of the roots since they result in slower rates of moisture loss.

An experimental study elsewhere (Namutebi et al., 2004) showed the moisture content in pit stored roots increased within the first 35days of storage then decreased but in one variety the moisture content continually decreased gradually.

5.4.2 Starch Content

Table 5.2 shows the initial starch content of Kenspot 2 (Ksp) variety, 45.92±0.40%,was significantly ($p<0.001$) lower than that of Kabode (Kb) variety,54.80 ±0.15%, on dryweight basis. The difference could be due to genotype. These values are lower than the range (60.1% - 71.4%) reported in other studies (Ji et al., 2015). Losses in starch content after 7days of storage ranged from 0.1%(Ksp-UFGB) to 4.8% (Ksp-WRTT) in Kenspot-1(Ksp) variety samples while in Kabode (K) variety samples losses ranged from 0.3% (K-UFGB) to 17.8% (K-WRTT) as shown in Table 5.2.

Table 5. 2: Starch content of two sweetpotato varieties subjected to different packaging and storage conditions

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	45.92±0.40a	44.62±0.59a	42.72±0.07ab	41.77±0.14ce
Ksp- UFT	45.92±0.40a	45.23±0.52a	44.81±0.54bc	44.40±0.52ef
Ksp- WFGB	45.92±0.40a	45.19±0.26a	44.66±0.62bc	44.53±0.57ef
Ksp- UFGB	45.92±0.40a	45.89±0.4a	45.85±0.45cd	45.70±0.42f
Ksp- WFJB	45.92±0.40a	45.68±0.64a	45.56±0.76cd	45.53±0.76f
Ksp- UFJB	45.92±0.40a	45.80±0.47a	45.67±0.28cd	45.70±0.38f
Ksp- WRTT	45.92±0.40a	43.72±2.10a	42.38±1.34a	34.98±0.30a
Ksp- URTT	45.92±0.40a	45.10±0.95a	44.68±1.20bc	37.36±0.62ab
Ksp- WRTGB	45.92±0.40a	44.19±1.15a	41.22±0.21a	36.91±4.22ab
Ksp- URTGB	45.92±0.40a	45.10±0.95a	42.10±0.52a	38.50±1.65bc
Ksp- WRTJB	45.92±0.40a	45.66±0.33a	44.78±1.34bc	42.77±0.71ef
Ksp- URTJB	45.92±0.40a	45.64±0.62a	45.52±0.64cd	43.65±0.59ef
Kb- WFT	54.80 ±0.15b	50.74±0.86bc	49.74±1.29e	49.22±0.68g
Kb- UFT	54.80 ±0.15b	52.83±0.12cd	52.80±0.09f	52.48±0.31ghi
Kb- WFGB	54.80 ±0.15b	53.95±0.25d	53.37±0.28f	51.64±0.09ghi
Kb- UFGB	54.80 ±0.15b	54.63±0.21d	53.44±0.19f	53.22±0.12hi
Kb- WFJB	54.80 ±0.15b	54.50±0.16d	54.20±0.09f	50.04±0.37gh
Kb- UFJB	54.80 ±0.15b	54.61±0.18d	54.44±0.19f	54.34±0.12i
Kb- WRTT	54.80 ±0.15b	45.02±1.44a	41.80±0.64a	38.50±4.53bcd
Kb- URTT	54.80 ±0.15b	52.61±1.23cd	47.76±0.76de	45.76±0.03f
Kb- WRTGB	54.80 ±0.15b	50.28±1.39bc	48.50±0.89e	46.02±1.75f
Kb- URTGB	54.80 ±0.15b	51.70±4.05bcd	48.11±0.52e	45.41±1.75f
Kb- WRTJB	54.80 ±0.15b	49.47±1.66b	44.91±3.32bc	43.23±1.32ef
Kb- URTJB	54.80 ±0.15b	53.00±1.54cd	45.83±0.62cd	44.24±1.99ef
% CV	0.6	2.6	2.1	3.4
Grand mean	50.36	48.55	46.87	44.83
S.E	0.31	1.25	0.97	1.534
P value	<0.001	<0.001	<0.001	<0.001

Means ±SD followed by same alphabetical letter in the same column arenot significantly different at p≤ 0.05.**Ksp-** Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB** – Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

After 14days of storage, losses in starch content ranged from 0.2% (Ksp-UFGB) to 10.2% (Ksp-WRTGB) for Ksp variety and between 0.7% (K-UFJB) and 23.7%(K-WRTT) for Kabode (K) samples. Starch content losses of between 0.5% (Ksp-UFGB and Ksp-UFSB) to 23.8% (Ksp-WRTT) were found in Ksp variety while between 0.8% (K-UFJB) and 29.7% (K-WRTT) were recorded in Kabode variety after 21days of storage. In both varieties, the roots showed a decreasing, though gradual trend in starch content. A decreasing trend of starch content was also noted in roots of six genotypes of sweetpotatoes in another study as storage time increased up to 180 days (Dandago et al., 2011; Zhang et al., 2002). Losses of up to about 25.5% starch in non-cured roots stored in room conditions (23–26°C and relative humidity of 70–80%) for eight weeks, have been reported in other studies too (Nabubuya et al., 2017). Decrease in starch content during storage of sweetpotato roots has been linked to respiration in the roots (Sugri et al., 2017) where starch in the roots is the respiratory substrate (Dandago et al., 2011; Ray and Ravi, 2005). From the findings in the current study it is evident that, unwashed roots, packaging in gunny or jute bags prior to storage and use of controlled temperatures of about 12-13ºC and relative humidity 80-90% slowed down the loss of starch during storage of roots and should therefore be encouraged.

Starch is a very key ingredient for commercial use in both food and non-food applications. There is need to harness sweetpotato starch so that it contributes immensely to the growing demand of starch for commercial use and subsequently contribute to better incomes for sweetpotato farmers.

5.4.3 Reducing Sugars content

Table 5.3 shows that the initial reducing sugars content on dry weight basis (dwb) of Kenspot 2 (Ksp) variety, 8.34±0.47mg/100g, were significantly ($p<0.001$) lower than that of Kabode (Kb) variety, 11.17±0.37 mg/100g. These values are far much lower than those recorded in a study of six sweetpotato varieties which ranged from 102.04 to 145.60mg/100g (Lyimo et al., 2010). The variation could be due to the environment and soils where the roots were grown. Orange-fleshed varieties are known to have higher reducing sugars content than white and yellow fleshed varieties (Lyimo et al., 2010) and this is largely due to genotype differences.

Table 5. 3: Reducing sugars content of two sweetpotato varieties subjected to different packaging and storage conditions

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	8.34±0.47a	9.09± 0.83ab	9.27±0.71ab	9.45±0.88abc
Ksp- UFT	8.34±0.47a	8.75±0.49a	8.90±0.42a	8.98±0.64a
Ksp- WFGB	8.34±0.47a	9.15±0.59ab	9.48±54abc	9.82±0.97abc
Ksp- UFGB	8.34±0.47a	8.69±0.16a	9.75±0.17abcd	10.03±0.28abc
Ksp- WFJB	8.34±0.47a	8.88±0.26a	8.80±0.04a	9.08±0.07ab
Ksp- UFJB	8.34±0.47a	9.04±0.19ab	9.15±0.17ab	9.85±0.03abc
Ksp- WRTT	8.34±0.47a	12.09±0.54de	22.09±5.4fg	24.20±2.45hi
Ksp- URTT	8.34±0.47a	15.67±0.28g	26.00±0.15h	26.12±0.02hij
Ksp- WRTGB	8.34±0.47a	12.16±0.05de	24.79±0.02gh	32.17±0.14k
Ksp- URTGB	8.34±0.47a	10.65±0.07bcd	22.05±0.03fg	24.45±0.21hi
Ksp- WRTJB	8.34±0.47a	10.13±0.09abc	20.05±0.88ef	27.29±1.15j
Ksp- URTJB	8.34±0.47a	9.34±0.23ab	17.71±1.68f	19.21±2.52g
Kb- WFT	11.17±0.37b	11.35±0.37cd	11.66±0.62abcd	11.76±0.52cd
Kb- UFT	11.17±0.37b	11.30±0.43cd	11.44±0.3abcd	11.52±0.25bcd
Kb- WFGB	11.17±0.37b	11.46±0.34cd	11.65±0.31abcd	11.96±0.37cd
Kb- UFGB	11.17±0.37b	11.48±0.25cd	13.00±0.42cd	14.97±0.09ef
Kb- WFJB	11.17±0.37b	12.35±0.74de	13.37±0.21d	13.91±0.06de
Kb- UFJB	11.17±0.37b	11.63±0.09cde	12.76±0.70bcd	13.34±0.98de
Kb- WRTT	11.17±0.37b	12.09±1.44g	19.71±2.09ef	23.82±2.58h
Kb- URTT	11.17±0.37b	11.09±2.52cd	13.13±3.93d	17.17±1.78fg
Kb- WRTGB	11.17±0.37b	16.74±0.49g	21.45±0.04fg	25.61±0.68hij
Kb- URTGB	11.17±0.37b	16.37±0.95g	22.04±0.00fg	27.48±0.06j
Kb- WRTJB	11.17±0.37b	14.07±0.59f	20.05±1.29ef	26.59±0.03ij
Kb- URTJB	11.17±0.37b	13.30±0.43ef	19.30±0.00ef	27.76±0.03j
% CV	4.3	6.3	9.8	5.9
Grand mean	9.75	11.70	15.73	18.19
S.E	0.42	0.74	1.54	1.07
P value	<0.001	<0.001	<0.001	<0.001

Means of duplicate ±SD followed by same alphabetical letter in the same row arenot significantly different at p≤ 0.05.**Ksp-** Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Significant differences ($p \leq 0.05$) amongst the samples were noted after every seven days of storage and the differences increased with length of storage. The differences can be attributed to the packaging material and storage temperature. Generally, reducing sugars content (%) in the samples increased with storage period in both varieties as shown in Table 5.3. Among Ksp variety samples, increases of between 4.2% (Ksp-UFGB) and 87.9% (Ksp-URTT) were recorded after seven days. The sugars were shown to have tripled up in sample Ksp-URTT after 14days storage and also in sample Ksp-WRTGB after 21days storage. In the Kabode variety samples, reducing sugars increase ranging from 0.8% (K-URTT) to 49.8% (K-WRTGB) after 7days storage, increases ranging from 2.3% (K-UFT) to 113.2% (K-WRTT) after 14days storage. The reducing sugars had doubled up in sample K-UFT after 14days storage and in sample K-URTJB after 21days storage. Samples stored at room temperature,22-24^{o}C with relative humidity 60-70%, exhibited significantly ($p \leq 0.05$) higher increases in reducing sugars as storage time increased compared to those samples stored at temperatures 12-13^{o}C and relative humidity 80-90% for both varieties. In other studies, (Sugri et al., 2017; Zhang et al., 2002), sucrose and glucose concentration in stored sweetpotato roots showed an increasing trend in early storage then remained at fairly constant levels. It would have been interesting to monitor the concentration of reducing sugars beyond the storage time in this study so as to observe point at which they become constant.

The increase in concentration of reducing sugars in stored sweetpotato roots is found to be as a result of conversion of some starch in the roots to sucrose and then to reducing sugars (Ingabire and Vasanthakaalam, 2011; Salunke and Kadam 1998). Glucose and sucrose concentrations can increase by 1.35 % and 3.1% respectively during roots storage (Nabubuyaet al., 2017). Monitoring the changes in reducing sugars content in stored roots is very important since higher amounts are known to favor oxidation reactions which increase the cost of sweetpotato processing (Rukundo et al., 2013; Mckibbin et al., 2006). It is therefore necessary to store sweetpotatoes in controlled temperatures less than 15°C to slow down the rates at which starch gets converted into reducing sugars.

5.4.4 Beta carotene

Table 5.4 shows the initial beta carotene content on dry weight basis of Kenspot 2 (Ksp) variety,0.18±0.07mg/100g, was significantly ($p<0.001$) lower than that of Kabode (Kb) variety,18.78±0.68mg/100 g. These values are within the range (0.43 – 18.37mg/100g) reported by other studies in nine varieties ranging from cream to different shades of orange (Niringiye et al., 2014). Orange-fleshed varieties like Kabode are known to contain higher beta carotene content than yellow and white (like Kenspot 2) fleshed varieties (Tumuhimbise et al., 2013) and the difference is largely attributed to genotype. Significant differences ($p\leq 0.05$) especially amongst the Kabode (kb-) samples were noted after every seven days of storage and the differences increased with length of storage. The differences among samples can be associated with the type of packaging and storage temperature. Losses in beta carotene were reported with storage time as shown in Table 5.4. After seven days period, losses ranging from 8% (Ksp-WRTGB) to 91.6% (Ksp-URTGB) in Kenspot 2 (Ksp) variety samples and losses ranging from 9.6% (K-WRTT) to 52.7%(K-UFJB) in Kabode variety samples were found. Losses ranging from 36.1% (Ksp-URTJB) to 91.7% (Ksp-WFGB) in Ksp variety and 9.6% (K-WRTT) to 75.7% (K-UFJB) in Kabode variety were recorded after 14days of storage. At the end of 21day storage, a range of between 54.6% (Ksp-URTJB) and 100% (Ksp-URTGB and K-UFT) beta carotene losses in Ksp variety samples and between 41.6% (K-WRTGB) and 79.6% (K-URTT) losses in Kabode samples were recorded. Over 50% of provitamin A (beta carotene) were reported lost in studies elsewhere in six-week storage of sweetpotato roots in jute sacks, basket and in ground trench (Wheatley and Loechl, 2008; Feruzi et al., 2001).

Table 5. 4 : Beta carotene content of two sweetpotato varieties subjected to different packaging and storage conditions

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	0.18±0.07a	0.15±0.07a	0.07±0.00a	0.05±0.03a
Ksp- UFT	0.18±0.07a	0.14±0.05a	0.03±0.00a	0.00±0.00a
Ksp- WFGB	0.18±0.07a	0.14±0.00a	0.02±0.02a	0.02±0.02a
Ksp- UFGB	0.18±0.07a	0.09±0.02a	0.05±0.03a	0.02±0.02a
Ksp- WFJB	0.18±0.07a	0.14±0.05a	0.09±0.02a	0.03±0.00a
Ksp- UFJB	0.18±0.07a	0.03±0.00a	0.03±0.00a	0.09±0.02a
Ksp- WRTT	0.18±0.07a	0.03±0.00a	0.03±0.00a	0.03±0.00a
Ksp- URTT	0.18±0.07a	0.12±0.02a	0.07±0.05a	0.02±0.02a
Ksp- WRTGB	0.18±0.07a	0.17±0.05a	0.08±0.07a	0.02±0.02a
Ksp- URTGB	0.18±0.07a	0.02±0.02a	0.05±0.03a	0.00±0.00a
Ksp- WRTJB	0.18±0.07a	0.08±0.07a	0.08±0.07a	0.10±0.04a
Ksp- URTJB	0.18±0.07a	0.12±0.02a	0.12±0.02a	0.08±0.07a
Kb- WFT	18.78±0.68b	16.53±0.06j	13.11±0.16k	10.52±0.00k
Kb- UFT	18.78±0.68b	15.74±0.00i	11.24±0.03h	9.48±0.00i
Kb- WFGB	18.78±0.68b	10.05±0.06c	7.63±0.03d	6.61±0.06f
Kb- UFGB	18.78±0.68b	15.09±0.49h	1.33±0.04h	4.79±0.06d
Kb- WFJB	18.78±0.68b	13.07±0.04e	12.57±0.56j	4.61±0.00d
Kb- UFJB	18.78±0.68b	8.89±.0.03b	4.57±0.00b	5.72±0.09e
Kb- WRTT	18.78±0.68b	16.99±0.02l	16.98±0.40l	9.94±0.15j
Kb- URTT	18.78±0.68b	16.70±0.18jk	10.11±0.16g	3.83±0.06b
Kb- WRTGB	18.78±0.68b	14.09±0.12f	11.81±0.04i	10.96±0.43l
Kb- URTGB	18.78±0.68b	14.68±0.04g	8.52±0.00f	8.31±0.06h
Kb- WRTJB	18.78±0.68b	16.81±0.09kl	8.04±0.00e	7.35±0.06g
Kb- URTJB	18.78±0.68b	11.30±0.00d	7.05±0.06c	4.33±0.09c
% CV	5.1	1.6	2.9	2.8
Grand mean	9.48	7.13	1.19	3.62
S.E	0.48	0.12	0.03	0.10
P value	<0.001	<0.001	<0.001	<0.001

Means ±SD followed by same alphabetical letter in the same column are not significantly different at p≤ 0.05.**Ksp-** Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

Some earlier studies have however reported increase in beta carotene content during the storage of sweetpotato roots. For instance, in an experimental study in Uganda, sweetpotato roots stored in pits (17-21^{o}C, RH 90-100%) resulted in higher levels of beta carotene retention than roots that were stored in conditions that were ambient (24-27^{o}C, RH 68-100%) (Tumuhimbise et al., 2010). Curing and storage were found likely to increase beta carotene concentration of sweetpotato roots (Ezell et al., 1952; Okwuowulu 2003). Carotene gain of up to 15% has also been reported in some varieties of sweetpotatoes after storage (Mercedante and Rodriguez-Amaya, 1991). Beta carotene content variation in sweetpotato cultivars may be a result of inherent differences in cultivars, maturity at harvest, storage time and storage conditions (Tumuhimbise et al., 2010; Ezell and Wilcox, 1946). It is of necessity that the stability of beta carotene in sweetpotato roots during storage be established so that consumers get maximum nutritional benefit.

5.4.5 Vitamin C content

Initial vitamin C content on dry weight basis (Table 5.5) in Kabode variety (102.09±0.55mg/100g) was significantly ($p<0.05$) higher than in Kenspot 2 variety (57.07±1.36mg/100g). The difference between the two can be attributed to variety since Kabode is orange fleshed while Kenspot 2 is white fleshed. The contents are higher than the values reported for 21 Caribbean varieties varying from 5.2mg/100gto 31.2mg/100g (Aina et al., 2009). Both varieties in the current study had considerable amounts of vitamin C. Significant changes were noticed in vitamin C content among the samples after every week of storage. The changes are presumably due to the storage method and temperature.Washed samples stored at room temperature on trays (WRTT) showed the highest loss in vitamin C among the samples while the unwashed samples stored in the fridge in bags displayed least losses in Vitamin C. Sweetpotato roots should therefore not be washed before storage and should be stored at temperatures below 15^{o}C for high retention of Vitamin C. Losses in vitamin C content after 7-day storage period varied significantly ($p<0.05$) and ranged from 0.1% (Ksp-UFJB) to 37.6% (Ksp-WRTT) in KSP variety samples while in Kabode (Kb) variety samples ranged from 4.5% (Kb-UFGB and Kb-UFJB) to 22.2% (Kb-URTT) as shown in Table 5.5.

Table 5. 5: Vitamin C content of two sweetpotato varieties subjected to different packaging and storage conditions

SAMPLE	DAY 1	DAY7	DAY14	DAY21
Ksp- WFT	57.07±1.36a	37.30±0.18ab	35.42±0.21b	34.89±0.54c
Ksp- UFT	57.07±1.36a	46.14±3.73de	41.65±0.11cd	36.80±3.86cd
Ksp- WFGB	57.07±1.36a	49.00±0.71ef	45.83±0.85de	38.67±1.46cd
Ksp- UFGB	57.07±1.36a	54.63±2.45gh	47.97±1.75e	46.23±0.28ef
Ksp- WFJB	57.07±1.36a	52.47±0.71fg	50.31±0.30e	46.02±2.52ef
Ksp- UFJB	57.07±1.36a	57.00±3.30h	48.78±8.41e	47.64±4.86fg
Ksp- WRTT	57.07±1.36a	35.62±0.12a	27.80±0.18a	25.04±1.51a
Ksp- URTT	57.07±1.36a	44.10±0.14cd	35.44±1.36b	30.34±2.21b
Ksp- WRTGB	57.07±1.36a	40.69±4.93bc	39.48±5.30bc	35.41±0.87c
Ksp- URTGB	57.07±1.36a	51.30±0.24fg	41.12±1.44cd	38.53±0.05cd
Ksp- WRTJB	57.07±1.36a	49.39±1.96ef	45.43±0.57de	41.65±1.24de
Ksp- URTJB	57.07±1.36a	53.03±0.47fgh	48.20±1.17e	41.35±1.77d
Kb- WFT	102.09±0.55b	84.91±0.37j	74.69±1.66f	73.24±1.69i
Kb- UFT	102.09±0.55b	93.26±3.26kl	84.28±0.34gh	79.91±0.06jk
Kb- WFGB	102.09±0.55b	95.61±0.37kl	91.37±0.28ij	89.35±1.10l
Kb- UFGB	102.09±0.55b	97.50±2.36l	96.05±1.90j	96.48±1.60m
Kb- WFJB	102.09±0.55b	97.41±1.63l	96.59±1.14j	93.33±0.77lm
Kb- UFJB	102.09±0.55b	97.50±2.36l	96.63±0.58j	96.28±0.59m
Kb- WRTT	102.09±0.55b	85.24±0.4j	69.66±0.25f	38.78±1.66cd
Kb- URTT	102.09±0.55b	79.44±2.21i	73.39±3.56f	51.56±4.30g
Kb- WRTGB	102.09±0.55b	91.98±1.02k	84.22±1.53g	65.16±2.18h
Kb- URTGB	102.09±0.55b	97.15±1.81l	89.54±2.24gi	81.09±2.46jk
Kb- WRTJB	102.09±0.55b	96.19±0.28kl	92.13±2.15ij	76.76±1.20ij
Kb- URTJB	102.09±0.55b	96.98±2.12l	91.35±3.38ij	82.78±3.13k
% CV	1.3	2.8	3.9	3.7
Grand mean	79.58	70.16	64.47	57.80
S.E	1.04	1.98	2.52	2.15
P value	<0.000	<0.001	<0.001	<0.001

Means ±SD followed by same alphabetical letter in the same column arenot significantly different at $p \leq 0.05$.**Ksp-** Kenspot 2 variety**, Kb-** Kabode variety**; U – U**nwashed**; W-** Washed**; FT –** Fridge Tray**; FGB –** Fridge Gunny Bag**; FJB –** Fridge Jute Bag**; RTT –** Room Temperature Tray**; RTGB –** Room Temperature Gunny Bag**; RTJB –** Room Temperature Jute Bag**.**

After storage for a fortnight, vitamin C losses still varied significantly ($p<0.05$) and ranged from 11.8% (Ksp-WFJB) to 51.3% (Ksp-WRTT) in KSP variety samples while in Kabode (Kb) variety samples, losses ranged from 5.3% (Kb-UFJB) to 31.8% (Kb-WRTT).

At the end of 21-day storage, significant ($p<0.05$) vitamin C losses of between 19% (Ksp-UFJB and 56.1% (Ksp-WRTT) were recorded in KSP variety samples while significant ($p<0.05$) losses of between 5.5% (Kb-UFGB) and as high as 62% (Kb-WRTT) were recorded in Kabode samples. Washed samples (-W) were more susceptible to higher Vitamin C losses compared to the unwashed samples (-U) when subjected to similar storage conditions and time. Samples stored in the chamber (-FT, -FGB, -FJB) at 12-13^{o}C from both varieties (Ksp and Kb) recorded significantly ($p<0.05$) lower losses in vitamin C compared to similar samples stored at room temperature of 22-24^{o}C (RTT, RTGB, RTJB). For each sample, there was significantly (≤ 0.05) high vitamin C loss with increased storage time up to 21days. These losses can be possibly attributed to leaching (since vitamin C is highly soluble in water) and oxidation, storage condition and package as well as the variety of sweetpotato. Vitamin C loss in other studies was attributed to the way roots are stored, method of vitamin C extraction from samples and type of solvents used in extraction (Galani et al., 2017). Vitamin C easily oxidizes when exposed to favourable conditions during processing (Dandago et al., 2011; Wilcox 2006). Longer storage period and high temperatures during storage have been cited by some authors as facilitating vitamin C loss among all vegetables (Lee and Kader, 2000). The loss of vitamin C usually begins immediately a crop is harvested and can be varied even among cultivars of the same commodity (Bouzari et al., 2014). In sweetpotato roots, the loss can double per every 10^{o}C temperature rise (Dandago et al., 2011; Kader, 2006). Storage of roots in an atmosphere of less oxygen (Lee and Kader, 2000) or under refrigeration (Bouzari et al., 2014) can however, slow down vitamin C loss.

Sweetpotato stands out among other starchy staples in terms of having ascorbic acid (vitamin C) content in amounts that are appreciable (Olatunde et al., 2016; Bradbury and Singh 1986; Bradbury et al., 1985).Vitamin C is well known for its antioxidant properties against free radicals in our bodies, anti-aging, lowering risks of certain cancers, improving iron absorption, rapid healing of wounds, improving the body's immune system and formation of a skin-making protein among other uses (Abdulla et al., 2014; Sweetman 2007; Babalola et al., 2010; Everetteand Islam, 2012). The recommended daily allowance of vitamin C for adults is 75mg/day (Babalola et al., 2010). Vitamin C is among the least stable nutrients and its stability in a given handling process can be used to also indicate stability of other nutrients (Bouzari et al., 2014).

5.5 Conclusion and Recommendation

Washing of roots should not be encouraged priror to storage as it resulted in quicker deteroriation of the quality. Storage of roots at temperature 12-13^{o}C with relative humidity of 80-90% were better conditions for both varieties. Jute and sisal bags packaging were conducive prior to storage since they showed lower rates of nutrient losses compared to unpackaged samples. Variety was of no effect to the storage conditions since both Kabode and Kenspot 2 showed significant losses in moisture content, starch, reducing sugars, beta carotene and vitamin C during the 21days of storage.

More research can be done to find out the effect of curing on stability of nutrients in sweetpotatoes under similar storage conditions as in the present study.

CHAPTER SIX: GENERAL CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Postharvest practices on sweetpotato roots were similar in both Bungoma and Homabay counties. There lacked organized systems for channeling the roots into the market. Poor linkages did exist among the actors in the sweetpotato value chain. Limited market of the roots was due to limited use mainly as boiled in households. Unexploited industrial use in both food and non-food application limited the utilization of the roots.

The physicochemical properties of the sweetpotato roots differed significantly due to variety. Pasting profiles of the flours revealed that the roots of different varieties are suitable for industrial use in food applications for diverse products. The flour from orange fleshed varities can be blended with other flours while the non-orange fleshed varieties can also be utilized for starch production. Washing of roots, packaging material and storage conditions were found to have significant effect on the quality of the roots during srorage. Storage at room temperature and without packaging resulted in quicker deteroriation of the physichochemical properties for both the white and orange fleshed roots. Storage at temperatures 12-13^{o}C and relative humidity 80%-90% are sutiable for sweetpotato roots for extended shelflife.

6.2 RECOMMENDATIONS

The findings in this study will help inform stakeholders on the existing sweetpotato postharvest handling practices in Kenya and offer insights in to the available opportunities in the sweetpotato value chain. Relevant stakeholders and development partners in sweetpotato should focus more attention on postharvest handling of the roots for sustainability of the value chain. There should be deliberate efforts by actors in the sweetpotato value chain to address the weak forward and backward linkages. Further research can be done to find out the effect of curing on the sweetpotato roots during storage. More research on sweetpotato roots value addition should be encouraged to increase the knowledge base.

Kenya sweetpotato policy should address issues of marketing/ trading, utilization, processing and storage of sweetpotato roots.

REFERENCES

Abdel, G., and Abdel, R. (2012). Characterization of three genotypes of sweetpotato and their suitability for jam making. 2 (1), 1–9. Retrieved from http : / / azurihealth . webs . com / azurihealthproducts.htm

Abdulla, G., El-Shourbagy, G. A., and Sitohy, M. Z. (2014). Effect of Pre-drying, Blanching and Citric Acid Treatments on the Quality of Fried Sweet Potato Chips. American Journal of Food Technology, 9(1),39-48.

Abong', G. **O., Okoth, M.W., Imungi, J.K., and Kabira, J.N**. (2011). Loses of Ascorbic Aacid During Storage of Fresh Tubers, Frying, Packaging and Storage of Potato Crisps from Four Kenyan Potato Cultivars. American Journal of Food Technology, 6(9), 772-780.

Adebowale, A. A., Sanni, L. O., and Fadahunsi, E. L. (2011). Functional and pasting properties of cassava – sweetpotato starch blends. African Journal of Root and Tuber Crops, 9(1),6-10.

Adepoju, A. L., and Adejumo, B. A. (2015). Some Proximate Properties of Sweetpotato (Ipomoea Batatas L) as Influenced by Cooking Methods.International Journal of Scientific & Technology Research, 4(03), XX – YY.

Adeyemi, P. O. A., and Salaam, A. R. B. (2015). Effect of Processing Conditions on the Quality of Fried Sweetpotato Chips. The International Journal of Science &Technoledge, 3(2), xx YY.

Adjatin, A., Dansi, A., Badoussi, E., Sanoussi, A. F., Dansi, M., Azokpota. P., Ahissou, H., Akouegninou, A., Akpagana, K. and Sanni, A. (2013). Proximate, mineral and vitamin C composition of vegetable Gbolo [*Crassocephalumrubens*(Juss. Ex Jacq.) S. Moore and

C. crepidioides(Benth.) S. Moore] in Benin.International Journal of Biology and Chemical Sciences, 7(1), 319-331.

Aina, A. J., **Falade,** K. O., **Akingbala,** J. O., and **Pathelene, T**. (2009). Physicochemical Properties of twenty-one Caribbean sweet potato cultivars. International Journal of Food Science and Technology,44,1696–170. https://doi.org/10.1111/j.1365-2621.2009.01941.x

Akissoe, N., Hounhouigan, J., Mestres, C., and Nago, M. (2003**).** How blanching and drying affect the colour and functional characteristics of yam (Dioscoreacayenensisrotundata) flour. Journal of Food Chemistry, 82, 257-264.

Alinnor, I. J., and Oze, R. (2011). Chemical evaluation of the nutritive value of *Pentaclethramacrophyllabenth* (African Oil Bean) Seeds. Pakistan Journal of Nutrition,10(4), 355-359.

Andrade, M., Barker, I., Cole, D., Dapaah, H., Elliot, H., Fuentes, S., Gruneberg, W., Kapinga, R., Kroschel, J., Labarta, R., Lemaga, B., Loechl, C., Low, J., Lynam, J., Mwanga, R., Ortiz, O., Oswald, A. and Thiele, G. (2009). Unleashing the Potential of sweetpotato in Sub-Saharan Africa: Current challenges and way forward. International Potato Center (CIP), Lima, Peru. Working Paper, 1: 197.

Andzouana, M., and Mombouli, J. B. (2012). Assessment of the Chemical and Phytochemical Constituents of the Leaves of a Wild Vegetable-*Ochthocharisdicellandroides*(Gilg). Pakistan Journal of Nutrition,11(1), 94-99.

Antia, B. S., Akpan, E. J., Okon, P. A., and Umoren, I. U. (2006). Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. Pakistan Journal of Nutrition, 2,166–8.

AOAC. (2000). Association of Official and Analytical Chemists.15th Ed (Helrich, K.). Arlington, Virgina, USA.

AOAC. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists (15th edition), Washington DC :992 – 995.

AOAC. (2005). Official Methods of Analysis. 18th Edition, Association of Official Analytical Chemists. Washington D.C, USA.

AOAC. (2003). Official methods of theAssociation of official's Analytical Chemists. 17th Edition.

Aprianita, A., Purwandari, U, Watson, B., and Vasiljevic, T. (2009). Physico-chemical properties of flours and starches from selected commercial tubers available in Australia. International Food Research Journal, 16 (4), 507-520.

Avula, R.Y. (2005). Rheological and Functional Properties of Potato and Sweetpotato Flour and Evaluation of its Application in some Selected Food Products.

Away, A. K., Nawiri, M. P., and Nyambaka, H. N. (2013). Nutrient Variation in Colored Varieties of Ipomeabatatas grown in Vihiga County, Western Kenya. International Food Research Journal, 20(2), 819-825.

Babalola, O. O., Adubiaro, H. O., and Ikusika, O. (2010). The Effect of Some Processing Methods on the Vitamin C Content of Sweet and Irish Potato. Research Journal of Agriculture and Biological Sciences, 6(6), 981-982.

Babalola, O. O., Adubiaro, H. O., and Ikusika, O. (2010). The Effect of Some Processing Methods on the Vitamin C content of Sweet and Irish potato. Electronic Journal of Environment, Agriculture and Food Chemistry, 9, 679-681.

Bechoff, A., Dufour, D., Dhuique-Mayer, C., Marouzé, C., Reynes, M., and Westby, A. (2008). Effect of hot air, solar and sun drying treatments on provitaminA retention in orange-fleshed sweetpotato. Journal of Food Engineering, 92(2),164-171.

Bouzari, A., Holstege, D., and Barrett, D. M. (2014). Vitamin Retention in Eight Fruits and Vegetables: A Comparison of Refrigerated and Frozen Storage. Journal of Agriculture and Food Chemistry, 40:30:30. DOI: 10.1021/jf5058793.

Bovell-Benjamin, A. C. (2007). Sweet potato: a review of its past, present, and future role in human nutrition. Advanced Food Nutrition Research, 52,1–59.

Bradbury, J. H., Hammer, B., Nguyen, T., Anders, M., and Millar, J. S. (1985). Protein quantity and quality and trypsin inhibitor content of sweet potato cultivars from the highlands of Papua New Guinea. Journal of Agriculture and Food Chemistry, 33(2), 281–285.

Bradbury, J. H., and Singh, U. (1986). Ascorbic and dehydroascorbic acid content of tropical root crops from the South Pacific. Journal of Food Science, 51(4),975–978.

Burri, B. J. (2011). Evaluating Sweetpotato as an Intervention Food to Prevent Vitamin A Deficiency. Comprehensive Reviews in Food Science and Food Safety, 10.

Carvalho, L. M. J., Oliveira, A. R. G., Godoy, R. L. O., Pacheco, S., Nutti, M. R., de Carvalho, J. L. V., Pereira, E. J., and Fukuda, W.G. (2012). Retention of total Carotenoid and β Carotene in yellow sweet cassava (ManihotesculentaCrantz) after domestic cooking. Food Nutrition Research, *56* (10).

Chaney, S. G. (2006). Principles of Nutrition II: Micronutrients. In: Textbook of Biochemistry, with Clinical Correlation, 6th edition. Devlin, T.M. (ed.), John Wiley and Sons: New York, NY. 1091-1120. ISBN: 10 0-471-67808-2.

Chang, H. S., Spriggs, J., and Newman, S. M. (2008). Improving Sweetpotato Marketing in the Papua New Guinea Highlands. Acta Horticulture, 794,55-64.

Chen, Z., Schols, H., and Voragen, A. (2003). Physicochemical properties of starches obtained from three varieties of Chinese sweet potatoes. Journal of Food Science, 68, 431-437.

Cooley, J. S. (1951). The Sweetpotato: Its Origin and Primitive Storage Practices. Economic Botany, 5 (4), 378-386.

Dandago, M. A., and Gungula, D. T. (2011). Effects of various storage methods on the quality and nutritional composition of sweet potato (*Ipomeabatatas*L.) in Yola Nigeria.International Food Research Journal, 18, 271-278.

De Moura, F. F., Miloff, A., and Boy, E. (2015). Retention of Provitamin A Carotenoids in Staple Crops Targeted for Biofortification in Africa: Cassava, Maize and Sweet Potato, Critical Reviews in Food Science and Nutrition, 55(9), 1246-1269. DOI: 10.1080/10408398.2012.724477.

Dimitropoulou, P., Nayee, S., Liu, F. J., Demetriou, L., van Tongeren, M., Hepworth, J. S., and Muir, R. K. (2008). Dietary zinc intake and brain cancer in adults: a case–control study. British Journal of Nutrition, 99, 667–673. doi: 10.1017/S0007114507831692.

Eke-Ejiofor, J. (2015). Physico-chemical and pasting properties of starches from cassava, sweetpotato and three leaf yam and their application in salad cream production. International Journal of Biotechnology and Food Science, *3*(2), 23-30.

Eniola, L., and Delarosa, L. C. (1981). Physichochemical characterizes of yam starches. Journal of Food Biochemistry, 5, 115-130.

Everette, J. D., and Islam, S. (2012). Effect of Extraction Procedures, Genotypes and Screening Methods to measure the antioxidant Potential and Phenolic content of Orange-fleshed Sweetpotatoes (Ipomeabatatas L.). American Journal of Food Technology, 7, 50-61.

Ewell, P. T. (2011). Sweet potato in the Food Systems of Eastern and Southern Africa. In: Proceeding of the 9th symposium of the International Society for Tropical Root Crops, 20-22 October 1991, Accra Ghana.

Ezell, B. D., and Wilcox, M. S. (1946). The ratio of carotene to carotenoids pigments in sweet potato varieties. Science, 103, 193-194.

Ezell, B. D., Wilcox, M. S., and Crowder, J. N. (1952). Pre and post harvest changes in carotene, total carotenoids and ascorbic acid content of sweet potatoes. Plant Physiology, 27, 355-369.

Ezeocha, C. V., and Ironkwe, D. G. (2017). Effect of Storage Methods and Period on the Physiological and Nutrient Components of Livingstone Potato (*Plectranthusesculentus*) in Abia State, Nigeria.Open Agriculture, 2, 213–219. DOI 10.1515/opag-2017-0022

FAOSTAT. (2009**).** FAO Statistics. http://faostat.fao.org/site/567/default.aspx#ancor

FAOSTAT. (2013). Food and Agricultural Organization of the United Nations, StatisticsDivision. Avaliable at www.faostat3.fao.org/browse/Q/QC/E (Accessed May 24, 2017).

Fernandez-Stark, K., Bamber, P., and Gerefi, G. (2011). The Fruit and Vegetables Global Value Chain: Economic Upgrading and Workforce Development. Center on Globalization, Governance & Competitiveness, Duke University.

Feruzi, M., Phemba, P., Ngongo, M., Hagenimana, V., and Lutaladio, N. B. (2001). Evaluation Post Recolte de six Genotypes de patatedouceselectionnesAl'est du Congo. African Crop Science Journal, 9(1),33-39.

Fetuga, G., Tomlins, K., Henshaw, F., and Idowu, M. (2014). Effect of variety and processing method on functional properties of traditional sweet potato flour ("elubo") and sensory acceptability of cooked paste ("amala"). Food Science & Nutrition, 2(6), 682– 691.

Food and Agricultural Organization (FAO). (1997). Available at<http://apps.fao.org/>, accessed on 8th, June, 2009

Galani, H. Y. J., Patel, S. J., Patel, J. N., and Talati, J. G. (2017). Storage of Fruits and Vegetables in Refrigerator Increases their Phenolic Acids but Decreases the Total Phenolics, Anthocyanins and Vitamin C with Subsequent Loss of their Antioxidant Capacity. Antioxidants,6(3),59. doi:10.3390/antiox6030059.

Grüneberg, W, Ma D., Chokkappan, M., Ssemakula, G., Ndirigwe, J., Chipungu, F., Jackson, G., Hossain, M., Andrade, M., Carey, T., Tjintokohadi, K., Mwanga, R., Attaluri, S., and Yakub, M. J. (2012). Advances in sweetpotato breeding from 1992 to 2012.

Hall, A., and Devereau, S. (2000). Low-cost Storage of fresh sweetpotatoes in Uganda: Lessons from participatory and on-station approaches to technology choice and adaptive testing. Agriculture, 29(4), 275-282.

Hall, A., Bockett, G., and Nahdy, S. (1998). Sweetpotato Post harvest Systems in Uganda: Strategies, Constraints, and Potentials. Social Science Department Working Paper No. 1998-7. International Potato Center (CIP), Lima, Peru.

Ikegwu, O. J., Nwobasi, V. N., Odoh, M. O., and Oledinma, N. U. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. African Journal of Biotechnology, *8* (10), 2310-2315, 18.

Ingabire, M. R., and Vasanthakaalam, H. (2011). Comparison of the Nutrient Composition of four sweet potato Varieties cultivated in Rwanda. American Journal of Food and Nutrition, 1(1), 34-38.

Jaetzold, R., Schmidt, H., Hornetz, B., and Shisanya, C. (2006). Farm Management Handbook of Kenya.Volume II – Natural Conditions and Farm Management Information, 2nd Edition.

Ji, H., Zhang, H., Li, H., and Li, Y. (2015). Analysis on the Nutrition Composition and Antioxidant Activity of Different Types of Sweet Potato Cultivars. Food and Nutrition Sciences, 6, 161-167.

Julianti, E., Rusmarilin, H., Ridwansyah., and Yusraini, E. (2015). Functional and Rheological properties of composite flour from sweetpotato, maize, soybean and xanthum gum. Journal of the Saudi Society of Agricultural Sciences. http://dx.doi.org/10.1016/j.jssas.2015.05.005.

Kader, A. (2006). Changes in Ascorbic acid contents in stored sweet potatoes. Personal correspondence.

Kaur, M., and Singh, N. (2005). Studies on Functional thermal and pasting properties of flours from different chickpea (Cicer arietinum L.) cultivars. Food Chemistry, 91, 403-411.

Kembie, J. (2004). Harvesting and Curing Sweetpotatoes. AlabamaCoperative Extension System. ANR-III.

Kenya National Bureau of Statistics. (2015). Economic Survey.

Kidmose, U., Christensen, L. P., Agili, S. M., and Thilsted, S. H. (2007). Effect of Home Preparation Practices on the Content of provitamin A carotenoids in ColouredSweetpotato varieties (*Ipomoea batatas* Lam.) from Kenya. Innovative Food Science & Emerging Technologies, *8*(3), 399-406. 4thInternational Congress on Pigments in Food: Pigments in Food – A challenge to Life Sciences. Elsevier Ltd.

Kitinoja, L., Saran, S., Susanta, K. R., and Kader, A. A. (2010). Postharvest technology for developing countries: challenges and opportunities in research, outreach and advocacy. Journal of Science Food and Agriculture, 91, 597-603.

Kivuva, B. M., Musembi, J., Githiri, M. S., Yencho, C. G., and Sibiya, J. (2014). Assessment of Production Constraints and Farmers Preferences for sweetpotato Genotypes. Journal of Plant Breeding and Genetics, 02 (01), 15-29.

Laurie, S. M., van Jaarsveld, P. J., Faber, M., Philpott, M. F., and Labuschagne, M. T. (2012).Trans-b-carotene, selected mineral content and potential nutritional contribution of 12 sweet potato varieties. Journal of Food Composition and Analysis, 27, 151 -159.

Lee, S. K., and Kader, A. A. (2000). Preharvest and Postharvest Factors Influencing Vitamin C content of Horticultural Crops. Postharvest Biology and Technology, 20, 207–220.

Leighton, C. S., Schönfeldt, H. C., and Kruger, R. (2010). Quantitative descriptive sensory analysis of five different cultivars of sweet potato to determine sensory and textural profiles. Journal of Sensory Studies, 25, 2-18.

Li, S., Zhang, Y., Wei, Y., Zhang, W., and Zhang, B. (2014). Thermal, Pasting and Gel Textural Properties of Commercial Starches from Different Botanical Sources. Journal of Bioprocess Biotechnology, 4, 161. doi: 10.4172/2155-9821.1000161**.**

Linne, K., Osumba, J., and Jacobi, P. (2013). Climate Risk and Vulnerability Profiles for Homa Bay and Busia Counties, Kenya.Adaptation to Climate Change and Insurance (ACCI). Nairobi, Kenya.

Lokuruka, Michael. (2012). Role of Zinc in Human Health with Reference to African Elderly: A Review. African Journal of Food, Agriculture, Nutrition and Development, 12(6), 6647-6664.

Low, J., W, Arimond M., Osman, N., Cunguara, B., Zano, F., and Tschirley, D. (2007). Ensuring the supply of and creating demand for a biofortified crop with a visible trait: Lessons learned from the introduction of orange-fleshed sweetpotato in drought-prone areas of Mozambique. Food and Nutrition Bulletin, 28(2) (supplement). The United Nations University.

Lyimo, M. E., Gimbi, D. M., and Kihinga, T. (2010). Effect of processing methods on Nutrient contents of six sweetpotato Varieties Grown in Lake Zone of Tanzania. Tanzania Journal of Agricultural Sciences,10 (1), 55-61.

Maalekuu, B. K., Saajah, J. K., and Addae, A. K. (2014). Effect of three storagemethods on the quality and shelf life of white yam (Dioscorearotundata) cultivars Pona and Tela. Journal of Agricultural science, 6(7), 221-230.

Mais, A., NIAR, PNG. (2014). Final report: Market Diversification and sweetpotato processing in Papua New Guinea: a prefeasibility study. ACIAR, Canberra ACT Australia: 13-14.

McKibbin, R. S., Muttucumaru, N., Paul, M. J., Powers, S. J., Burrell, M. M., Coates, S., Purcell, P. C., Tiessen, A., Geigenberger, P., and Halford, N. G. (2006). Production of high starch, low glucose potatoes through over expression of the metabolic regulator SnRK1. Plant Biotechnology Journal, 4, 409-418.

Mercadante, A. Z., and Rodriguez-Amaya, D. B. (1991). Carotenoid composition of a leafy vegetable in relation to some agricultural variables. Journal of Agriculture and Food Chemistry, 39, 1094-1097.

Ministry of Agriculture. (2010). Agriculture Sector Development Strategy 2010 -2020, Nairobi Kenya, Government of Kenya Printer. Nairobi.

Ministry of Agriculture. (2012). National Agribusiness Strategy. Making Kenya's agribusiness sector a competitive driver of growth. Nairobi, Kenya, Government of Kenya Printer.

Mmasa, J. J., and **Msuya, E. E**. (2012). Mapping of the Sweetpotato Value Chain Linkages between Actors, Processes and Activities in the Value Chain: A Case of "*Michembe*" and "*Matobolwa*" Products. Sustainable Agriculture Research, 1(1), 130.

Mohammed, A. (2013). Analysis of Production and Trade of Selected Root and Tuber Crops within the CARICOM Region, USA, Canada and the United Kingdom.

Mohd, Hanim A. B., Chin, N. L., and Yusof, Y. A. (2014). Physico-chemical and flowability characteristics of a new variety of Malaysian sweet potato, VitAto Flour. International Food Research Journal, 21(5), 2099-2107.

Monjero, K. (2013). Sweetpotato virus disease research and diagnostic tools development at the Kenya Agricultural Research Institute Biotechnology Centre.

Mukhtar, A. A., Tamimu, B., Arunah, U. L., and Babaji, B. A. (2010). Evaluation of the Agronomic Characters of Sweet Potato Varieties Grown at Varying Levels of Organic and Inorganic Fertilizer. World Journal of Agricultural Sciences, 6 (4), 370-373.

Mukras, M. S., Odondo, J. A., and Momanyi, G. (2013). Determinants of Demand for Sweetpotatoes at the Farm, Retail and Wholesale Markets in Kenya. Advances in Economics and Business, 1(2), 150-158.

Mukundi, E., Mathenge, M., and Ngigi, M. (2013). Sweetpotato Marketing Among Smallholder Farmers: The Role of Collective Action. Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, Hammamet, Tunisia.

Mwanga, R., Odongo, B., Niringiye, C., Kapinga, R., Tumwegamire, S., Abidin, P., Carey, E., Lemaga, B., Nsumba, J., and Zhang, D. (2010). Sweetpotato selection releases: Lessons learnt from Uganda. AfricanCrop Sciences Journal, 15, 11-23.

Nabubuya, A., Namutebi, A., Byaruhanga, Y., Narvhus, J., and Wicklund, T. (2017). Influence of development, postharvest handling, and storage conditions on the carbohydrate components of sweetpotato (*Ipomeabatatas Lam*) roots. Food Science Nutrition, 00, 1–11. https://doi.org/10.1002/fsn3.496.

Nabubuya, A., Namutebi, A., Byayuhanga, Y., Narvhus, J., and Wickland, T. (2012). Potential Use of Selected sweetpotato (Ipomeabatatas Lam) Varieties as defined by chemical and flour pasting characteristics. Food and Nutrition Sciences, *3*, 889-896.

Nair, A. G., Pradeesh, S., Devi, C. M., Mini, I., and Swapna, T. S. (2013). Diplaziumesculentum: A Wild Nutrient-Rich Leafy Vegetable from WesternGhats. Prospects in Bioscience, 1, 293-301.

Namutebi, A., Natabirwa, H., Lemaga, B., Kapinga, R., Matovu, M., Tumwegamire, S., Nsumba, J., and Ocom, J. (2004). Long-term storage of sweetpotato by small-scale farmers through improved post harvest technologies. Uganda Journal of Agricultural Sciences, 9, 914-922.

Niringiye, C. S., Ssemakula, G. N., Namakula, J., Kigozi, C. B., Alajo, A., Mpembe, I., and Mwanga, R. O. M. (2014). Evaluation of Promising Orange Fleshed Sweetpotato

Genotypes in Different Agroecological Zones of Uganda. International Journal of Agriculture and Crop Sciences, 7(13), 1312-1321.

Nyambok, D., Oyia, J. R., and Braidotti, F (eds). (2011). Good agronomic practices for Sweetpotato in Western Kenya. Training Manual for trainers. Creative Commons Attribution Non-Commercial No Derivatives 2.5 Italy License.

Okwuowulu, P. A. (2003). Effect of harvest age on the storability of four sweet potato varieties in an indoor barn. Tropical Science, 43, 35-38.

Oladebeye, A. O., Oshodi, A. A., and Oladebeye, A. A. (2009). Physicochemical Properties of Starches of Sweetpotato (*Ipomeabatata*) and Red Cocoyam (*Colocasiaesculenta*) Cormels.Pakistan Journal of Nutrition, *8*(4), 313-315.

Olatunde, G. O., Folake, O. Henshaw., Idowu, M. A., and Tomlins, K. (2016). Quality attributes of sweet potato flour as influenced by variety, Pretreatment and Drying method. Food Science & Nutrition, 4(4), 623–635.

Oloo, B. O., Shitandi, A., Mahungu, S., Malinga, J. B., and Ogata, B. R. (2014). Effects of Lactic Acid Fermentation on the Retention of Beta-Carotene Content in Orange Fleshed Sweetpotatoes. International Journal of Food Studies, 3, 13-33.

Onwuegbuzie, A. J., and Kathleen, M. T. C. (2007). A Typology of Mixed Methods Sampling Designs in Social Science Research. The Qualitative Report, 12(2), 281-316.

Onyango, R., Thagana, W., Gweyi, J. L., and Laura, Karanja. (2015). Yield and Nutritive Attributes Are Not Considered by Farmers in Choice of Sweet Potato Varieties Grown in East Kamagak Location – Homabay County Kenya. The International Journal of Science and Technoledge, 3(9), 69-73.

Osundahunsi, O. F., Fagbemi, T. N., Kesselman, E., and Shimoni, E. (2003). Comparison of the Physicochemical Properties and Pasting Characteristics of Flour and Starch from Red and White Sweetpotato Cultivars. Journal of Agricultural and Food Chemistry, 51, 2232-2236.

Padda, M. S. (2006). Phenolic Composition and Antioxidant Activity of Sweetpotatoes [Ipomoea Batatas(L.) Lam]. A Dissertation Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy in The Department of Horticulture.

Pedreschi, F., Leon, J., Mery, D., Moyano, P., Pedreschi, R., Kaack, K., and Granby, K. (2007). Colour Development and Acrylamide content of predried potato chips. Journal of Food Engineering, 79, 786-793.

Quirien, E. A., van Oirschot., Rees, D., and Aked, J. (2002). Sensory characteristics of five sweetpotato cultivars and their changes during storage under tropical conditions. Food Quality and Preference, 14(8), 673-680.

Rando, R. R. (1990). The chemistry of vitamin A and vision. AngewandteChemstry International, 29, 461–480.

Ray, R. C., and Ravi, V. (2005). Post Harvest spoilage of sweet potato in Tropics and control measures. Critical Reviews in Food Science and Nutrition, 45, 23-64.

Rees, D., Van Oirschot, Q., and Kapinga, R. (eds). (2003). Sweetpotato Post-Harvest Assessment: Experiences from East Africa. Chatham, UK: Natural Resource Institute.

Republic of Kenya. (2015). Ministry of Agriculture, Livestock and Fisheries: Economic Review of Agriculture. Government of Kenya Printer.Nairobi.

Rono, C. S., Wanyama, J. M., Mose, L.O., Mutoko, C.M., Lusweti, C., Wanjekeche, E., and Wachiye, B. (2006). Assessing The Impact of Sweet Potato Production and Utilization Technologies On Food Security In North Rift Region.

Rukundo, P., Shimelis, H., Laing, M., and Gahakwa, D. (2013). Storage root formation, dry matter synthesis, accumulation and genetics in sweetpotato. Australian Journal of Crop Science, *7*(13), 2054-2061.

Salunkhe., and Kadam. (1998). Handbook of Vegatable Science and Technology. CRC Press, New York, USA.

Sapei, Lanny., and Hwa, Lie. (2014). Study on the Kinetics of Vitamin C Degradation in Fresh Strawberry Juices. International Conference and Workshop on Chemical Engineering UNPAR 2013, ICCE UNPAR 2013. Procedia Chemistry, 9, 62 – 68.

Sanoussi, A. F., Adjatin, A., Dansi1, A., Adebowale, A., Sannil, O., and Sanni, A. (2016). Mineral Composition of Ten Elites Sweet Potato (*Ipomoea Batatas* [L.] Lam) Landraces of Benin.International Journal of Current Microbiology and Applied Sciences, 5(1), 103-115.

Senga, K. P., OpotaOnya, D., Tamba, V. A., Tona, L. G., Kambu, K. O., Covaci, A., Apers S., and Pieters, C. K. L. (2013). Chemical composition and nutritive value study of the seed oil of *Adenantherapavonina*L. (Fabaceae) growing in Democratic Republic of Congo. International Journal of Pharmtech Research, 5(1), 205-216.

Sgroppo, S. C., Vergara, L. E., and Tenev, M. D. (2010). Effects of sodium metabisulphite and citric acid on the shelf life of fresh cut sweet potatoes. Spanish Journal of Agricultural Research, 8(3), 686-693.

Smith, C. D. (2012). Optimal Cultural Practices for Processed Sweetpotato Products. A thesis submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College.

Sohail, M., Khan, R. U., Afridi, S. R., Imad, M., and Mehrin, B. (2013). Preparation and Quality Evaluation of Sweetpotato ready to drink Beverage. ARPN Journal of Agricultural and Biological Science, 8(4).

Sugri, I., Maalekuu, B. K., Kusi, F., and Gaveh, E. (2017). Quality and shelf-life of sweet potato as influenced by Storage and Postharvest Treatments. Trends in Horticultural Research, 7: 1-10.

Sweetman, J. (2007). Importance of Vitamin C in the body. Advance Food Biochemistry. Plenum Press, New York/London, 283-321.

Taiwo, K. A., Baik, O. D., and Farinu, A. O. (2009). Kinetics of heat mass transfer and colour Development of pretreated sweetpotatoes during frying. Transactions of the ASABE (American Society of Agricultural and Biological Engineers), l (50), 129-135.

Takavarasha, T., and Rukovo, A. (1989). Food security issues and challenges for the 1990's. In Rukuni, M. 1989.Food Security Policies in the SADC Region. Harare. University of Zimbabwe and Michigan state University Food Security Research in Sothern Africa Project. Department of Agricultural economics and Extension.

Tedesco, I., and Stathers, T. (2015). Sweetpotato value chains in Kenya: a business opportunity for puree processing and the potential role for commercial fresh root storage. NRI report, February 2015, University of Greenwich, Chatham: UK. 117.

Thottappilly, G., and Loebenstein, G. (eds.). (2009). The Sweetpotato, Sardaya College of Engineering and Technology, Kodakara, Kerala, India Springer Science+Business Media B.V.

Timson, D. J. (2014). Purple sweetpotatocolour- a potential therapy for galactosemia? International Journal of Food Science and Nutrition, June; 65(4), 391-3.

Tomlins, K., Ndunguru, G., Kimenya, F., Ngendello, T., Rwiza, E., Amour, R., van Oirschot, Q., and Westby, A. (2007). On-farm evaluation of methods for storing fresh sweetpotato roots in East Africa. Tropical Science, 47(4), 197-210.

Tomlins, K., Owori, C., Bechoff, A., Menya, G., and Westby, A. (2012). Relationship among the carotenoid content, dry matter content and sensory attributes of sweetpotato. Food Chemistry, 131 (1), 14-21.

Truong, V. D., Mcfeeters, R. F., Thompson, R. T., Dean, L. L., and Shofran, B. (2007). Phenolic Acid Content and Composition in Leaves and Roots of Common Commercial Sweetpotato (*Ipomeabatatas*L.) Cultivars in the United States. Journal of Food Science C: Food Chemistry and Toxicology, 72, Nr. 6.

Tsakama, M., Mwangwela, A. M., Manani, T. A., and Mahungu, N. M. (2011). Effect of heat moisture treatment on physicochemical and pasting properties of starch extracted from eleven sweet potato varieties. International Research Journal of Agricultural Science and Soil Science, 1(7), 254-260.

Tumuhimbise, G. A., Namutebi, A., and Muyonga, J. H. (2010). Changes In Microstructure, Beta Carotene Content and *InVitro*Bioaccessibility of Orange-Fleshed Sweet Potato Roots Stored under Different Conditions. African Journal of Food Agriculture Nutrition and Development, 10(8),3016-3028.

Tumuhimbise, G. A., Orishaba, J., Atukwase, A., and Namutebi, A. (2013). Effect of Salt on the Sensory and Keeping Quality of Orange Fleshed SweetpotatoCrisps.Food and Nutrition Sciences, 4, 454-460. http://dx.doi.org/10.4236/fns.2013.44058.

Ukom, A. N., Ojimelukwe, P. C., and Okpara, D. A. (2009). Nutrient Composition of Selected Sweet Potato [*Ipomea batatas (L) Lam*] Varieties as Influenced by Different Levels of Nitrogen Fertilizer Application.Pakistan Journal of Nutrition, 8(11), 1791-1795.

Valkonen, J. P. T., Ndunguru, J., and Kreuze, J. F. (2013). Disease management, especially viruses in potato and sweetpotato. In Book of Abstracts.30th June-4th July 2013, 9th Triennial African Potato Association Conference Naivasha, Kenya.

van den Berg, H., Faulks, R., Granado, H. F., Hirschberg, J., Olmedilla, B., Sandmann, G., Southon, S., and Stahl, W. (2000). The potential for the improvement of carotenoid levels in foods and the likely systemic effects. Journal of the Science of Food and Agriculture, 80, 880–912.

Van Oirschot, Q., Ngendello, T., Rwiza, E., Amour, R., Tomlins, K., Rees, D., and Westby, A. (2007). The potential for storageof fresh sweet potato under tropical conditions: evaluation of physiological changes and quality aspects. In: Proceedings, 13th Symposium of the International Society for Tropical Root Crops, Arusha, Tanzania, 9–15 November 2003, 423–434.

Vimala, B., & Nambisan, B., and Hariprakash, B. (2011). Retention of carotenoids in orange-fleshed sweetpotato during processing. Journal of Food Science and Technology, 48(4), 520–524.

Were, H. K., Omuterema, S., Ndolo, P., Imbuga, B., Omuse, C. N., and Keya, N. C. O. (2013). Sweetpotato Production and use in sugarcane growing areas of Western Kenya. International Journal of Disaster Management and Risk Reduction, 5 (1), 121-132.

West, C. E., Rombout, J. M., Van der Ziypp, A. J., and Siytsma, S. R. (1991). Vitamin A and Immune Function. Proceedings of the Nutrition Society, 50, 251–262.

Wheatley, C., and Loechl, C. (2008). A critical review of sweetpotato processing research conducted by CIP and partners in Sub-Saharan Africa. International Potato Center (CIP), Lima, Peru. Social Sciences Working Paper, *3*:48.

White, R. J., Abbas, I. R., and Johnson, L. A. (1989). Freeze-thaw stability and refrigerated storage retrogradation of starches. Starch/Starke, 41, 176-180.

WHO. (2009). Global prevalence of vitamin A deficiency in populations at risk 1995–2005. WHO Global Database on Vitamin A Deficiency [Internet]. WHO Geneva, Switzerland. http://whqlibdoc.who.int/publications/2009/9789241598019_eng.pdf. Accessed May 26, 2017.

Wiesenborn, D., Orr, P., Casper, H., and Tacke, B. (1994). Potato starch paste behavior as related to some physical/chemical properties. Journal of Food Science, 58, 644–648.

Wilcox, B. F. (2006). Fundamentals of Food Chemistry 1st Edition. Vol. 1-2. Yola: Paraclete Publishers Nigeria.

Woolfe, J. (1992). Sweetpotato: An untapped food resource, Cambridge University Press. 1 – 13, 366 – 372.

Woolfe, J. A. (1987). The Potato in the Human Diet.Cambridge University Press, Cambridge, United Kingdom.

Xiao, H. W., Lin, H., Yao, X.D., Du, Z. L, Lou, Z., and Gao, Z. C. (2009). Effects of different pretreatments on drying kinetics and quality of sweetpotato bars undergoing air impingement drying. InternationalJournalof Food Engineering, 5(5).

Yanagisawa, H. (2004). Zinc Deficiency and Clinical Practice.Journal of the Japan Medical Association, 47(8), 359–364.

Zhang, Z., Wheatley, C. C., and Corke, H. (2002). Biochemical changes during storage of sweet potato roots differing in dry matter content.

Zhu, F., and Corke, H. (2011). Gelatinization, Pasting, and Gelling Properties of Sweetpotato and Wheat Starch Blends. Cereal Chemistry, 88 (3), 302 –309. **http://dx.doi.org/10.1094/CCHEM-10-10-0145**.

APPENDICES

APPENDIX A: Farmers Questionnaire

ASURVEY OF POSTHARVEST PRACTICES ON SWEETPOTATO IN KENYA

Dear respondent,

The author of this questionnaire is a Masters student at the University of Nairobi, carrying out a survey on the "**Postharvest practices on Sweetpotatoes in Kenya.** To facilitate this work, I kindly request you to fill this questionnaire sincerely. The information you will give will be used for the intended purpose and will be handled with confidentiality.

Enumerator's name ___________________________

Start time_________________________ End time _________________________

Background information - Respondent

1: General information

1.1 Date of interview		1.4 Constituency	
1.2 County		1.5 Ward	
1.3 Sub-County		1.6 Village	

2: Respondent and general household information. Please tick in the brackets

	Name of respondent	
2.1	Respondent gender	1= Male [ ] 2 = Female [ ]
2.2	What is your relationship to the householdhead?	1= Head household[ ], 2 = Spouse [ ], 3 = Son [ ], 4 = daughter [ ], 5 = grand Son [ ], 6= granddaughter [ ] 7=Parent[ ], 8=employee, 9=relative [ ]
2.3	Marital status of respondent	1=Married living with spouse [ ], 2=Married but spouse away [ ], 3=Divorced/separated [ ],4=Widow/widower [ ],5=Not married [ ]
2.4	Educational level of respondent	1=No formal education [ ], 2=Primary [ ], 3=Secondary [ ], 4= College / University [ ]
2.5	Age of respondent (years)	
2.6	Main occupation	1=Farming [ ], 2=Self-employed off-farm[ ], 3= Employed Casual labourer [ ], 4= Employed Salaried [ ] , 5 =Farm worker [ ], 6= Student/pupil [ ], 7=unemployed
2.7	Household family size	1= (1-2persons) [ ], 2=(3-5persons)[ ], 3= (6-8persons) [ ], 4= (9-12persons) [ ], 5= (Above 12)[ ]
2.8	Household farm size	1=0-0.5acres [ ], 2=0.6 -1acres[ ], 3=1.1-2 acres [ ], 4=2.1-4acres [ ], 5=4.1- 6acres[ ], 6= 6-10acres[ ], 7= Above 10acres [ ]
2.9	Land size under sweetpotatoes	1=0-0.5acres [ ], 2= 0.6 -1acres[ ],3=1.1-2 acres [ ], 4= 2.1-4acres [ ], 5= Above 4acres (state size)…………
2.10	Source of farm labour	1=Family members [ ], 2=hired casual labor [ ], 3= both family &hired casual labor

General Food Crops production by the household

3i) Kindly list below the 5major crops you produce in order of their importance and indicate using given codes why you grow them

a) Crop	b) 1= Grown as Food crop; 2= Grown as Cash crop; 3= both food and cash crop
3.1	3.1.1
3.2	3.2.1
3.3	3.3.1
3.4	3.4.1
3.5	3.5.1

ii) If sweetpotato is not among crops in 3(i), what position are they in your household? ……………….

Sweetpotato production

3 In the table below, list all the sweetpotato varieties you grow (in order of preference beginning with the most preferred) and why you like them

a) Variety of sweetpotato	b) Reason for liking variety. List all reasons (see codes below)
4.1	4.1.1
4.2	4.2.1
4.3	4.3.1
4.4	4.4.1
4.5	4.5.1
4.6	4.6.1

Codes for reasons for liking variety: 1=short Maturity period, 2= marketability / consumer preference,3=high yielding, 4= disease resistance, 5= taste, 6= availability of planting material, 7= Disease resistance, 8=others (specify)

5. Maturity age for harvesting sweet potato roots

Variety (indicate name of variety)	Age at first harvest (months)	Reason for harvesting at this age (1=money, 2=food, 3=maturity, 4=others)	How do you know when it is mature for harvesting?
Variety 1			
Variety 2			
Variety 3			
Variety 4			
Variety 5			

6. Sweetpotato Harvesting

a) Which method of harvesting do you use: 1= piecemeal ;2= wholesale(everything at once)	b)Which tools do you use in harvesting: 1= hand, 2= jembe, 3= panga 4=wooden stick 5= others (specify)	c) At what time do you harvest? (see codes below) **Codes:** 1=Early morning;2= Late morning;3= Afternoon; 4=Evening; 5=Anytime; 6=Other (specify)	d) What is the reason for harvesting at this time? 1=market requirements; 2= labor availability, 3=temperatures; 4=other(specify) 5= No reason
6.1.1	6.1.2	6.1.3	6.1.4

7. Sorting and grading of sweetpotato after harvesting

a) Do you sort and grade sweetpotatoes after harvest? 1= No; 2= Yes	b) What is the reason for your answer in 7(a)? (1= specific markets, 2= price considerations, 3= storage ,4=others(specify), 5= not important	If Yes to 7(a), what criteria do you use for grading/ sorting? (1=size, 2=colour, 3=shape, 4=damage, 5=others (specify) 6= do not grade
7.1.1	7.1.2	7.1.3

8. What do you do with roots that are damaged at harvesting time?

a)Type of damage	b) Use of roots(1= immediate boiling, 2= immediate processing, 3= livestock feed,4=other(specify)
8.1 Mechanical damage (scars)	
8.2 Pest damage (e.g weevils)	
8.3 Rotting	

9. Destination, transportation and Packaging of sweetpotato after harvesting

a) Where do you transport sweetpotato after harvest?: 1= homestead, 2= local open markets, 3= processor	b) What means of transportation do you use from the farm? (1=Motor vehicles, 2= motorcycles, 3=bicycles, 4= animal transport, 5= foot, 6=cart)	c) Which containers do you use during handling and transportation from the farm? 1= baskets, 2= Buckets, 3= Gunny Bags, 4= Wooden/plastic boxes, 5= others(specify)………
9.1.1	9.1.2	9.1.3

9. Destination, transportation and Packaging of sweetpotato after harvesting

a) Where do you transport sweetpotato after harvest?(1= homestead, 2= local open markets, 3= processor)	**b) What means of transportation do you use from the farm?** (1=motorvehicles, 2=motorcycles, 3=bicycles, 4=animal transport, 5=foot, 6=cart)	**c) Which containers do you use during handling and transportation from the farm?** (1= baskets, 2=buckets, 3=Gunny bags, 4=Wooden/plastic boxes, 5=others (specify)
9.1.1	9.1.2	9.1.3

10. Curing of fresh sweetpotato tubers after harvest

a) Do you practice curing of sweetpotato roots after harvest? 1=yes; 2=No	b) What are your reasons for your answer in (a)? (1= wound healing; 2= improve taste; 3= prolong storage; 4= don't have idea; 5=don't find it necessary; 6= other reason)	C) If yes, how long does this process take? (days)	d) If yes in (a), under what conditions do you subject the roots during this process? (please indicate the temperatures)	e) Where did you learn about this curing of sweetpotato roots? 1=College/school; 2=other farmers/friends; 3=agriculture extension officer; 4=Internet; 5=others (specify)
10.1 Roots	10.1.1	10.1.2	10.1.3	10.1.4

11. Preservation of fresh sweetpotatoroots after harvest

a) Do you preserve sweetpotato roots? 1= Yes; 2=No	b) What are your reasons for your answer in (a)? 1=longer storage; 2=holding for market stability; 3=don't know how to preserve; 4=other reasons (specify)	c) If yes in (a) which preservation methods do you use? 1=crop kept in garden(unharvested); 2= under shade; 3=underground; 4=water; 5=sawdust; 6=in a cool room; 7=waxing; 8=sun drying; 9=others (specify)…, 10=don't preserve	c) Where did you learn about the preservation method? 1=College/ school; 2=group members / friends; 3=agriculture extension officer; 4=Internet; 5=others (specify)	d) Length of preservati on time (days)
11.1 Roots	11.1.1	11.1.2	11.1.3	11.1.4

Sweetpotato Drying

12. If you practice drying (11c), fill in the table below.

Product	a)Which drying structures do you (see codes below)	b) What are the reasons for use of the structures? 1= availability; 2=cheap; 3=effective; 4=other reason	c) Which problems do you encounter with the structures? (Codes: 1= discoloration, 2= animals/insects/birds, 3=Labor shortage 4=Weather changes, 5=other (specify)	d) Which coping mechanisms do you use to counter the problems?
12.1 Roots	12.1.1	12.1.2	12.1.3	12.1.4

Drying structure: 1. Bare ground; 2. Drying rack;3. Solar dryer; 4. Mats;5. Roof tops;6. Rocks; 7.Cemented drying yard; 8. Polythene sheet; 9.Others (specify) …………

13. Storage of roots

a) Do you store sweetpotatoroots ? Yes=1; No=2	b) What are your reasons for your answers in (a)? 1= longer storage; 2= holding for market stability; 3=don't know how to store; 4= no surplus for storage; 5=lack of storage facilities; 6= other reason (specify)	c) If yes in (a), under what environmental conditions do you store?	d) For how long do you normally store sweetpotatoes? (days or months)
13.1	13.1.1	13.1.2	13.1.3

14. Consumption of sweetpotatoes

a) In what form do you consume sweet potatoes roots? List all codes applicable. 1= boiled roots with skin; 2= boiled roots without skin; 3= fried slices; 4= fried chips; 5= fried crisps; 6= sweet potato flour; 7= sweet potato juice; 8= mashed sweet potato with other food; 9= roasted; 10= say other method	b) How often does your household consume sweet potato roots? 1= daily; 2= 2-3 times a week; 3= once a week,4= once in two weeks; 5= monthly; 6= specify other frequency	c) Please estimate the number of kgs consumed by your household as per your answer in (b)
14.1	14.1.1	14.1.2

Sweet Potato Processing

15. On-farm processing of sweet potato

Product	a) Do you process sweet potato on-farm? Yes=1; No=2		b) What are your reasons for not doing on-farm processing? 1= low production; 2= lack of knowledge; 3=not interested; 4= other reason (specify)		c) What are your reasons for doing on-farm processing? 1= high production of sweetpotato; 2= increase shelf life;3= ready market; 4= high income; 5= other reason (specify)		d) If you process, where did you acquire knowledge on processing sweet potatoes? College/ school =1; group members /friends = 2; agriculture extension officers = 3; Internet =4; others = 5 (specify) ……………………	
Roots	15.1.1		15.1.2		15.1.3		15.1.4	

16. List three most important products you make from sweet potato roots, frequency, and reasons.

a) Product:1=Chips, 2=Flour, 3=Grates, 4= Crisps, 5= juice 6=puree 7= crackers 8=Alcohol beverage, 9= Animal Feed, 10= other (specify)	**b) Why do you process this product?** 1= market demand; 2= knowledge; 3= available equipment; 4= preservation	**c) Where does processing take place?** 1= in a room in the house, 2=at a yard outside the house, 3= in the house kitchen, 4=other...	**d) How often do you process the product?** (1=daily, 2=weekly, 3=monthly, 4= seasonal, 5= On demand	**e) What is the reason for processing at this frequency?** 1= customer demand; 2= availability of raw materials; 3= other reason(specify)
16.1	16.1.1	16.1.2	16.1.3	16.1.4
16.2	16.2.1	16.2.2	16.2.3	16.2.4
16.3	16.3.1	16.3.2	16.3.3	16.3.4

17. For the three most important products you process (12), list the respective sweet potato varieties you use.

a) Product(s) 1=Chips, 2=Flour, 3=Grates, 4= Crisps, 5= juice 6=puree 7= crackers 8= Alcoholic beverage, 9= Animal Feed, 10= other (specify)	**b) Which Sweet potato varieties do you use? List all varieties you use**	**c) What are the reasons for using the variety to make the product(s)?** 1= availability 2= taste 3= cost 4=color 5=bulk /weight 6=other (specify)	**d) How long after harvesting the roots do you process?**1=within24hrs; 2=25 – 48hours; 3=49 – 72hours; 4= 1-2weeks; 5= other period (specify)
17.1	17.1.1	17.1.2	17.1.3
17.2	17.2.1	17.2.2	17.2.3
17.3	17.3.1	17.2.3	17.3.3

18. Which equipment do you use during sweetpotatoroots Processing

(list all codes applicable)

Codes for the commonly used processing equipment/tools. 1=chippers, 2= graters, 3= solar dryers, 4= Pounding mortar, 5= Pangas, 6= Knives, 7= Grinding mill, 8=others (name)_

19. Constraints to processing sweet potato (whether you process or not)

Challenge	**Ranking (1= major; 2= minor)**
19.1 lack of appropriate equipment and tools	
19.2 Equipment not affordable	
19.3 Inadequate knowledge on processing	
19.4 Lack of time for processing	
19.5 Inadequate supply of raw materials	
19.6 Quality never constant	
19.7 Lack of labor	
19.8 Low demand by consumers	

Sweet potato Storage

20. How do you store the listed sweet potato products? Please list the products: fresh roots, dried chips, flour, dried leaves, crisps, puree, juice, etc

Product (list the products)	a) Do you store sweet potato products? 1= Yes, 2= No	b)What are your reasons for not storing 1= no surplus, 2= produced on demand, 3= no storage place, 4= don't know how to store, 5=other reason (specify)	c)If Yes, where do you store product (see codes below)	d) Which storage container do you use? (1= Polyethylene bags 2. Baskets 3. Canvas bags, 4= sisal/Jute Bags 5= Drums, 6= Others (specify))	e)What are reasons for use of the storage container: 1= readily available; 2= affordable; 3= damage proof; 4= takes less space; 5= other reason (specify)
20.1 Roots	20.1.1	20.1.2	20.1.3	20.1.4	20.1.5
20.2	20.2.1	20.2.2	20.2.3	20.2.4	20.2.5
20.3	20.3.1	20.3.2	20.3.3	20.3.4	20.3.5
20.4	20.4.1	20.4.2	20.4.3	20.4.4	20.4.5

Codes for "where do you store products?" 1= On floor in house 2= On a raised platform in house. 3. In a Granary, 4. Others (specify)

21. How long do you normally store each of the products (roots, leaves, flour, dried chips, crisps etc) before utilization /sale?

Product	Maximum Length (in days, weeks, months) of storage
21.1	21.1.1
21.2	21.2.1
21.3	21.3.1
21.4	21.4.1

22. Select one of the processes below that you apply for freshly harvested sweet potato tubers before storage

[1]Remove excess soil→clean with water→ dry in the sun→storage in a cool place [ ]
[2] Remove excess soil→dry in the sun→storage in a cool place [ ]
[3] Remove excess soil→storage in a cool place [ ]
[4]Direct storage without soil removal
[5] Others

23. Losses in Sweet potato

Stage of handling 1= harvesting 2= during transportation, 3=during storage	**What is the estimated percentage of loss incurred?** [1] = 10 – 20% , [2]=20-30%, [3]= 30 - 40%, [4]= above 40%, [5] = less than 10%, [6] = no loss experienced		**What are the main causes of lossif any?** 1= Pests; 2= harvesting method; 3= mode of transport; 4=Rotting; 5= theft; 6= Others (specify)	
23.1 harvesting	23.1.2		23.1.3	
23.2 during transport	23.2.2		23.2.3	
23.3 during storage	23.3.2		23.3.3	

Packaging and Marketing of sweet potato and sweet potato products

24. i) Which sweet potato products do you sell? Tick all (in the brackets) the products that you sell.

1 = Leaves [ ], 2 = Fresh tubers [ ], 3 = Dry chips [ ], 4 =Flour [ ], 5 = Animal feeds [ ], 6 = other processed products (specify) [ ], 7= don't sell [ ]

ii) Packaging of products. Please fill in the table below

a) Product: 1= Leaves; 2= Fresh tubers; 3= Dry chips; 4=Flour; 5= Animal feeds; 6= other product (specify)	**b) What type of packaging do you use for your products during sale?** 1= Polyethylene bags; 2= Baskets; 3. Gunny /jute bags; 4= Drums,5= plastic containers 6=Brown paper bags; 7= Others(specify) 8= don't pack	**c) What are your reasons for your answer in 20. b)?** 1= readily available; 2= affordable; 3= damage proof; 4= other reason (specify)	**d) What constraints do you face with the package?**1= expensive; 2= prone to product damage; 3= light / easy to tear; 4= other (specify)
24.1	24.1.1	24.1.2	24.1.3
24.2	24.2.1	24.2.2	24.2.3
24.3	24.3.1	24.3.2	24.3.3
24.4	24.4.1	24.4.2	24.4.3

25. Market of sweet potato products (fresh roots, leaves, flour, dried chips, juice, pureee.t.c)

Product (list product)		Location of sale (see codes below)		Distance to the market (km)		Means of transport to the market (see codes below)		Who buys? (Buyer) (see codes below)	
25.1	Roots	25.1.1		25.1.2		25.1.3		25.1.4	
25.2		25.2.1		25.2.2		25.2.3		25.2.4	

Codes for location of sale: 1= Local market; 2=Urban market; 3= Farm gate; 4=. Others (specify)
Codes for means of transport: (1=Motor vehicles, 2= motorcycles, 3=bicycles, 4= animal transport, 5= foot, 6=cart)
Codes for buyer: 1. Broker; 2. Local trader; 3. Fellow farmers; 4. Institutions (specify) 5. Individual consumers; 6=Processors; 7.= Supermarkets.

26. What challenges do you experience during marketing of your sweet potato products?

a) Problems in marketing (list all codes applicable)	b) Copying strategy (list codes below)

Problems: 1= low prices; 2= unstable prices; 3= high perishability of products; 4= middlemen interference; 5= poor road network; 6= other problem (specify)
Copying strategy: 1= sell at farm gate; 2= sell through marketing group/ cooperative; 3= preserve for later sale; 4= other strategy………..

27. Any recommendation / suggestion on sweet potato post harvest you would wish to share

____

Thanks

APPENDIX B: Traders Questionnaire

A SURVEY OF POSTHARVEST PRACTICES ON SWEETPOTATO IN KENYA

Dear respondent,

The author of this questionnaire is a Masters student at the University of Nairobi carrying out a survey on the "**Postharvest practices on Sweet potatoes in Kenya"**. To facilitate this work, I kindly request you to fill this questionnaire sincerely. The information you will give will be used for the intended purpose and will be handled with confidentiality. Your participation and cooperation will be highly appreciated.

Enumerator's name __________________ Start time___________ End time _________

1. Background information

1.1 Date of interview		1.4 Constituency	
1.2 County		1.5 Ward	
1.3 Sub-County		1.6 Village	
1.4 Name of town/ trading centre/ Market			
Date checked		Date of data entry	

2. Description of the Respondent

2.1 Category of business	1= Middleman/broker [ ]; 2=Distributor/wholesaler [ ]; 3= Retail Trader [ ]; 4= Supermarket [ ].
Name of respondent	
2.2 Respondent's gender	1= Male [ ] 2 = Female [ ]
2.3 Age (years)	
2.4 Educational level	1=No formal education [ ]; 2=Primary [ ]; 3= Secondary [ ]; 4= College / University [ ].
2.5 In what way are you related to this business?	1= owner [ ]; 2= employed manager [ ]; 3= Others (specify) …………………[ ]

Trading in sweet potato products

3. Please indicate sweetpotato products you have handled in the last one year

a)Sweet potato products **(see code 1)**	b)What's the product source? **(see code 2)**	c)Unit of purchase **(see code 3)**	d)To whom do you Sell (**See code 4)**	e)What units do you use forselling? **(see code 3)**	f)Transport Mode used (**See Code 5)**
3.1	3.1.1	3.1.2	3.1.3	3.1.4	3.1.5
3.2	3.2.1	3.2.2	3.2.3	3.2.4	3.2.5
3.3	3.3.1	3.3.2	3.3.3	3.3.4	3.3.5
3.4	3.4.1	3.4.2	3.4.3	3.4.4	3.4.5
3.5	3.5.1	3.5.2	3.5.3	3.5.4	3.5.5

Codes

1. **Products:1** = tubers/roots**2**= crisps **3**= composite flour 4= flour, 5= sweet potato Juice 6= sweet potato dry chips 7= sweet potato animal feed, 8= Others (specify)
2. **Source: 1=** Open market **2=** Shop/supermarket **3=** Farmer4= processor 5= broker/middleman
3. **Unit of purchase / sale: 1** = Heap/pile **2**= Sachet **3**= wheel barrow **4**= Kilogram **5**= bags, 6= Gorogoro, 7= number, 8=others (specify)
4. **To whom do you sell: 1=** Retailer **2=** Final consumer **3=** Both consumer and retailer **4=** processors/millers,5= institution**,6=** others (specify)
5. **Transport mode 1=**Bicycle **2=** Public service vehicle **3= ox-cart 4=** back/head **5=** pick up **6=** others (specify)

4. How often do you buy sweet potato tubers (roots)? (Tick in brackets) 1= daily [ ], 2= 2-3 times a week [ ], **3**= Weekly[ ], **4**= fortnight[ ], **5**= monthly[ ], **6**= others (specify) [ ]

5. What do you do with damaged/defective sweet potato tubers in your stock?

Type of damage		**Use of roots** (1= immediate boiling, 2= immediate processing, 3= livestock feed,4= throw them away, 5=store them for home use, 6= sell them 7=give them away, 8=other(specify)……..9= don't buy damaged
5.1	Mechanical damage/ injury due to harvest, transport	
5.2	Pest damage (weevils)	
5.3	Rot	

Drying Sweet potatoes

6.1 Do you dry sweet potato tubers (roots) or do you buy them already dried?
1= I dry [ ]; 2= I buy already dried [ ]; 3= **I**buy fresh but do not dry [ ]

6.1.1 If you dry them, in what form do you dry the sweet potato tubers?
1=Whole potatoes in their skins [ ];2=Peeled Potato slices [ ]; 3= Grated chips [ ]; 4= other form (please specify) [ ]………………………………

6.1.2 What is the reason for the answer (6.1.1) above?1= easy to dry [ ];2= easy to store [ ]; 3= reduce bulkiness [ ]; 4= don't have a reason [ ]; 5= other reason [ ](specify)…

6.1.3 If you dry, for how many days do you normally dry sweet potatoes? 1= 1to 2days[ ]; 2= 3 to 4 days [ ]; 3= other (specify)[ ]………………

. 7. If you dry, fill in the Table below appropriately

a) Product (1= Tubers, 2= sliced /grated chips,3= leaves,4= other product(specify)	b)Which drying structures do you use? (See codes below table)	c)What is the reason for structures used? 1= cheap and readily available, 2= dries faster, 3= safety from birds and rodents, 4= less contamination, 5= other reason (specify)	d)Which challenges do you face with the drying structures? 1=contamination by foreign objects, 2= discoloration, 3= domestic animals/birds; 4=Labor shortage 5=Weather changes, 6=other (specify)	e)Which coping mechanisms do you apply for the challenges?
7.1	7.1.1	7.1.2	7.1.3	7.1.4
7.2	7.2.1	7.2.2	7.2.3	7.2.4
7.3	7.3.1	7.3.2	7.3.3	7.3.4
7.4	7.4.1	7.4.2	7.4.3	7.4.4

Drying structure codes - Cemented drying yard [1], Drying Racks [2], Solar Driers [3], Roof Top [4], Rocks [5], Mats [6], Tarpaulin/ canvas [7], on grass [8], Others(indicate)…… [9]

8. Storage of sweet potato

a)Product (Tubers, dried chips/grates, flours, leaves, etc)	b)Where do you store (see codes)	c)Which storage container do you use?1= Polythene bags 2= Baskets 3= Canvas bags, 4= Jute/gunny, Bags 5= Drums, 6= no container, 7= Others(specify)	d)What are reasons for use of container: 1= cheap and readily available, 2= safety of tubers from dampness, 3= takes less storage space, 4= other (specify,) 5= no reason	e) What treatments do you give to the tubers during storage? 1= store at room temperature, 2= store at controlled temperatures, 3= periodicdrying, 4= others (specify)……..
8.1	8.1.1	8.1.2	8.1.3	8.1.4
8.2	8.2.1	8.2.2	8.2.3	8.2.4
8.3	8.3.1	8.3.2	8.3.3	8.3.4
8.4	8.4.1	8.4.2	8.4.3	8.4.4

Codesfor where do you store: 1= On floor in a room; 2= On a raised platform in a room; 3= in a market store; 4= covered on market stalls 5=Others (specify); 6= do not store

9. Losses in Sweet potato

a)Stage of loss occurrence 1= during transportation, 2=during storage, 3= at the market , 4=others (specify)	**b) What is the estimated loss per month?** [1] = 10 – 20% , [2]=20-30%, [3]= 30 - 40%, [4]= above 40%, [5] = less than 10%, [6] = no loss	**c) What are the main causes of loss?** 1= Pests 2= Molds; 3= Theft; 4=Rotting; 5= mechanical damage; 6= Others (specify)
9.1 During transport	9.1.1	9.1.2
9.2 during storage	9.2.1	9.2.2
9.3 At the market	9.3.1	9.3.2
9.4		

Marketing sweet potatoes

10. What challenges do you face in marketing sweet potatoes and it's products?

Please rate the challenges in the table below as major or minor.

Challenge	**Ranking** (1= Major;2= Minor)
10.1 High perishability of products	
10.2 Unreliable supply (seasonality)	
10.3 Poor quality due to a lot of mechanical injuries	
10.4 Quality never constant	
10.5 Transportation due to poor road network	
10.6 Lack of appropriate packaging	
10.7 Low demand by consumers	
10.8 Lack of appropriate storage facilities	
10.9Low profit	

11. Value chain activities

11.1 Do you belong to any association of businesses dealing in sweet potato and sweet potato products? 1=yes 2=No

11.2 What are the main activities of the Association?

……………………………………………………………………………………….

11.3 Would you be willing to work with other chain actors to improve the sweet potato trade? 1= Yes 2= No

11.4 Give reason for your answer

…………………………………………………………………………………………

12. Any recommendation / suggestion on sweet potato you would wish to share regarding trading/marketing, storage, packaging and quality?

____

____

Thank you

APPENDIX C: Processors Questionnaire

A SURVEY OF POSTHARVEST PRACTICES ON SWEETPOTATO IN KENYA

Dear respondent,

The author of this questionnaire is a Masters student at the University of Nairobi, carrying out a survey on the "**Postharvest practices on Sweet potatoes in Kenya"**. To facilitate this work, I kindly request you to fill this questionnaire sincerely. The information you will give will be used for the intended purpose and will be handled with confidentiality. Your participation and cooperation will be highly appreciated.

Enumerator's name ___________________ Start time___________ End time _________

1. General Information - Respondent

1.1 Date of interview		1.4 Constituency	
1.2 County		1.5 Ward	
1.3 Sub-County		1.6 Village	
1.7 Name of town/ trading centre			
Date checked		Date of data entry	

2. Description of the Respondent

Name of respondent: ____

2.1 Nature of business: 1= farmer group business; 2= sole proprietor 3= other (specify)………………..

2. 2 Gender of respondent: 1=Male 2= Female

2.3 Age of the respondent (Years): _____________________________________

2.4 Education Level: [1=No formal education, 2=Primary, 3=Secondary, 4=Tertiary]

2.5 What is your responsibility in this business? 1= Owner 2= Hired manager 3 = Others (specify) …………………………………….

2.6 How long (months or years) have you been processing sweet potatoes? ………………

3. What sweet potato products have you been processing?

a)Sweet potato products **(see code 1)**		b)Source of raw material **(see code 2)**		c)Unit of purchase **(see code 3)**		d) How long (hours/days) after buying do you process?		e) To whom do you sell the finished products **(see code 4)**		f) Unit of sale **(see code 3)**	
3.1		3.1.1		3.1.2		3.1.3		3.1.4		3.1.5	
3.2		3.2.1		3.2.2		3.2.3		3.2.4		3.2.5	
3.3		3.3.1		3.3.2		3.3.3		3.3.4		3.3.5	
3.4		3.4.1		3.4.2		3.4.3		3.4.4		3.4.5	

Codes
Code 1: Products:1= sweet potato crisps **2**= sweet potato composite flour **3**= sweet potato flour, **4**= sweet potato dry chips **5**= sweet potato animal feed, **6**=sweet potato puree 7=sweet potato crackers 8= Others (specify)
Code 2: Source: 1= Open market **2=** Shop/supermarket **3=** Farmers **4=** broker/middlemen
Code 3: Unit of purchase/sell: 1 = Sachet **2**= Kilogram **3**=bags **4**= heap /pile 5= gorogoro 6= number**7=** others
Code 4: To whom did you sell: 1= Retailer **2=** Final consumer **3=** Both consumer and retailer **4=** distributors **5=**institution **6=**others (specify)

Scale of operation, frequency of processing and quantity/quality criteria for sweet potato

4. How frequently do you buy sweet potatoraw materials for processing?

   1= daily [ ]; **2**= 2-3 time a week [ ]; **3**= Weekly [ ]; **4**= fortnight [ ]; **5**= monthly [ ]; **6**= others (specify)_______________

5. Processing frequency

a)Product (list products you process)		b)Frequency of processing: 1= daily; 2= weekly; 3=fortnightly; 4=monthly; 5= other (specify)		c) Reason for processing at this frequency: 1= demand; 2= availability of raw materials; 3= other reason(specify)		d)Volume of production per frequency (kg)		e) Do you do marketing promotion for your products 1= Yes; 2= No	
5.1		**5.1.1**		**5.1.2**		**5.1.3**		**5.1.4**	
5.2		**5.2.1**		**5.2.2**		**5.2.3**		**5.2.4**	
5.3		**5.3.1**		**5.3.2**		**5.3.3**		**5.3.4**	
5.4		**5.4.1**		**5.4.2**		**5.4.3**		**5.4.4**	

6. Using the scores below, Score how important youconsider the characteristics when buying processedsweet potato products?

Products Characteristics	Level of importance as per consumers: (Codes 1= Not important; 2= Fairly important;3= Very important)
6.1 Size	
6.2 Color	
6.3 Storability	
6.4 Taste	
6.5 Nutritive value	
6.6 Texture	
6.7 Packaging	

7. Please rateas major and minor the challenges you face while transacting your business associated with sweet potato processed products.

Challenge	**Ranking (1= major; 2= minor)**
7.1 High perishability of raw materials	
7.2 Seasonal supply of raw materials	
7.3 Non –uniform quality of raw materials	
7.4 Lack of appropriate packaging	
7.5 Low demand of products by consumers	

Processing equipment and premises

8.1 Where does processing take place?
1= designated factory [ ]; 2= designated room [ ]; 3= open yard [ ]; 4= other (specify]

8.2

8.2 List the common equipment/tools you use for processing	If more than one, list all codes
1=chippers, 2= graters, 3= solar dryers, 4= Pounding mortar, 5= Pangas, 6= Knives, 7= Grinding mill, 8=others (name them)_	

9. What are your copingmechanisms for the constraints below with the processing sweet potato?

Constraints	Coping mechanism
9.1 Expensive equipment	
9.2 Inadequate knowledge/skills	
9.3 High government taxes	
9.4 High cost of premises/rent	

10.1 Would you be willing to work with other chain actors to improve the sweet potato processing &trade? 1= Yes, 2= No

10.2 Give reason for your answer in 10.1____

11.1 Do you belong to any association of businesses dealing in sweet potato products? 1=yes 2=No

11.2 If yes, what are the main activities of the Association?

…………………………………………………………………………………………

Storage of processed products

12.1 Do you store sweet potatoprocessed products? 1. Yes [ ]; 2. No [ ]

12.2 If no, why don't you store sweet potato products?1= highly perishable [ ]; 2= low prices [ ]; 3= lack of appropriate storage facilities [ ]; 4= low production volumes [ ]; 5= other specify [ ]__

12.3 If yes, why do you store? 1= sell in a distant market [ ]; 2= to build up stock [ ]; 3= economical to produce large volumes [ ]; 4= other specify [ ] ___

12.3.1 How do you package your processed products for storage? 1= Polyethylene bags[ ]; 2.Baskets[ ]; 3. Gunny/ jute bags [ ]; 4= Drums [ ];5= plastic containers [ ]; 6=Brown paper bags [ ]; 7=Others (specify)[ ]____

13. Whereand how long do you normally store your packaged sweet potatoprocessedproductbeforesale?(table below)

Product		a)Where is the product stored (Use codes below)		b)Length (in days, weeks, months) of storage		**c) what are the main causes of loss if any** 1= Pests; 2= Molds; 3= Theft; 4=mechanical damage; 5= spoilage due to poor processing; 6= spoilage due to packaging; 7= Others (specify); 8= no loss	**d) What's the estimated loss per month** [1] = 10 – 20% , [2]=20-30%, [3]= 30 - 40%, [4]= above 40%, [5] = less than 10%, [6] = zero	
13.1		13.1.1		13.1.2		13.1.3	13.1.4	
13.2		13.2.1		13.2.2		13.2.3	13.2.4	
13.3		13.3.1		13.3.2		13.3.3	13.3.4	
13.4		13.4.1		13.4.2		13.4.3	13.4.4	

Codes for where do you store: 1= Onshelves in a store 2= On racks 3=Boxes 4=Others (specify)

14. What do you do with the damaged/spoilt sweet potatoraw tuber and processed products? List codes applicable

a) Damaged/broken products	b) spoilt (molded/caked)

Codes: 1= thrown away; 2= feed to animals; 3= sold to consumers at low cost; 4= given to workers; 5= other means (specify) ………………………………………..

15. **Any** recommendation to improve sweet potatoprocessing you would wish to share with us?

____

____

(Thank you).

APPENDIX D: Checklist for Focused Group Discussion

County____________________sub-county_________________constituency _______________

1. Which varieties of sweet potato do you grow and why do you prefer those varieties?
2. How do you harvest? (roots, leaves) –(tools)
3. How many times do you harvest the crop? Reasons?
4. Are some of sweet potatoes damaged during harvesting and handling?
5. What do you do with the damaged tubers after harvest?
6. What challenges do you face at harvesting?
7. Which parts of the sweet potato do you utilize?
8. How do you utilize them? i) tubers ii)leaves
9. How do you store sweet potato tubers if you do? (what treatment before storage?)
10. Do you preserve sweet potato tubers? How do you preserve them?
11. What are the major causes of sweet potato losses?
12. At which stages do you experience these loses?
13. How do you avoid / limit these losses?
14. Do you process sweet potatoes? Reasons for your answer
15. If you process which products? How often?
16. What challenges do you experience in marketing sweet potatoes if you do?
17. Which packages do you use for handling sweet potato products?

APPENDIX E: Key Informant Interview checklist – Agriculture Extension Officers

1. **General Information**

Name of County________________________ Constituency ______________________

Date of interview ________________________

2. **Description of the Respondent**

Name of respondent: _______________________Deployment ______________________

Gender of respondent 1=Male 2= Female

3. Which varieties of sweet potato are commonly grown here by farmers and what are the reasons for the varieties?

4. What challenges do farmers face at harvest?

5. Do farmers practice curing and storage? How do they do it? If no why?

6. What are the challenges farmers face in curing and storage?

7. What challenges are faced in packaging?

8. What challenges are faced during transportation?

9. What are the marketing challenges?

10. What are the challenges for processing sweet potatoes?

11. Give 2 suggestions to improve sweet potato post harvest handling in order to realize its maximum potential.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

THANK YOU