PRODUCTION, STORAGE AND QUALITY CHARACTERISTICS OF SWEET POTATO VARIETIES

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DECLARATION

Declaration by the Student

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DEDICATION

I dedicate this work to my late husband, Mr. Eliud Yego, and my children.

ABSTRACT

Sweet potato (*Ipomeabatatas*) is an important subsistence crop in Eastern Africa and is fast becoming an important supplementary staple food in Kenya. It is harvested fresh but the shelf life is short. Little is known in regard to storability of local varieties grown by farmers and its effect on culinary characteristics and nutritional value. The main objective of the study was to evaluate the production, processing, utilization and effect of various storage methods on preservation of nutritional quality (βeta - carotene) of sweet potatoes in Kabras and Kabondo wards. The study adopted a cross sectional survey and experimental research designs using 211 sweet potato farmers who were a stratified random sample. A questionnaire was used to collect data on production, processing and utilization of the sweet potato. The storage experiment involved the use of pit and clamp storage methods. The nutritional quality of the stored sweet potato, particularly the effect of storage on Trans –βeta carotene content cis-isomers, was determined by UV-Spectrophotometer. Data was analyzed using the Statistical Package for Social Sciences (SPSS V.20). T-test and ANOVA for the various variables were determined. The study results showed that 73.3% of the respondents in Kabondo and 86.7% in Kabras; 91.7% were women 64.2% and 39.7 of the farmers in the two study areas preferred the yellow local variety of sweet potatoes and grew sweet potatoes twice a year. There was no significant difference in the mean βeta carotene levels in selected sweet potato varieties stored under pit and clamp methods ($p \leq 0.05$). The clamp storage method was generally better than the pit storage method as it had fairly higher sensory trait means as compared to the pit storage method, using a five unit hedonic scale. There is need for use of improved storage methods as this will boost food and livelihood security at household, community and national level and also to address nutritional problems.

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LIST OF ACRONYMS

CIP	International Potato Centre
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics Database
GoK	Government of Kenya
KALRO	Kenya Agricultural Livestock and Research Organization
OFSP	Orange Fleshed Sweet Potato
SP	Sweet potato
VA	Vitamin A

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Sweetpotato, *Ipomoea batatas* L. (Lam.), is an important economic crop in many countries. In terms of annual production, sweetpotato ranks as the fifth most important food crop in the tropics and the seventh in the world food production after wheat, rice, maize, potato, barley, and cassava (FAO 2016). Sweet potato roots have high nutritional value and sensory versatility in terms of taste, texture, and flesh color (white, cream; yellow, orange, purple). Depending on the flesh color, sweet potatoes contain high levels of β-carotene, anthocyanins, phenolics, dietary fiber, vitamins, minerals, and other bioactive compounds. The β-carotene in orange-fleshed sweet potatoes can play a significant role as a viable long-term food-based strategy for combating vitamin A deficiency in the world. Studies in Africa demonstrated that increased consumption of orange-fleshed sweet potatoes improved the vitamin A status of children, pregnant women, and lactating mothers (Hotz et al., 2012; Van Jaarsveld et al., 2005).

Sweet potato can be grown in extreme conditions in a lot of soil types; hence it plays a huge economic role in a number of countries around the globe. Tuber storage and quality preservation are the key elements in the supply chain. Lack of appropriate, experimentally-proven and tested storage method, as well as storing sweet potato tubers in unsuitable conditions are among the most common reasons of spoilage directly after harvest. During long-term storage of sweet potato tubers, biochemical and physiological processes take place resulting in qualitative and quantitative changes (Grace et al., 2014). However, the quality of sweet potato decreased due to the decay and incorrect handling practices after harvest. Curing and storage temperature of sweet potato storage roots has been recognized as one of the most effective ways of reducing the risk of postharvest infection and decay (Lee et al., 2018).

Several surveys conducted over the past few years have indicated that the perishability of the sweetpotato storage root following harvest constitutes a major constraint to its potential as a food security crop. Although large-scale physical losses are not generally observed, this appears to be because the pattern of consumption and marketing has been adapted to the short shelf-life of the commodity, whereas a longer shelf-life would increase opportunities for consumption and marketing. Recommendations have therefore been made, in a number of reports that efforts should be made to increase shelf-life through the improvement of handling practices or cultivar selection (Fowler and Stabrawa 1993; Kapinga et al. 1995).

During storage, the roots are very perishable because they contain high moisture content (60-75%) hence low mechanical strength as well as high susceptible to microbial decay. They have high respiratory rate and the resultant heat production softens the textures which make them susceptible to damage. Postharvest quality deterioration emanates from respiration, weight loss, microbial attack, weevil damage and sprouting. Respiration and sprouting result in loss of nutritive value of organs. Sprouting in particular leads to weight loss, reduction of nutritional, processing and marketable quality of roots. The shelf-life therefore varies from few days or months according to the cultivar and storage conditions. In general, integrated pre and postharvest treatments, design considerations or improved-traditional storage methods that can reduce these limitations may be a viable option to improving shelf-life in smallholder production systems (Sugri et al., 2017).

Various traditional methods of sweet potato storage such as heap storage, in-ground storage, platform and pit storage methods have been practiced in Kenya and across African countries by farmers but the most common traditional method is the pit storage. This method has been reported in Indonesia, Zimbabwe, and Malawi by Woolfe (1992) and in Nigeria by Awojobi, (2004). Pit storage can generally be considered to be cheap for the rural communities since it requires minimum materials. The modifications of the various storage methods was because the methods that were e being practiced did not completely prevent deterioration and changes in the composition of the potatoes but only succeeded in slowing down the rate of deterioration.

1.2 Statement of the Problem

Sweet potato is the world's seventh most important food crop, after wheat, rice, maize, potato, barley and cassava. The crop is highly perishable with a shelf life of only 5-7 days. A lot of emphasis has been put on research and development of agricultural production while fewer resources have been invested in post-harvest development (Tomlins *et al*., 2008). Despite the clear potential of sweet potato in helping to meet Kenya's food needs, full exploitation is constrained by its bulkiness and perishability. According to Ndunguru (2005), sweet potato perishes easily and problems within ground storage mean that it is only available in certain seasons, often with large changes in prices. There has been enormous wastage of harvested tubers due to lack of proper storage technology and hence sale of the produce at unfavorable prices. The tubers tend to lose their nutritive value due to poor storage conditions hence the need to develop better storage techniques.

Lack of suitable storage facilities among small holder farmers continues to expose them to crop losses (Mutandwa and Gadzirayi, 2007). There is need, therefore for simple and cheap storage methods that will not affect market quality as well nutritive value. This will enhance food security at house hold level as well as increase income for farmers.

It is therefore important to carry out a study on the effects of some storage methods on the stored sweet potatoes in order to develop improved methods of storage of the crop that will not compromise the nutritive value.

1.3 Objectives of Study

1.3.1 Broad Objective

To assess the production, storage , methods and quality characteristics of sweet potato varieties grown in western Kenya and effect of different storage technologies on beta carotene and the sensory characteristics of the sweet potato.

1.3.2 Specific Objectives

1. To assess the current production, processing and utilization methods of the sweet potato in Kabras and Kabondo divisions.
2. To determine the effects of storage using pit and clamp storage methods on beta carotene levels in selected sweet potato varieties.
3. To evaluate the sensory characteristics of the sweet potato varieties stored using the pit and clamp methods.

1.4 Hypotheses of the Study

H_{01}: The pit or the clamp storage method did not affect the beta carotene levels in the selected sweet potato varieties.

H_{02}: The duration of storage did not affect the beta carotene levels in the selected sweet potato varieties.

H_{03}: Sensory characteristics of the selected sweet potato varieties are not affected by storage

1.5 Purpose of the Study

The purpose of this study was to examine the production, storage methods of the selected sweet potato varieties and how they cause post-harvest losses with an aim to improve them for food and nutrition.

1.6 Justification of the Study

The International Potato Center (CIP) has demonstrated the ability of beta-carotene-rich, orange-fleshed sweet potato (OFSP) varieties to reduce vitamin A deficiency (VAD) and improve food security, but smallholders in Africa have a hard time preserving those nutritious roots, especially in drought-prone areas, where they become scarce soon after the harvest. Sweet potato roots generally only keep for a few weeks, and OFSP roots are perceived to have especially short shelf lives. This short shelf life reduces the health benefits of OFSP, since it means fresh roots are only available to eat for two or three months of a year. It also reduces marketing opportunities, since most roots are sold during the weeks following the harvest, when prices are normally low due to a glut. And it results in a shortage of planting material at the beginning of each rainy season. Farmers have tried various methods to extend the shelf life of their sweet potatoes, which include storing the roots in soil, grass or ash, placing them in storage pits, or simply leaving them in the field and harvesting them piecemeal. However, such storage methods are usually only effective for a month or two, after which root quality declines due to rotting, infestation by pests and physiological deterioration. Hence, the application of storage knowledge is expected to contribute to the families having reliable supply of nutritious OFSP and subsequently improve household food and nutritional contents. Sweet potato can be bred for high levels of vitamin A. Therefore, the crop has the potential to help reduce the dietary deficiency of vitamin A, which is a leading cause of blindness and deaths among children throughout sub-Saharan Africa (Wheatley and Loechl, 2008).

This will gear towards the attainment of Sustainable Development Goals specifically: 1, 2, 3 and 5 to eradicate extreme poverty and hunger, promote gender equality and moreover, it will positively influence the achievement of the social and economic pillars of Vision 2030 and effective implementation of the Kenya Constitution towards the right to food. This study will form a basis of future research on indigenous technologies that may be duplicated.

1.7 Limitations of the Study

This study was conducted in western region of Kenya which might have different climatic and soil conditions that may limit generalization of the findings to other areas of the Country.

1.8. Assumptions of the Study

The study assumes that all the famers have the same economic endowment and they experience the same environmental conditions.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview

This chapter gives an insight into the sweet potato production globally, in Sub-Saharan Africa and Kenya, and the dynamics and factors contributing to low production of sweet potato in Kenya. It also highlights the different storage methods and the implications of different storage methods on the nutritional value of the tuber crops.

2.2 Sweet potato production globally and in Kenya

Sweet potato (*Ipomoea batatas L.*) is grown in more than 110 countries of the world (Gruneberg *et al.,* 2012). The crop accounted for about 12% of the world's root and tuber production with a total production of about 103 million tonnes in 2013 (Barrera, 2014). It was ranked 9th in 2011 in terms of worldwide production after maize, rice, wheat, potatoes, soybean, cassava, tomatoes and bananas (Barrera, 2014). Based on total production, it's the 7th most important crop in developing countries4 and is an important subsistence crop in East Africa (Valkonen *et al.*, 2013). It is also ranked the fifth most important crop in economic value in developing countries (Monjero, 2013), sixth in dry matter production, seventh in energy production and ninth in protein production (Thottappily, 2009). According to FAOSTAT, about 80% of the world's total sweet potato production is from the Asian continent while Africa accounts for about 20%. China is the world's leading sweet potato producing country with about 70 million tonnes in 2013 (FAOSTAT, 2015). In Africa, Tanzania and Nigeria are the leading producers of sweet potato, while Uganda and Kenya are third and sixth producers respectively (FAOSTAT, 2015).

In Kenya, Sweet potato is cultivated in 43 of the 47 counties in Kenya (Abong *et al.*, 2016). Major production counties in 2014 in descending order were Bungoma, Homabay, Busia and Migori at 133,037, 127,725, 119,970, and 69,642 tonnes, respectively (GoK, 2015). Sweet potato production in Kenya stood at 763,643 tonnes from 61,067 hectares in 2014 and it was valued at USD 0.23 Billion (GoK, 2015).
Sweet potato is a native crop of Central America where it was domesticated at least 5000 years ago and is one of the oldest vegetables known to man (International Potato Centre, 2015). It is one of the most important staple crops in densely populated parts of Eastern Africa and is fast becoming an important supplementary staple in the southern part of the continent. It is vital to destitute, small-scale farmers with limited land, labour and capital. One of its greatest assets is its ability to be harvested piecemeal as needed for home consumption or income generation (Michira, 2016).

Sweet potato ranks the seventh most important food crop in the world and fourth in tropical countries (FAOSTAT, 2013). In comparison to other major staple food crops, sweet potato has the following positive attributes: wide production geography, adaptability to marginal conditions, short production cycle, high nutritional value and sensory versatility in terms of flesh colours, taste and texture. Depending on the flesh color, sweet potatoes are rich in ß -carotene, anthocyanins, total phenolics, dietary fiber, ascorbic acid, folic acid and minerals (ILSI, 2008). Therefore, sweet potato has an exciting potential for contributing to the human diets around the world. However, the world trends in sweet potato production and consumption do not support the position of this highly nutritious vegetable.

In Kenya, sweet potato is an important food crop that has gained increased importance due to its role in food security, ability to withstand drought as well as its potential for commercial processing (FAO, 2015). A comparison with other food crops shows that sweet potato yields more calories per unit area than either maize or Irish potato and nearly as much as cassava, while its protein yields is far higher than the latter.

Sweet potato plays a major role as a famine reserve for many rural and urban households due to its tolerance to drought, short growing period and high yields with limited inputs (Edward and Vital, 2002). Its cultivation in many parts of the country is enhanced by its ability to adapt to a wide range of climatic conditions including marginal areas. It has the ability to establish ground maintenance cover very fast enabling suppression of weeds, controlling of soil erosion and maintaining soil fertility. All around the world people eat and use its plants, leaves and roots. The main producing areas in Kenya are Kakamega, Busia, Bungoma, Rachuonyo and Kisii districts with considerable production from some parts of Central, Eastern and Rift Valley provinces (One Acre fund, 2016).

Every year more than 130 million tons are produced around the world (FAO, 2004). The majority comes from China with the production of 105 million tons from 49,000 ha. Sweet potato is among the most important staples grown in sub- Saharan Africa (Byamukama *et al*, 2009). In Kenya fresh tubers yield up to 13 tons with an increased popularity of yellow fleshed tubers; a type that is rich in vitamin A (Mugai, 2000). Among the varieties developed in Kenya by KARI and CIP are *Kemb* 10, *Kemb* 23, Japanese 420009 pumpkin, SPK 013, SPK 004, SPK 004/6, *Ejumla*, *Kabondo* among others.

Sweet potato produces satiety and is good for those who are trying to lose weight. Beta carotene in sweet potatoes help to fight free radicals and also helps in blood purification and lowering of blood pressure, due to its richness in iron (1.46 mg) and calcium (22.58mg). Regular consumption is good for managing stomach ulcers and inflamed condition of the colon. Most of the varieties grown in East Africa are cream and white fleshed which contain Beta-carotene, a precursor to vitamin A in the body. Being rich in beta-carotene, it is thought that promotion of sweet potato, is an effective way of addressing sub clinical vitamin A deficiencies (Olakesusi, 2004).Vitamin A deficiency may lead to night blindness and reduced ability to fight Malaria and other diseases.

International potato centre (CIP) and its partner organizations have taken up the food-based options to combat the vitamin A deficiency in the sub-Saharan Africa through promotion of orange-fleshed sweet potato (CIP, 2016). The orange-fleshed sweet potato varieties have high ß-carotene contents and can be a cheaper and a complementary source of vitamin A to the rural and urban poor families. By this, sweet potatoes combine a number of advantages that make it a choice crop for sustainable food security, improved nutrition and income generation (Ewell, 2012).

2.3 Sweet Potato as a Food Security Crop

Sweet potato forms part of the world's most important and versatile food crops. With annual production of about 107.3 million tons; it is recorded as the fifth most important food crop in developing countries (FAO, 2009). This tuber is an important food security crop worldwide. In Africa, sweet potato is the second most important tuber crop after cassava, with its production concentrated in the Eastern and Southern Africa countries (Abong *et al.*, 2016). Sweet potato production is projected to expand in Africa, and has been increasing steadily in importance in most countries in Eastern and Southern Africa.

Sweet potato is one of the world's most important food crops in terms of human consumption, especially in Sub-Saharan Africa (SSA), parts of Asia and the Pacific

Islands (Barrera, 2014). The world average per capita consumption (kg) of sweet potato was recorded as 7.97, 8.01, and 8.22 for the years 2011, 2010 and 2009, respectively (FAOSTAT, 2015). Per capita per year consumption varies between 90 – 100 kg in Uganda and about 24 kg in Kenya mainly consumed boiled or fried (Were *et al.,* 2013, Ingabire and Vasanthakaalam, 2011).

Many villages in East Africa depend on sweet potato for food security (Thottappilly, 2009). There has been a sharp increase (300%) in consumption of sweet potatoes in Kenya from 2012 to 2014. Currently, sweet potato production trends are changing as most people now grow it for both food and commercial purposes, due to increasing demand and prices attached to it. The crop has more commercial market especially in schools, hospitals, prisons and other institutions. Reports from FoodNet Uganda and sweet potato trading associations indicate that during general food security, the crop becomes the most preferred crop for both rural and urban households especially by the low income dwellers. Studies have shown that in households that grew sweet potato, food insecurity significantly improved (Okonyo and Krosch et al 2014).

2.4 Harvest and Post-Harvest Handling of Sweet Potatoes

Piecemeal harvesting, where only enough is taken for one or two meals, is a common practice for home consumption and small-scale marketing (Okonyo and Krosch et al, 2014). Mature roots, harvested from the mound, make room for additional roots to develop. The process of piecemeal harvesting can continue for about three months, again depending on the cultivar and conditions, but after that time any roots remaining in the soil will succumb to sweet potato weevil attacks or other pests, or otherwise deteriorate. The harvesting of roots close to or protruding from the ground might, however, help deter weevil attacks (Zorogastua *et al.,* 2006).

Sweet potato is perishable and bulky to transport, and packaging is one of the major steps in post-harvest handling of sweet potatoes. Due to the fact that piece meal harvesting is common in Kenya, most of the sweet potato is packaged in baskets or sacs depending on the availability and distance of transportation. There are no developed specific packaging technologies for sweet potato in Kenya (Abung'o *et al.*, 2016). Traders commonly pack the commodity in gunny bags/sacs, which are susceptible to physical damage, attack from pests and microorganisms and 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 [41] at the producer, wholesaler, and retailer levels. Appropriate packaging equipment and containers are required not only to facilitate safe transport of sweet potato, but also for storage of low volume produce and for product presentation at the markets. In Uganda, the roots are roughly forced into overfilled sacs with an extension so that a 100 kg bag holds 120 kg, and brokers make extra profit at the farm gate price (Andrade *et al.*, 2009).

The role of packaging of sweet potato (and other materials), is to protect the roots from undesirable weather conditions, facilitate other processes of storage, supply of the roots, marketing and safety in transportation. Good packaging technologies should address a number of concerns, amongst which have sufficient strength in compression and against impact and vibrations, stability during the value chain, should be reasonably affordable, durable, and easily printable (helps to advertise the products).

Post-harvest losses of fruits and vegetables before they reach the consumers are estimated to be between 30% and 40% (Abong *et al.*, 2016). Physical and quality losses are mainly due to poor temperature management, use of poor quality packages, rough handling, and a general lack of education regarding the needs for maintaining quality and safety of perishables at the producer, wholesaler, and retailer levels (Kitinoja *et al.,* 2011). Physical and quality losses in turn lead to loss of market value, concerns about food safety, and lower incomes for growers (Kitinoja *et al.,* 2011). Insufficient and poorly maintained transport and market infrastructure for handling food products in urban and rural areas have frequently resulted in high level of waste and spoilage.

2.5 Factors Contributing to Low Sweet Potato Production in Kenya

Production of sweet potatoes in Kenya has seen a gradual increase in the past few years (Abong *et al.,* 2016) but not without challenges. According to International Potato Centre (CIP) (2016), production of sweet potatoes at large scale in Western Kenya is commonly hindered by seasonality, poor storability due to bulkiness, poor marketing capacity, weak value chain linkages, little investment in post-harvest, limited range of utilization and the risk of women losing control of the crop as it commercializes.

A study by Muthuri, (2016) on factors that hinder the adoption of sweet potatoes in Embu, Eastern Kenya, found that water scarcity was indicated as a major challenge by 32.7% of the farmers interviewed. Pest infestation especially weevils (23.3%), moles attack (12.7%), and price fluctuations was at 11.5% were also mentioned as challenges to sweet potato production.

Furthermore, lack of an organized marketing system thus resulting to low market prices for their tubers. For the low markets, farmers looked for the highest buyers and sought for better markets from other farmers. Lack of transport to the market was also a challenge as most farmers are poor thus only rely on brokers to buy their produce directly from their farms and in return result to extortion of these farmers (Muthuri, 2016).

High labor involved in the production process is an impediment to sweet potato production in Kenya. According to One Acre Fund (2017), there is poor adoption of mechanization among small holder farmers who produce sweet potatoes in Western Kenya. This is further exacerbated by high costs of inputs and poor infrastructure to transport produce to the market as it is perishable.

Furthermore, the perception that a sweet potato is a poor man's crop is one of the challenges affecting its production in Kenya. According to a study by (Khullar, 2016) in Western Kenya revealed that the crop was majorly consumed by households from a low socio-economic strata, and when the respondents were asked where they would continue consuming the tuber if their socio-economic status improved, most of them said they would not continue to consume it.

2.6 Sweet potato Storage Methods and Effect on Nutritional Qualities

A number of studies have been conducted that shows the relationship between sweet potato storage methods and effect on nutritional qualities. Agbemafle et al., (2014) studied the effect of different storage methods on the proximate composition and functional properties of cream-skinned sweet potato (Ipomea batatas Lam). The results of the analysis of the stored samples showed no significant variations in fibre, and reducing sugar, foaming capacity and swelling power with the storage methods and time but showed that moisture, ash, protein, fat, carbohydrate, foaming capacity and swelling power varied significantly with storage time.

Mpagalile et al., (2007) examined the effect of different storage methods on the shelf-life of fresh sweetpotatoes in Gairo, Tanzania. The storage methods covered under this study included traditional pit, improved open pit, improved housed pit (mjinge) and raised woven structure (kihenge). Results obtained from this study showed that housed pit storage (mjinge) performed comparatively well whereas the traditional method was the poorest in all attributes. For example, sugar content of sweetpotato stored using mjinge method increased significantly from 6.25% to 9.25%. Although kihenge method performed well with respect to crude protein that increased from 4.90% to 6.06%, its performance in other attributes was poor. In addition, sweetpotatoes stored by mjinge method had good quality attributes of sweetness, starchy mouth feel, smell, colour and general acceptability, scoring between 3.37 and 4.19 in the hedonic scale (0- 5). Sweetpotato stored using this method could be processed for blending with cereals to make composite flours for porridge and also for making fried snacks.

Dandago and Gungula (2011) studied the effects of various storage methods on the quality and nutritional composition of sweet potato (Ipomea batatas L.) in Yola Nigeria. The samples were again analyzed for moisture, protein, starch, Vitamins A and C at the end of the five months storage period. Data collected were analyzed using the GLM procedure of SAS version 9.2 and means that were significant were separated using LSD method. Results showed significant differences among the various treatments. It was concluded that two storage methods moist sawdust in wooden box and pit storage with layer of river sand have good potentials for storage of sweet potatoes in Yola for up to five months without serious change in nutrient content and could therefore be recommended to farmers.

2.7 Construction of Silo

The silo consists of a round hole dug in the ground, 80-120 cm deep, with a conical straw roof. The hole is dug at a shady, airy, dry location. The ratio of its depth to its diameter is approximately. 1:1.2 to 1:1.5. After the hole has been dug the straw roof is built over it, with access to the hole. Soil is placed on the border of the roof to keep it on the ground. The silo (Fig. 1) is suitable for storing tubers without treating the interior beforehand. The roof is sometimes protected with a covering of thorny branches, but only at locations where the silos could be destroyed by cattle roaming free. (Kibinzi,2016)

The sweet potatoes to be stored in the silo have to satisfy stringent selection criteria. They must show no sign of mechanical damage, nor must they have been attacked by parasites or pests. Any parts damaged by attack would lead to rotting during storage.

In addition to these criteria, it is also important that the shape of the tubers should be as uniform as possible. So the ideal sweet potato for this storage method is an evenly shaped tuber without any sign of attack, disease or damage sustained during harvesting or transport. Selection is done in two stages. The first stage is in the field, at harvest time. As the plants are harvested the tubers are inspected for size and to see if they are diseased or damaged. The potatoes selected in the field are then transported to the silo in baskets.

The second stage in the selection process takes place immediately prior to storing the produce in the silo. This second stage which consists of inspecting and assessing every single potato is carried out by an experienced farmer. The tubers are placed in the silo individually. In the silos, which are usually filled up to ground level, the tubers stayed in good condition from   Tubers conserved in this way can be prepared for eating in any of the usual ways. The later stage of development of the shoots, which drain the substance of the tuber, causes a noticeable deterioration in its suitability for culinary purposes. At a certain stage, however, these germinating tubers are ideal as seed for nursery cultures for the next field crop.

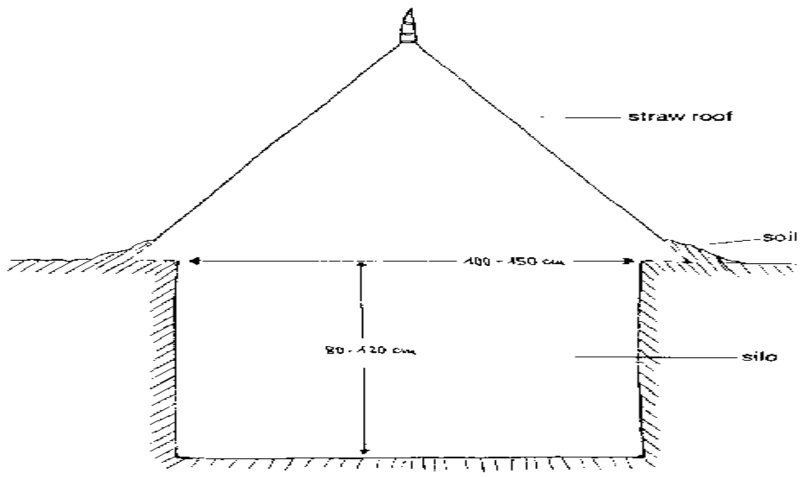


Figure 1: Silo

Source: Ray (2005)

Storage under tropical conditions has been shown not to affect the texture characteristics and overall changes in sweet potato, with special reference to orange fleshed sweet potatoes (OFSP) (De Moura *et al.*, 2013). The provitaminA carotenoid (pVAC) retention of staple crops during storage reached levels as low as 20% after one to four months of storage and was highly dependent on genotype. Short durations of four weeks storage at a low temperature(5°C) was found to significantly increase phenolic compound concentration and antioxidant activity in sweet potatoes, and these increased significantly when low temperature-stored roots were transferred to ambient temperature (about 22 °C). However, it was also noted that non-cured tubers accumulated a higher phenolic content and antioxidant activity than cured roots. A brief period (about three weeks) of low temperature storage may significantly increase phenolic content and antioxidant activity without causing a loss in root marketability (Motsa, 2015).

Tsakama (2010) reported that the chemical composition of sweet potatoes was not much affected after 4 months storage. According to Yakubu (2009) the pit storage method appeared to be the best traditional method because deteriorations such as sprouting moisture loss and pathological losses were minimal compared to other storage methods. In addition Mbeza and Kwapata (2009) also stated that in Malawi the pit storage method is the most common traditional method of sweet potato storage and changes are minimal.

An experimental in Uganda showed that storage of tubers of Ejumula and *SPK004/6/6* in a pit at ($17-21^{\circ}$ C, RH 90-100%) resulted in a higher retention of beta carotene compared to those stored at ambient conditions ($24-27^{\circ}$C, 68-100 %) and in saw dust at ($19-23^{\circ}$ C, RH 86-100%). The farmers in Uganda reported storage losses amounting to approximately 27% of total output. There are no current research results which show the new trend of sweet potato storage in Uganda (Stevenson, 2009). Farmers find it difficult to store sweet potato because of *Cylas formicarius*, sweet potato weevil and its related species, and this has prevented a sustained investment in storage facilities (Ebregt *et al.,* 2007). Because of this threat, majority of Kenyan farmers leave the roots in the ground and harvest it only when there is need.

2.8 Farmers' Preference for Different Sweet Potato Cultivars

According to Thottappilly (2009) the red-or orange-fleshed types are preferred for their moist flesh and sweet flavor, and phytochemicals[8]. African producers and consumers prefer starchy, high dry matter and sweet potato cultivars resistant to viruses and weevils. The adoption will be higher if the OFSP cultivars find ready markets, both as fresh roots and vines and as processed foods with added value (Kapinga *et al.,* 2007). Studies by Kivuva *et al.* (2014) revealed that farmers in central, eastern and western Kenya preferred sweet potato cultivars Vitaa, Kemb 10 and Kabode because of their orange flesh with high beta carotene. Small-scale farmers in sub-Saharan Africa prefer cultivars that have high dry matter content (Rukundo *et al.,* 2013), low fibre and good taste, especially women farmers. Most preferred genotypes of sweet potato by farmers in Kenya have qualities like orange flesh, high dry matter (favorable starch and sugar content), and low fibre content, do not overcook in normal cooking time and are high yielding, Andarde *et al.,* (2009). Another study on sweet potato cultivar selection in Kenya by Were *et al*.,(2013) revealed that farmers' top criteria in Busia, Kakamega,Bungoma and Butere-Mumias were taste; yield and maturity period followed by disease or pest resistance, availability of planting material and lastly market preference.

In Uganda, OFSP is mainly grown for its perceived nutritional benefits and the monetary value attached to it, but is disliked by the farmers because of its high perishability and vulnerability to harsh conditions, low dry matter content and the lower sweet taste (Abong *et al.,* 2016). The white fleshed sweet potato cultivars, especially Kawogo, Dimbuka, Sukali, and Tanzania are most preferred by farmers. This is so because of their ability to resist harsh conditions, they have a high dry matter content and have sweet taste. Over 86% of sweet potato farmers in Uganda grow these cultivars and are mainly used as fresh roots, and making amukeke (dried white fleshed slices) and kasende (sweet potato flour) (Nakanyike, 2014).

2.9 Nutritional Quality of Sweet Potato

Sweet potato (SP) is best known for its carbohydrate content, the predominant form of it being starch (Adeyemi & Salaam, 2015), and are good sources of dietary fibre (Viimala *et al.,* 2011). The tubers are largely rich sources of energy about 440 kJ per 100 g of edible portion. Sweet potato is a good source of vitamins C (ascorbic acid) and B_4. They also contain minerals as well as an assortment of photochemical (Adeyemi& Salaam, 2015). Sweet potato and its leaves are good sources of antioxidants (Burri, 2011), fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron and vitamin C (Burri, 2011).The orange and yellow cultivars have high carotenoids content (Adeyemi and Salaam, 2015). Improved OFSP cultivars have been shown to have high content of all-*trans*-b-carotene and are particularly important in combating Vitamin A Deficiency (VAD) in SSA (Low *et al.,* 2007). The purple sweet potato colour is rich in acetylated anthocyanins shown to minimize free radical production hence therapy for galactosemia (Timson, 2014).

Sweet potato roots and leaf are rich in various mineral elements, whose concentration depends on cultivar, location and agronomical conditions. A study on four cultivars in Rwanda showed the ash content ranged from 0.4% to 0.44%22. Generally, OFSP is rich in Fe (50 ppm DM) and Zn (40 ppm DM) (Kivuva *et al*., 2014). Cultivars grown in Vihiga County in Kenya showed iron content (mg/100 g) ranges of 1.10 - 1.30, 1.28 – 1.30, 1.03 – 1.28, and 1.28 – 1.40 for the white, purple, yellow, and orange flesh cultivars respectively and calcium (mg/100 g) ranges of 25.30 – 26.0, 18.50 – 24.43, 24.75 – 27.35, and 21.28 – 24.31 for white, purple, yellow and orange flesh cultivars

Table 1: Nutritional value for Sweet Potato, Raw, Unprepared

Value	Unit	value/100 g
Energy	Kcal	86
Protein	G	1.57
Total lipids(fat)	G	0.05
carbohydrate by difference	G	20.12
Fiber,total dietary	G	3
Calcium	mg	30
Iron	\mg	0.61
Magnesium	mg	25
Phosphorus	mg	47
Potassium	mg	337
Sodium	mg	55
Zinc	mg	0.3
vitamin c	mg	2.4
Thiamin	mg	0.078
Riboflavin	mg	0.061
Niacin	mg	0.557
Vitamin B-6	mg	0.209
Foliate	µg	11
Vitamin A	µg	709
Vitamin A	IU	14187

Source: USDA National Nutrient Database for Standard Reference (2016)

2.10 Carotenoids in sweet potatoes

Carotenoids have been credited with several health-promoting effects: immune enhancement and a reduced risk of developing degenerative diseases, such as cancer, cardiovascular diseases, cataract, and mascular degeneration. Orange fleshed cultivars are dominantly rich in pro Vitamin A carotenoids Some OFSP cultivars have yielded about 8000 µg b-carotene per 100g of fresh weight. Among the carotenoids, a-carotene and b-carotene have a high provitamin A activity. Some studies on raw peeled tubers of Kenyan OFSP cultivars have yielded beta carotene ranges between 1240–10,800 µg/100g fresh weights. Carotenoids are known to undergo degradation when exposed to heat and light and through various processing methods including cooking. There is, therefore, the need to handle sweet potato to minimize loss of carotenoids. The effect of storage on the vitamin content of different crops is not well a common knowledge to all according to Wilcox (2006). However, Ascorbic acid and β-carotenes are known to fluctuate according to the difference in the environmental conditions of the place where potato is grown. Beta carotene content of fresh roots changes because is the most sensitive of all nutritious content of the potato. Esheik and Ray (2005) noted that there existed a gradual decrease in beta carotene content of sweet potato after storage. Kader (2018) also reported that loss in ascorbic acid and beta carotene content of sweet potato increase with temperature.

2.11 Gender Aspects in Sweet Potato Production

According to Doss (2011) and FAO (2011) women are mostly responsible for household food production in the developing world and particularly the Sub Saharan Africa region. In the context of sweet potato, this crop has been considered to be a woman's crop and its production is mostly left to women (Ume *et al.,* 2016). According to a survey on sweet potato production dynamics in Busia and Bungoma districts, Ambitsi (2013) found that most of the production work was done by the women. This concurs with a study by (Onyango, 2013) among orange fleshed sweet potato farmers in Ugunja and Gem districts in Siaya County (Low, 2013).

However, that sweet potato is mainly considered to be a woman's crop seems to change. In a study by Gichuki, (2013), respondents were asked the most responsible gender for each of the sweet potato production activities. The findings show that men are actively involved in sweet potato production. The highest percentage of respondents reported men to be equally responsible with women, in ploughing of land (48.1%), ridging (48.8%), bed preparation (7.9%), planting vines (41.9%), weeding (58.3%), harvesting (51.9%), bagging (43.6%) and deciding how the sales money is spent (19.2%). On their own, men were reported to be the most responsible gender in preparing mounds (5.2%), and women dominated in cutting vines (31.2%), carrying vines to the plots for planting (39.5%), transporting sweet potato to the market (15.7%) and selling in the market (20.5%). With men getting more interested in sweet potato production, it becomes easier to promote OFSP production since there is likelihood that they will support women in OFSP production (Gichuki, 2013).

2.12 Summary of literature review and gaps in knowledge

From the literature above, there are few studies that have been done on the effects of different storage methods by farmers from developing countries, and particularly in high sweet potato producing areas in Western Kenya. Therefore this study sought to fill this gap in knowledge.

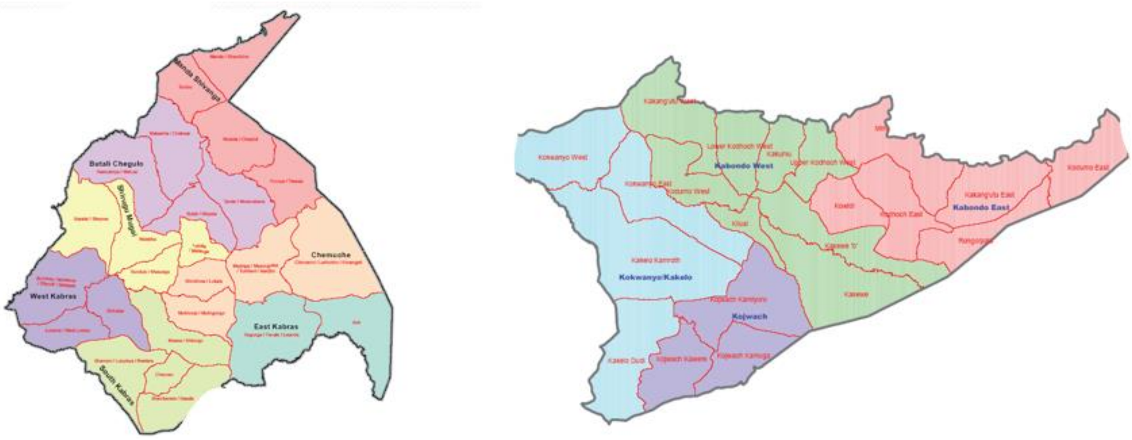
CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter outlines a plan for experimenting, the data collection, measurement and analysis. Therefore, this section sets to answer the research objective raised in the study. To achieve the objective of this chapter in research design, target population, data collection instruments, data collection procedures and finally data analysis techniques are addressed.

3.2 Study Area

The survey was carried out in Kabras ward, Kakamega County and Kabondo ward, Homabay County.



a)Kabras Ward in Malava Constituency b) Kabondo Ward in Kabondo Kasipul

3.2.1 Description of Study Area

Kakamega (0°17′N 34°45′E / 0.283°N 34.75°E) is a town in western Kenya lying about 30 km north of the Equator. It is the provincial headquarters of Western

Province. It is also headquarters to the Kakamega County which is one of the twelve sub counties of Western kenya. Kakamega is 52 km north of Kisumu, the third largest city in Kenya and a port city on Lake Victoria. The larger sub county has seven wards: Kabras, Shinyalu, Navakholo, Lurambi, Ikoloman and Ileho .It lies within altitude 1,250 m-2,000 m with the average annual rainfall ranging from 1250-1750 mm p.a. The average temperature in the district is 22.5 ^{0}C most of the year; Sweet potato is a major food security crop in the region with a yield of 10,390 bags (90 Kg) according to (MOA, 2009). Despite being the major sweet potato producing region in the country, vitamin A deficiency is still a common problem in the area and sweet potato consumption could be the best remedy. Kasipul Kabondo is in Rachuonyo. It is located in South Western part of Kenya and borders Nyakach Constituency. The area lies between longitudes 34° 25' and 35° 0' East and Latitudes 0° 15' and 0° 45'. It covers a total South area of 507 km^2. Kasipul Kabondo falls mainly under one main relief region – upland plateau with altitude range of 1,350m and 1.700m above i.e. sea level with temperatures between each 14°c and 25°c. Topographically this area has few isolated hills which include Wire Hills in Kasipul ward. The area has one major river namely Awach which originates from the Kisii Highlands and drains into Lake Victoria. Climatically, it exhibits an inland equatorial climate which is modified by the effect of the altitude and its proximity to Lake Victoria. Local temperatures are relatively high. Rainfall in the ward is caused by the convergence of the Westerlies and South Easterlies, which results in the heavy downpour with thunderstorms especially in the afternoons. This area has two main rainy seasons; the long rains which starts from late February and runs through June with rain fall ranging between 500 mm and 1,000 mm and the short rain season which occurs between the months of August and November with rainfall ranging between 250 mm and 700 mm. The area experiences the direct spell during the months of December to February and June to August during which agricultural activities are at minimum.

3.3. Methodology

3.3.1. Production, processing and utilization of the sweet potato in Kabras and Kabondo wards

3.3.1.1. Research study Design for the survey

The research employed both a cross sectional survey and experimental research designs. For Storage randomized completely block design was used and for Sensory characteristics of the different types of sweet potato hedonic using trained panelist was used.

3.3.1.2. Target Population

Target population regards to a group of members of real set persons, events or objects as to which a researcher is willing to generalize the results of the research study. Target population comprised of a total of 450 sweet potato farmers evenly distributed in the two divisions of Kabras in Kakamega County and Kabondo in Homa Bay County. This number consisted of those farmers who purely depended on potato farming and have a plantation of at least one acre.

3.3.1.3. Sample Size determination and sampling for the Survey

The sample size was determined using the formula for finite population (Reid and Boore, 2009) as follows;

$$n = \frac{N}{[(1 + N(e)^2]}$$

Where n = sample, N = population size and e = accepted level of error taking alpha as 0.05.

By substitution in the formula, we have sample size as;

$$n = \frac{450}{\{1+450(0.05)^2\}} = \mathbf{211} n = \frac{450}{\{1+450(0.05)^2\}} = \mathbf{211} \quad n = \frac{1200}{[1 + 1200(0.05)2]}$$

Thus a minimum of 211 sweet potato farmers were required for the study. According to the 2009 census, Kabras division had a total population of 149,410 whereas Kabondo division was found to have a population of 49,934, thus a total population of 199,344. This population numbers were used in determining the number of respondents

149,410 / 199,344 ×211 = 158 respondents

i. For Kabondo division:

49,934 / 199,344 × 211 = 53 respondents

Stratified random sampling was done where the population embraces a number of distinct categories; the frame can be organized by these categories into separate "strata" in this case were wards. Each stratum was then sampled as an independent sub-population, out of which individual elements can be randomly selected.

The two wards of Kabras and Kabondo were divided according to locations. Kabondo

Ward has a total of 2 wards of Kabondo East and Kabondo West. All of these locations depend on potato production as a major economic activity. Kabondo division was divided into 2 strata. From each of the 2 strata, respondents were chosen randomly to join the sample size. From Kabras division, random sampling was used to select potato farmers to join the sample for the completion of the study.

3.3.2 Storage Experiment in KARI – Kakamega

Samples were collected randomly from selected farms while taking into consideration the various sizes and varieties. The samples were labeled and stored under appropriate storage conditions. The study used two storage techniques as described below:

3.3.2.1 Clamp storage- The clamp consisted of a layer of straw laid on dry floor covered by heap of 50 roots followed by a layer of straw and final layer of soil. Openings were made at the bottom to provide some ventilation.

Tubers were heaped in a conical pile of 50 tubers on this straw bed. It was then covered with the straw to a thickness of 15cm, the soil was removed around the clamp to form a drainage ditch, and the clamp was under a shade.

3.3.2.2 Pit storage- Pits were dug to sufficient depth to restrict supply of air and moisture from the surrounding soil and atmosphere. The Pits were lined with plant material including chaff, grass, straw or maize stock, and left open for some time to allow curing before the cultivars are put in. It was closed and sealed with plant materials and soil or with stones.

3.3.3 Experimental layout

BLOCK 1	YP	WP	OP	YC	WC	OC
BLOCK	YC	OP	YP	WP	OC	WC
BLOCK 3	OP	YP	YC	WC	WP	OC

KEY

W – White flesh. O – Orange flesh. Y – Yellow flesh. P - Pit storage. C - Clamp storage

3.3.2 Nutrientional and sensory quality evaluation

Nutrient analysis and sensory analysis was conducted on randomly sampled cultivars after a period of three months. At the end of three months, levels of Beta-carotene were determined using UV- Spectrophotometer.

3.3.2.1 Determination of trans-β-Carotene Content by UV-Spectrophotometer of sweet Potato Products

A sample of 2 g was weighed to extract the Beta-carotene using a motor and pestle with small portions of acetone until the residual turned colorless. All extracts were combined into a 50 ml vol flask. Extracts of 25 ml of was poured into a 100 ml round bottom flask, and evaporated into dryness in rotary evaporator at about 50 c, to the evaporated sample 2 ml of petroleum spirit was added so as to dissolve Beta-carotene, elute the Beta-carotene through a packed column (silica gel of mesh), the elute was received into a 25 ml or 50 ml volumetric flask and the absorbance at 450 nm was read and the Beta-carotene was calculated as in the analysis section. This procedure was used to test the potatoes from various farmers in the two divisions. The results of this experiment were then recorded for further analysis and presentation.

3.3.2.2 Sensory Analysis

Sweet potato varieties samples were evaluated for sensory characteristics for colour, taste, texture and overall acceptability to distinguish between effects of pit and clamp storage. Each storage technique had three replicates of orange, white and yellow fleshed sweet potato. Mature sweet potatoes were left in the ground and harvested at piece meal to serve as control. A simple random sampling technique was used to select tubers from each treatment for sensory evaluation.

3.3.2.3 Sensory Evaluation

All the samples were cooked and subjected to sensory evaluation using a ten member panel selected based on their familiarity with the product in question within the University of Eldoret. The panel member comprised of 7 women and 3 men. Women were the majority because they were the ones involved in preparation of meals and were likely to be sensitive to taste than males (Kigel, 1999).

These were samples from two different varieties stored in the different storage technologies were coded, and then cooked on saucepans until ready as commonly done by most farmers. Freshly cooked samples were presented to the panel members who were seated in individual booths using partitioned plates for evaluation and were required to evaluate the samples for appearance, taste, texture and overall acceptability on a five point hedonic scale (1= very bad, 2= bad, 3= fair, 4= good and 5=very good). They were also required to comment freely on the samples. All the panel members evaluated each sample at a time. After each sample, they rinsed their mouth with water so as avoid carry over effect. The test was carried out before storage and after every month in storage for a period of three months.

Analysis was also done in the laboratory to determine the nutrient level of beta-carotene. This was done before storage and repeated after every month for a period of three consecutive months of storage.

3.4. Data Management and Analysis

3.4.1 Data Collection and Analysis

Questionnaire was the main data collection tool. It touched on production, processing, and utilization of the sweet potatoes. It was interviewer administered to the chosen respondents. The instrument was pre-tested in an area with similar population characteristic. The respondents in the pilot study did not participate in the major study. From the results of the pilot study, the researcher adjusted the questionnaires by restructuring some of the questions that seemed ambiguous to the respondents. Some of the questions were also added to the questionnaire to ensure that more relevant information would be found. Farmers cultivating sweet potatoes within the area of study were considered for the study.

Data collected was coded, entered and analyzed using SPSS (V.20) statistical software. The survey data was summarized using descriptive statistics that is frequencies, means and standard deviation. Chi square was used to determine the differences in the PPU practices and the satisfaction derived. Independent sample t-test and ANOVA were used to determine the differences in means between storage methods and length of storage. P-values less than 0.05 were considered significant. The results were presented in terms of tables and graphs.

3.4.2. Research Ethics

Before the research was conducted, the researcher sought permission from the university requesting for a letter of introduction. Permission was also sought from the local administration of both research areas to conduct the research. Written informed consent was sought from the farmers after a brief introduction of the purpose of the research. Participation in the study was on voluntary basis and any farmer was free to withdraw from the study anytime. The respondents were guaranteed confidentiality of any information that they gave during the interviews. No names were included on the data collection tools. Completed questionnaires were kept in a lockable place accessible to the researcher only. Electronic data was protected by use of password.

CHAPTER FOUR
RESULTS

4.1 Overview

This study sought to evaluate the implications of storage technologies of sweet potatoes and their nutritive value in Kabras and Kabondo Divisions in Western Kenya. In this study 210 farmers from both divisions were sampled. This chapter presents the results of the study based on the objectives and discusses the implication of these results.

4.2 Socio-demographic Characteristics, Production, Storage, Processing and Utilization of the Sweet Potato

4.2.1. Socio-demographic Characteristics of the Respondents

The background information sought included gender, age, highest levels of education, occupation and land sizes (Table 2). Majority of the respondents interviewed in the study areas were women, in which 86.7% were from Kabras and 73.3% Kabondo respectively. About 40% of the respondents in Kabondo were aged between 30-40 years while the majority in Kabras 35% was older between 41-50 years. In Kabondo, more than half 71.7% had primary education compared to 48% in Kabras. In both study areas, more than half 68.3% and 59.2% were self-employed for Kabondo and Kabras respectively as indicated in table 2. The implication of this is that most of these farmers are of low social status in terms of their level of education. In terms of the occupation, most them (68.3%, in Kabondo and 59.2% in Kabras) of the respondents were self-employed particularly in the sweet potato production chain mostly in the production, transportation of the crop to the market and also some actually sold the produce in the market. Only 28.3% and 4.1% of the farmers had more than 2 acres of land in Kabondo and Kabras respectively. Most of the farmers put 1-2 acres of their farms under the crop. This could be due to the fact that most of these farmers in the area produce the sweet potato for subsistence only and not for commercial purposes.

Table 2: Socio-demographic characteristics of the respondents in the surveyed area

Variable	Characteristics	Kabondo %	Kabras %
Gender	Male	26.7	13.3
	Female	73.3	86.7
Age	<30 years	23.3	24.7
	30-40 years	38.3	14.4
	41-50 years	21.7	35.1
	>50 years	16.7	25.8
Highest level of education	Informal	8.3	9.2
	Primary	71.7	48.0
	Secondary	20.0	39.8
	Tertiary	0.0	3.1
Occupation	Unemployed	23.3	29.6
	Self-employed	68.3	59.2
	Formal employment	8.3	11.2
Land size	<1 acre	35.0	46.9
	1-2 acre	36.7	49.0
	>2 acres	28.3	4.1

4.2.2. Types of Sweet Potatoes and Current Production Dynamics

4.2.2.1 Types of Sweet Potatoes Grown in Kabras and Kabondo

The types of sweet potatoes preferred by farmers in the two study areas was the local variety, which was preferred by 91.7% of the respondents in Kabondo and 63.3% by respondents in Kabras. In Kabondo only 5.0% of the locals grew improved variety of sweet potatoes compared to 5.1% of the respondents in Kabras. Both local and improved types of sweet potatoes were grown by only 3.3% and 31.6% of the farmers in Kabondo and Kabras respectively as indicated in Figure 2.

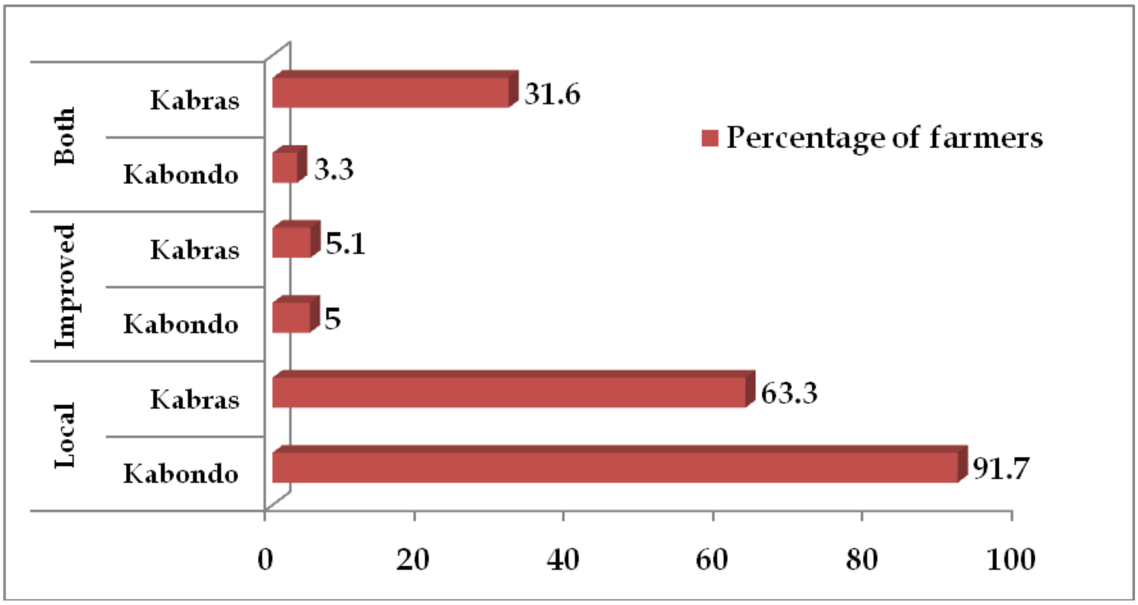


Figure 2: Types of sweet potatoes grown in the study areas

4.2.2.2. Colour of the local and improved varieties grown by the farmers

Table 3 shows that the most preferred local type of sweet potatoes by farmers in Kabondo was orange in colour (46.6%) and combined yellow and white colour in Kabras (64.2%). The colour of improved sweet potato types preferred by most farmers was yellow (75%) by farmers in Kabras and white among farmers in Kabondo (66.7%).

Table 3: Colour of the local and improved varieties grown by the farmers

Colour of the sweet potato	**Total respondents**	**Local**		**Improved**	
		Kabondo (%)	Kabras(%)	Kabondo (%)	Kabras (%)
Orange	211	46.6	32.6	33.3	75.0
White	211	13.8	2.1	66.7	0.0
Yellow and white	211	39.7	64.2	0.0	0.0

4.2.2.3. Production Dynamics of Sweet Potatoes

This study sought to examine the dynamics of sweet potato production in terms of production cycles per year, length of maturity, length of harvesting period and length of storage. Results showed that production cycles of sweet potatoes in Kabondo and Kabras were not significantly different (χ^2 = 9.403, df = 4, P = 0.052) as in Table 4. with most farmers in both study areas growing sweet potatoes twice in a year, 66.7% in Kabondo and 73.5% in Kabras (Table 4).

Results showed that there was no significant differences in terms of length of maturity period of the sweet potatoes (χ^2 = 2.120, df = 1, P = 0.145). For most of the farmers, the sweet potatoes took 6 months to fully mature. After maturity, most of the farmers in Kabondo harvested their sweet potatoes for 2 months (63.3%) while majority of the farmers in Kabras reported longer than 3 months of harvesting of their crops (51%).For farmers who did not consumed all their sweet potatoes and preferred storage, the length of storage of the sweet potatoes was significantly different among the farmers ($P < 0.05$) and between the farmers in Kabondo and those from Kabras (X^2 = 11.309, df = 4, P = 0.023). In Kabondo most of the farmers stored their sweet potatoes for 2 weeks (48.6%) while in Kabras most of the farmers stored their sweet potatoes for less than 1 week (35.7%) as indicated in Table 4.

Table 4: Production dynamics of sweet potatoes in Kabras and Kabondo

Production dynamics		Kabondo (%)	Kabras (%)	Chi-square	P-value
Production cycle per year	Once	21.7	16.3		
	Twice	66.7	73.5	9.403	**0.052**
	Thrice	11.7	10.2		
Length of maturity	3-4 months	13.3	22.8		
	6 months	86.7	77.2	2.120	**0.145**
Length of harvesting	1 month	11.7	1.0		
	2 months	63.3	32.7	12.357	**0.005 ***
	3 months	8.3	15.3		
	> 3 months	16.7	51.0		
Length of storage	< 1 week	33.3	35.7	11.309	**0.023***
	2 weeks	48.9	33.7		
	1 month	13.3	5.1		
	2 months	2.2	13.3		
	3 months	2.2	12.2		

***significant at p< 0.05**

4.2.2.4. Sweet potato storage methods used in Kabras and Kabondo

In terms of the sweet potato storage methods, 83.5% of the respondents in Kabras preferred the staggered method, while the same method was used by 38.1 % of the respondents in Kabondo. The open method was preferred by 35% of the respondents in Kabondo, and 11.5% of respondents in Kabras. On the same note, the pit method was used by 25.6% and 3% of the respondents in Kabondo and Kabras respectively. The clam method was used by 2% of the farmers from Kabondo and 1.5% of respondents from Kabras (Figure 3).

Result most showed that most (39% Vs 38.8%) of the respondents from Kabondo and

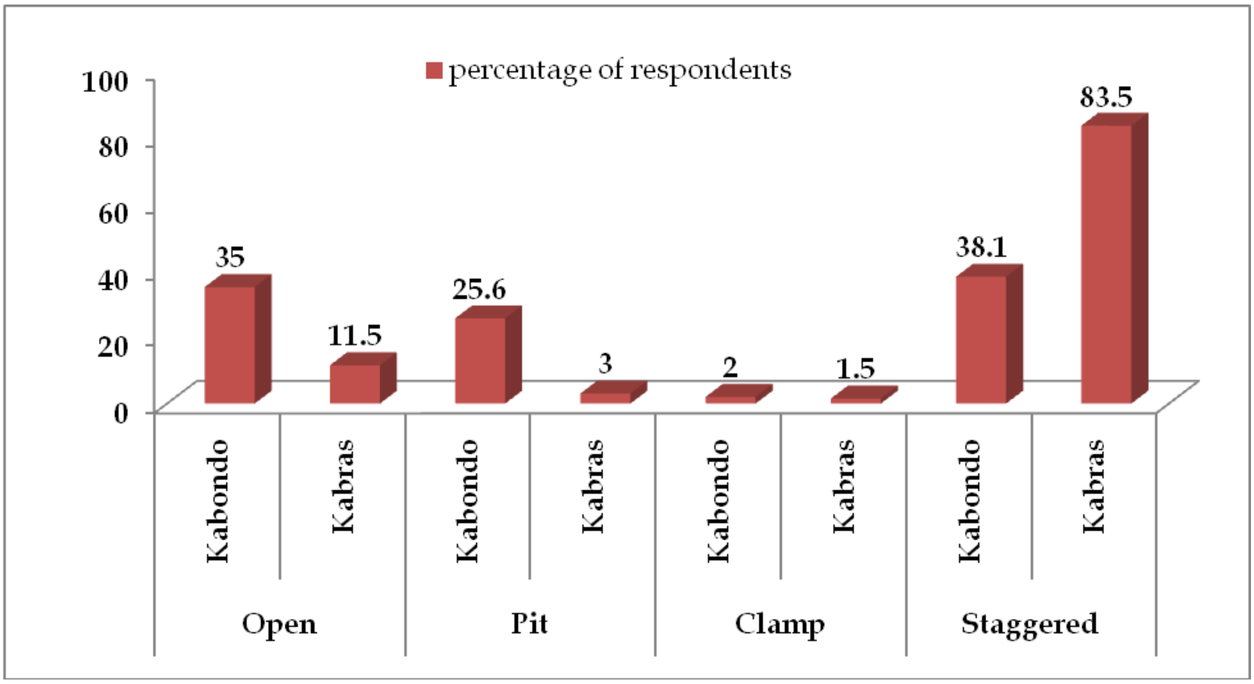


Figure 3: Sweet potato storage methods used by the farmers

4.2.2.5. Processing and Utilization of sweet potatoes

Results showed that 39% and 38.8% of the respondents from Kabondo and Kabras respectively ate sweet potatoes for breakfast, lunch, dinner and as a snack. In Kabondo, none of the respondents consumed it as a snack between meals, whereas in Kabras the least time the food was eaten for breakfast.

In terms of the method of cooking, results showed that the most common method used was boiling (88% and 83% for Kabondo and Kabras respectively). The least cooking methods in Kabondo were roasting, frying and baking. In Kabras, the least method of cooking was a combination of cooking, roasting, frying and baking, boiling and frying, and a combination of boiling and roasting (Table 4).

Respondents in Kabras 79.8% cooked *muchenye* and while in Kabondo, most of the respondents made porridge (25%) and potato chips (75%) with the sweet potatoes. In Kabondo, none of the respondents prepared chapatti, muchenye(amixture of sweet potato banana and beans, ugali or porridge from the sweet potato, whereas in Kabras, none of the respondents prepared porridge or chips from the crop (Table 5).

Table 5: Sweet Potato Utilization Methods

Sweet potato utilization methods		**Kabondo (%)**	**Kabras (%)**
Breakfast		22.0	7.1
Snack		0.0	4.1
Meal		16.9	12.2
Breakfast, snacks and meals		39.0	38.8
Breakfast and meals		22.0	37.8
Modes of cooking	Boiling	88.1	82.7
	Roasting	0.0	8.2
	Frying	0.0	5.1
	Baking	0.1	2.2
	Boiling, roasting, frying and baking	3.4	1.0
	Boiling and frying	5.1	1.0
	Boiling and roasting	3.4	1.0
Dishes made from sweet potatoes	Chapati	0.0	6.7
	"*Muchenye*"	0.0	79.8
	Ugali	0.0	4.5
	Chapati, *muchenye*,	0.0	9.0

ugali, porridge		
Porridge	25.0	0.0
Chips	75.0	0.0

4.3. Effects of Different Sweet Potato Storage Methods on Beta Carotene Levels

4.3.1. Effects of Storage Methods on beta Carotene amount in Selected Sweet Potato Varieties Stored for 3 Months

Sweet potatoes were stored for a period not exceeding 3 months both in Kabondo and Kabras divisions, with most of the potato harvest used within 2 weeks from the date of harvest. Based on the different varieties under study, there was no significant change in the beta carotene levels after storage for 3 months (Table 6).

Table 6: The amount of Beta Carotene per 100 g in the Storage Methods during storage time (µg/100 g)

Length of storage	Pit	Clamp
<1 week	0.210	0.260
2 weeks	0.170	0.160
1 month	0.140	0.120
2 months	0.120	0.110
3 months	0.120	0.110
F-value	**7.845**	**9.544**
P-value	**0.044**	**0.023**

Differences in beta- carotene of different sweet potato varieties stored for three months

Table 7: Differences in beta carotene levels per 100g in selected sweet potato varieties stored for 3 months (μg/100g)

Variety	Pit	Clamp	P-value
Yellow	0.12 ± 0.001	0.14±0.03	0.423
White	0.13± 0.014	0.15± 0.001	0.184
Orange	0.19 ± 0.028	0.26± 0.02	0.293

(Beta – carotene was not affected by storage time and the quantities did not differ in different varieties

4.4. Sensory characteristics of the sweet potato stored under various storage methods

4.4.1. Sensory Characteristics of the Sweet Potato Before Storage

Sensory evaluation is the process of using the five senses to analyze and evaluate a food product. In sensory evaluation, the following characteristics of food products were assessed - appearances, smell, taste and texture. In orange potato variety, color, texture appearance and acceptability were scored as good. The taste was scored as fair. On the other hand the yellow potato, colour, acceptability and taste were scored as good while white potato variety had good texture and appearance as shown in table 8.

Table 8: Sensory characteristics of the sweet potato before storage

Sensory attribute	Colour	Texture	Appearance	Taste	Acceptability
Yellow	3.5±0.8	3.3±1.2	3.10±0.10	3.26±0.01	3.50±0.02
Orange	4.0±0.2	3.5±0.09	3.85±0.12	3.15±0.8	4.0±0.03
White	3.2±0.8	3.5±0.1	3.60±0.10	3.01±0.02	3.26±0.01

Values are mean± SD. Overall liking ratings 1= Very bad, 2= Bad, 3=Fair, 4=Good, 5= Very good

4.4.2. Sensory characteristics of sweet potato after storage

After two months of storage the storage method were compared, it was noted that the clamp generally was better than the pit method. In sensory evaluation, the following characteristics of a food products were assessed - appearance, smell, taste and texture. In orange potato variety, taste, were scored as good. The color and appearance was scored as fair while acceptability was scored as very good. On the other hand the yellow potato, colour and a texture were scored as good while appearance and taste were fair, in white potato variety it had a fair texture, appearance, taste and acceptability as shown in table 8. Overall acceptability of sensory characteristics when comparing the two storage methods.

After two weeks of storage were compared, it was noted that the clamp generally was better than the pit method. This is because it had fairly higher trait means as compared to the pit method. Most of the potatoes stored under pit went bad which was not the case with clamp. The orange still had a fair color, appearance and was fairly acceptable by majority as compared to the yellow and white potatoes after storage.

From these scores, it can be deduced that clamp is a better method of storage and orange fleshed sweet potato has better traits even after storage as compared to yellow and white fleshed sweet potatoes as indicated in Figure 4.

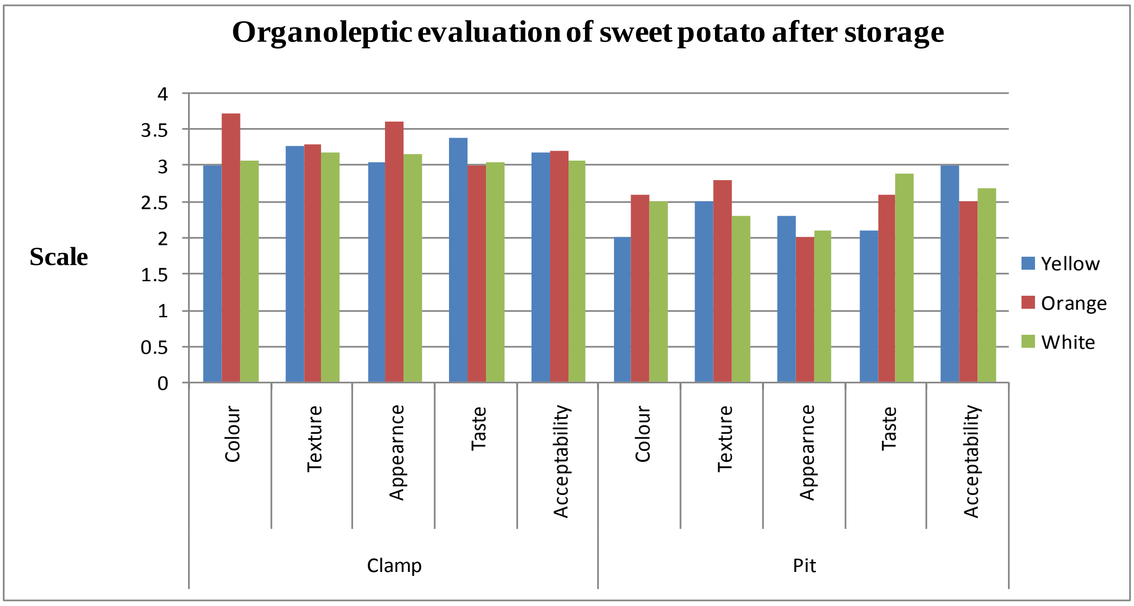


Figure 4: Sensory qualities of sweet potatoes stored in different methods

There was significant difference in the sensory qualities of selected sweet potato varieties (table 9).

Table 9: Differences in sensory qualities after being stored in the clamp and pit methods

Sensory attribute	Method	
	Clamp	**Pit**
Color	3.0^{a}±0.67	2.5^{b}±0.43
Texture	3.1^{a}±1.2	2.6^{b}±1.2
Appearance	3.4^{a}±0.89	2.5^{b}±0.04
Taste	3.0^{a}±0.45	2.6^{b}±0.12
Acceptability	3.4^{a}±0.56	2.1^{b}±0.65

Values are mean± SD. Values followed by different letter superscripts in a column are significantly different at P≤0.05 as assessed by Fisher's least significant test. Overall liking ratings 1= Very bad, 2= Bad, 3=Fair, 4=Good, 5= Very good

CHAPTER FIVE
DISCUSSION

5.1 Overview

This study sought to evaluate the implications of storage technologies of sweet potatoes and their nutritive value in Kabras and Kabondo Divisions in Western Kenya. In this study 210 farmers from both divisions were sampled. This chapter discusses the implication of these results.

5.2 Socio-demographic Characteristics, Production, storage, processing and utilization of the sweet potato in Kabras and Kabondo divisions

5.2.1 Socio-demographic Characteristics of the Respondents

5.2.1.1 Gender

The background information sought included gender, age, highest levels of education, occupation and land sizes (Table 2). Majority of the respondents interviewed in the study areas were females, 86.7% and 73.3% in Kabras and Kabondo respectively. Studies have shown that tuber and root crop production in developing countries is done by women (Ume et al., 2016). Furthermore, because sweet potato is a food security crop particularly in Sub-Saharan Africa, and the Tropics, its production is commonly carried out by women who commonly do it as a subsistence food crop (Tedeso and Stathers, 2015). An insight into the gender aspects of sweet potato production in Kenya and Uganda has shown that women participate most in the value chain in tuber production as compared to men (Kapinga*et al.,* 2012).Nwaru *et al.,* (2011) found that female sweet potato farmers were more technically and economically efficient than male sweet potato farmers—an encouraging result given the high percentage of rural farmers that are females and the fact that female farmers are increasingly taking over farm tasks and enterprises which traditionally belonged to their male counterparts (Mbasano *et al.,* 2012) Female participation is increasing mainly in response to the rural-urban migration of men, which increases pressure on women to ensure the family's survival by participating more fully in agricultural production activities (Nwaru *et al.,* 2012).

5.2.1.2 Age

About 40% of the respondents in kabondo were aged between 30-40 years while the majorities in Kabras 35% were older between 41-50 years. This means that the majority of the farmers are young, and therefore this shows that there is a good chance of uptake of sweet potato production in the study area This age class is receptive to technology adoption and they can withstand the rigor and strains in farming. These adequacies are capable of affecting their production and productivity (Ume *et al.,* 2016). A study by Gichangi (2013) revealed that most of the sweet potato farmers were young, and that age was a determinant in the adoption of new sweet potato varieties among farmers in Central Rift Districts. These findings corroborate with those of Onyenweau *et al.*,(2010), who found that sweet potato production in Nigeria was dominated by young energetic and enterprising individuals. However, they contradict with those of Ume et al., (2016) who found that most (66.7%) of the sweet potato farmers in Nigeria were between the ages 41-50.

5.2.1.3 Education

In Kabondo, more than half 71.7% had primary education compared to 48% in Kabras. In both study areas, more than half 68.3% and 59.2% were self-employed for Kabondo and Kabras respectively as indicated in table 2. The implication of this is that most of these farmers are of low social status in terms of their level of education. The percentage of the level of education concurs with that of Kenya Demographic Health Survey, where more than 50% of the population in Western Kenya achieved primary level of education (KNBS & ICF Macro, 2015). This could have implication on the level of knowledge on the nutritive value of the tuber and also the uptake of skills in the storage of the crop. A study by Gichangi (2013) found that level of education was one of the factors that determined the uptake of post-harvest technologies among sweet potato growing farmers in the Central Rift districts of Kenya.

5.2.1.4 Occupation

In terms of the occupation, most them (68.3%, in Kabondo and 59.2% in Kabras) of the respondents were self-employed particularly in the sweet potato production chain mostly in the production, transportation of the crop to the market and also some actually sold the produce in the market. This is quite encouraging because tuber crops have been promoted as one of the ways of alleviating rural poverty particularly among women in developing countries and the Sub Saharan Africa (Okonyo & Kroschel, 2014). A study by Chindi *et al.*, (2017) on the economic implications of sweet potato production in developing countries showed that there was significant improvement in the income levels of women who planted the crops. This is coupled with the gradual increase in the number of farmers planting the crops and also adoption of the crops as commercial venture for raw material production for industrial use (FAO, 2011).

5.2.1.5 Land Size

Only 28.3% and 4.1% of the farmers had more than 2 acres of land in Kabondo and Kabras respectively. Most of the farmers put 1-2 acres of their farms under the crop. This could be due to the fact that most of these farmers in the area produce the sweet potato for subsistence only and not for commercial purposes. This finding corroborates with previous findings that most of the farmers in developing countries are small scale. The implication of this is that mechanization and commercialization of farming activities becomes difficult (Therberye, 2009; Ume *et al.,* 2010).

5.3.1 Types of Sweet Potatoes Grown in the Study Area

The types of sweet potatoes preferred by farmers in the two study areas was the local variety, which was preferred by 91.7% of the respondents in Kabondo and 63.3% by respondents in Kabras. In Kabondo only 5.0% of the local grew improved variety of sweet potatoes compared to 5.1% of the respondents in Kabras. Both local and improved types of sweet potatoes were grown by only 3.3% and 31.6% of the farmers in Kabondo and Kabras respectively as indicated in figure 1. Colour of the local and improved varieties grown by the farmers

Table3 shows that the most preferred local type of sweet potatoes by farmers in Kabondo was yellow in colour (46.6%) and combined yellow and white colour in Kabras (64.2%). The colour of improved sweet potato types preferred by most farmers was yellow (75%) by farmers in Kabras and white among farmers in Kabondo (66.7%). Orange fleshed sweet potato (OSFP) has been documented to have high beta carotene content as compared to white sweet potato (WSP) (Low *et al.,* 2007). A study by Labarta *et al.,* (2009) among farmers in Mozambique (n=121) in terms of their Willingness To Pay (WTP) for sweet potato planting materials showed that farmers' WTP was higher for OFSP than WSP. This shows that the farmers were willing to plant the OSFP as compared to WSP. This finding concurs with the finding of this study that farmers in these study areas planted more of the OFSP compared to WSP.

5.3.2 Production Dynamics of Sweet Potatoes

This study sought to examine the dynamics of sweet potato production in terms of production cycles per year, length of maturity, length of harvesting period and length of storage. Results showed that production cycles of sweet potatoes in Kabondo and Kabras were not significantly different(X^2 = 9.403, df = 4, P = 0.052) as in table 4 with most farmers both study areas growing sweet potatoes twice in a year, 66.7% in Kabondo and 73.5% in Kabras (Table 4.3). Studies have shown that in Kabondo, the climatic conditions allow almost all year round production, and though the peak SP supply occurs in February/March fresh SP roots are harvested and traded all year round (Tedeso & Stathers, 2015). The number growing cycles of the crop is two times per year, even though the maturity time is around 3 months, and this could be attributed to long harvesting time, as the tubers would get spoilt if harvested at a go. This finding agree with that of Tedeso and Stathers (2015) who found that in Homa Bay, Busia and Siaya Counties, farmers grew sweet potatoes twice a year, planting bit by bit as the rains continue

Results showed that there was no significant differences in terms of length of maturity period of the sweet potatoes (X^2 = 2.120, df = 1, P = 0.145). For most of the farmers, the sweet potatoes took 6 months to fully mature. After maturity, most of the farmers in Kabondo harvested their sweet potatoes for 2 months (63.3%) while majority of the farmers in Kabras reported longer than 3 months of harvesting of their crops (51%).

For farmers who did not consumed all their sweet potatoes and preferred storage, the length of storage of the sweet potatoes was significantly different among the farmers ($P < 0.05$) and between the farmers in Kabondo and those from Kabras (X^2 = 11.309, df = 4, P = 0.023). In Kabondo most of the farmers stored their sweet potatoes for 2 weeks (48.6%) while in Kabras most of the farmers stored their sweet potatoes for less than 1 week (35.7%) as indicated in Table5. The short storage period could be due to the fact that sweet potatoes are highly perishable. The implication of this is that farmers will not be able to store the produce for long, and therefore are more likely to sell at lower prices at their farm gates. This again is going to have implications on the food security of the households as they will not be able to store to keep the produce for long for consumption when there is food insufficiency. This is critical particularly in Kabondo where farmers store the sweet potatoes for less than a week. Similar findings to these have bben documented by Tedesco and Stathers (2015) where farmers from Kabondo sell their sweet potatoes immediately after harvest because of lack of storage facilities, and poor road network to transport the produce to major marketing points.

5.4 Sweet Potato Storage Methods

In terms of the sweet potato storage methods, 83.5% of the respondents in Kabras preferred the staggered method, while the same method was used by 38.1 % of the respondents in Kabondo. The open method was preferred by 35% of the respondents in Kabondo, and 11.5% of respondents in Kabras. On the same note, the pit method was used by 25.6% and 3% of the respondents in Kabondo and Kabras respectively. The clamp method was used by 2% of the farmers from Kabondo and 1.5% of respondents from Kabras (Figure 6).

5.5. Utilization of Sweet Potatoes

Results showed that 39% and 38.8% of the respondents from Kapondo and Kabras respectively ate sweet potatoes for breakfast, lunch, dinner and as a snack. In Kabondo, none of the respondents consumed it as a snack between meals, whereas in Kabras the least time the food was eaten for breakfast. The implication of this consumption pattern is that the food was finding its way into the family menus during different times of the day. A study by Miyazaki *et al.,* (2013) in Zambia found that Sweet potatoes were most commonly served at breakfast as a main dish, and they were almost always boiled. When they were served at lunch and supper, they were served with *nshima* or other side dishes. In Homa Bay County, farmers typically boiled the sweet potato roots and took them with a cup of tea, mostly in for breakfast and lunch (Tedeso & Stathers, 2015).

5.5.1 Cooking Method

In terms of the method of cooking, results showed that the most common method used was boiling (88% and 83% for Kabondo and Kabras respectively). The least cooking methods in Kabondo were roasting, frying and baking. In Kabras, the least method of cooking was a combination of cooking, roasting, frying and baking, boiling and frying, and a combination of boiling and roasting (Table 4.4). Boiling has been documented in other studies as a common way in which sweet potatoes are prepared (Myakazi *et al.,* 2013). This finding agrees with that of Tedeso and Stathers (2015) who documented that the major cooking method of sweet potatoes among farmers from Homa Bay County was boiling. Generally, the method of cooking affects bio-availability of beta carotene in sweet potatoes. Burri (2011) reports that high is reported in deep fried sweet potato, steam/boiled, baked and raw in that order. A study by Jaarsveld *et al.,* (2006) recommended consumption of sweet potato with small quantities of fats as this increases the bioavailability of beta carotene as Vitamin A is a fat soluble vitamin (Whitney *et al.,* 2014). Results from the study showed that the most successful way to retain beta carotene (up to 92%) was by boiling for 20 minutes with the lid on/ when boiled with the lid off, the potatoes took longer to cook through and lost slightly more beta carotene (retention of 88%). Furthermore, results showed that consumption of sweet potato alongside fat improves its bioavailability by up to 20 fold.

5.5.2 Utilization

Respondents in Kabras 79.8% cooked *muchenye* and while in Kabondo, most of the respondents made porridge (25%) and potato chips (75%) with the sweet potatoes. In Kabondo, none of the respondents prepared chapatti, muchenye, ugali or porridge from the sweet potato, whereas in Kabras, none of the respondents prepared porridge or chips from the crop (Table7). The implication of this finding is that these farmers were willing to incorporate the sweet potato into culturally appropriate recipes. In Mozambique, studies have shown that one of the most effective ways in which households can adopt and use sweet potatoes in their daily recipes is though incorporation into local foods (Kipanga, 2007). For instance, according to the study by Kipanga (2007), OFSP was used in six different forms in the households; ad was the third important crop in the diets of the households because they had identified ways through which they could in their diets. This further led to increased consumption of OFSP was the farmers 2-3 times per week. Consumption of Vitamin A rich OSFP has been shown to influence Vitamin A intake regardless of the amount produced (de Braw*et al.,* 2013).

In this study, 75% of the respondents prepared fried chips from sweet potatoes. This is encouraging because it is recommended that Vitamin A rich/precursor foods should be cooked with fat to increase the bioavailability of Vitamin A (Whitney *et al.,* 2014). The implication of these finding is that residents from this study could be having maximum assimilation of beta carotene from the sweet potatoes, and therefore reduced chances of Vitamin A deficiency. A study by Low (2008) in Mozambique showed that fried chips made from OSFP yielded products with sufficient beta carotene content. Furthermore, the study showed that 110g of a bun with OSFP provided an excellent source of Vitamin A.

Results showed that none of the respondents from Kabondo made ugali, porridge or chapatti from sweet potato. This could have been due to cultural aspects of their foods and also poor sensory characteristics of these sweet potato products. A study by Carvalho *et al.,* (2014) showed that porridge made from OFSP was unappetizing and scored very low in all sensory characteristics examined. However, incorporation of cassava improved the sensory characteristics. This shows that in this context, there is need to educate the households of ways in which they can incorporate sweet potato into these dishes with a desirable sensory outcome. However this finding contradicts that of Tedesco and Stathers (2015) who found that sweet potato was utilized to make chips and porridge in Siaya and Homa Bay counties.

5.6 Effects of Different Sweet Potato Storage Methods on Beta Carotene Levels

Table 6 shows that in both pit storage and clamp storage used in the study area, the longer the storage duration, the lower the beta carotene content of the potato. Potatoes stored for one week or less had the highest beta carotene content with 21% and 26% for pit and clamp respectively. The beta carotene content then gradually decrease with time up to 12% and 11% for pit and clamp respectively after 2-3 months of storage. It is also worth noting that after 2 months of potato storage, the beta carotene content of the potatoes remained unchanged. This means that it attained stability after 2 months of potato storage. In addition, potatoes were observed to be stored for a period not exceeding 3 months both in Kabondo and Kabras divisions, with most of the potato harvest used within 2 weeks from the date of harvest, therefore the length of storage period affects the Beta carotene levels and cis isomers. From the table, it can be concluded that the length of storage significantly affects the beta carotene content in the sweet potatoes. Variation in β-carotene content may be due to differences in varieties, growing conditions, stages of maturity, harvesting and post-harvest handling, processing and storage of OFSP, air and soil temperature, radiation, location, soil moisture and fertilization (K'Osambo et al., 1998; Rodriguez-Amaya, 2000; Mbwaga et al., 2007; Ukom et al., 2009). Environmental conditions, genetic factors, crop age and cultivation management strategies can significantly influence the β-carotene content of varieties (K'Osambo et al., 1998). High irrigation levels were found to decrease β-carotene content (K'Osambo et al., 1998).

In this study, 75% of the respondents from kabondo prepared fried chips from sweet potatoes. This is encouraging because it is recommended that Vitamin A rich precursor foods should be cooked with fat to increase the bioavailability of Vitamin A. Results showed that none of the respondents from Kabondo made ugali, porridge or chapatti from sweet potato. This could have been due to cultural aspects of their foods and also poor sensory characteristics of these sweet potato products. A study by Carvalho *et al.,* (2014) showed that porridge made from OFSP was unappetizing and scored very low in all sensory characteristics examined. However, incorporation of sweet potato improved the sensory characteristics. This shows that in this context, there is need to educate the households of ways in which they can incorporate sweet potato into these dishes with a desirable sensory outcome. However this finding contradicts that of Tedesco and Stathers (2015) who found that sweet potato was utilized to make chips and porridge in Siaya and Homa Bay counties. Based on the different varieties under study, there was no significant change in the beta carotene levels after storage for 3 months (Table 8).

5.7. Sensory Characteristics of the Sweet Potato Before and After Storage

5.7.1 Sensory Characteristics of the Sweet Potato Before Storage

Sensory evaluation is the process of using the five senses to analyze and evaluate a food product. In sensory evaluation, the following characteristics of a food product are assessed appearance, smells, taste and texture. The orange potato colour, texture and appearance and acceptability were scored as good. Its taste was scored fair. On the other hand the yellow potato colour, acceptability its taste before storage were scored as good and white potato had good texture and appearance as shown in table 9

5.7.2 Sensory Characteristics of the Sweet Potato After Storage

After two methods of storage were compared, it was noted that the clamp generally was better than the pit method. This is because it had fairly higher trait means as compared to the pit method. Most of the potatoes stored under pit went bad which was not the case with clamp. The orange still had a fair color, appearance and was fairly acceptable by majority as compared to the yellow and white potatoes after storage. From these scores, it can be deduced that clamp is a better method of storage and orange fleshed sweet potato has better traits even after storage as compared to yellow and white fleshed sweet potatoes as indicated in Figure 4.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This chapter gives the conclusions and the recommendations based on the findings of the study

6.2 Conclusions

From the findings of this study, the following conclusions can be made:

1. The sweet potato varieties are utilized as boiled potatoes and eaten either as breakfast or lunch while majority of the sweet potato farmers are women, who mainly grow the local variety.
2. There was a small decrease of Betacarotene level by upto 12% and within 3 months of storage there after it remained unchanged.
3. Sweet potatoes stored in clamp storage method had slightly higher Betacarotene and better sensory characteristics than the pit storage method.

6.3 Recommendations

Recommendation for practice: There is need to increase the utilization of the sweet potato in the household, by preparing different dishes, in order to increase the use of the crop.

Vitamin A stabilizes during storage at 2 months. Storage is recommended for nutrition security as far as beta-carotene which is a precursor of Vitamin A deficiency (VAD) is concerned

The farmers should therefore continue to produce sweet potatoes with adequate levels of Vitamin A which can withstand storage periods.

Since sweet potato is a drought resistant crop, farmers should be encourages more to plant SP in place of maize which is not drought resistant and is predominantly and staple food crop in many homes.

Recommendation for policy: There is need for developing low-cost storage technologies capable of improving retaining the quality of the potatoes.

Recommendation for further research: Further studies should be done on the evaluation of different storage technologies of sweet potato and implications on nutritive value in other areas in Kenya to allow for generalization. Further studies can also be conducted in other crops of this family other than sweet potatoes for comparison purposes.

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APPENDICES

APPENDIX I: INTRODUCTORY LETTER

University of Eldoret

Dear Respondent

RE: DATA COLLECTION FOR ACADEMIC RESEARCH

I am a postgraduate student at University of Eldoret pursuing a Master of Science in Community Nutrition. In partial fulfillment of the requirements of the degree, I am required to submit a thesis. I am, therefore, conducting a research on "Evaluation of different storage technologies of sweet potato and implications on nutritive values in West Kenya, Kabras and Kabondo divisions."

It is in this respect that I hereby request you to assist me by filling the attached questionnaire with the most appropriate responses for all the questions and co-operating in the interviews as much as you possibly can. The information provided by you will be used for purely academic purposes and treated confidentially and thus will not be disclosed without prior permission from you.

Thank you for your support

Yours faithfully,

Romana C. Yego, AGR/PGF/02/08

APPENDIX II: UNIVERSITY APPROVAL

University of Eldoret

To whom it may concern,

Dear Sir / Madam,

RE: APPROVAL FOR RESEARCH

The holder of this letter Mrs. Romana C. Yego is a student at University of Eldoret pursuing a Masters degree of Science in Community Nutrition. She has been permitted to conduct research in Kabondo and Kabras divisions for the period between April and July, 2015. Her research topic is: **Evaluation of different storage technologies of sweet potato and implications on nutritive values in West Kenya, Kabras and Kabondo divisions**.

Kindly accord her the necessary assistance.

Research Coordinator, University of Eldoret

APPENDIX III: CONSENT FORM

Study Title: Evaluation of different storage technology on nutritive values sweet potato in Kabras Division Western Kenya

Investigator: Romana Yego (MCN Student)

School of Agriculture and Biotechnology

Department of Family and Consumer Science

Moi University

Purpose and background

This study is an academic requirement for a Master of Science in Community Nutrition of which the findings of this study will be used in policy making and proper guidance on proper storage techniques of sweet potatoes.

Confidentiality

All information will be treated with total confidentiality and not at any time the names of the respondents will be mentioned.

Right to refuse:

The subject's participation in the study is entirely voluntary and one is free to refuse to take part in the study and will not be bothered.

If you consent, please indicate so by signing this form:

I fully agree to participate in this study:

SIGNATURE ------------------------------ DATE -------------------------------

APPENDIX IV: QUESTIONNAIRE

Questionnaire No……………......

Household No……………...….   Date of interview…………………..

Interviewer…………………….

DEMOGRAPHIC CHARACTERISTICS

1. Sex i) Male□ ii) Female □

2. Age i) under 30 years□ ii) 30-40 years □ iii) 41-50 years□ iv) Over50 years □

3. Education level i) Informal □ ii) Primary □ iii) Secondary□ iv) Tertiary□

4. Occupation i) Unemployed □ ii) Self-employed □ iii) Formal employment □

PRODUCTION

1. How much land have you allocated to cultivation of sweet potato?

i) Less than 1 acre □ ii) 1-2 □ iii) More than 2acres □

2. Which varieties do you grow?

i) Local□ ii) improved iii) Both

3. If local which color

i) Local □ ii) Improved □ iii) Both □

4. If local which colour?

i) Yellow □ ii) White □ iii) Orange □ iv) Cream□

5. If improved which colour?

i) Yellow □ ii) White □ iii) Orange □ iv) Cream□

6. How many times in a year do you grow the sweet potatoes?

i) Once □ ii) Twice □ iii) Thrice □ iv) Four times □

7. How long do they take to mature?

i) 3-4 months □ ii) 6months □ iii) 1 year

8. What is the length of harvesting period after maturity?

i) 1 month ii)2 months iii) 3monhts iv)□any other

9. For what main reason do you grow sweet potato

i) Household consumption □

ii) Commercial purposes □

iii) Both household and commercial purposes □

10. Do you sell any of your sweet potato produce?

i) Yes □ ii) No □

11. If yes does it come from your own farm...?

12. Approximately how much do get from the sell of sweet potato per month...?

13. What is the advantage of sweet potatoes to other food that you grow? ………………………………………………………………………………..

PROCESSING TECHNOLOGIES

14. Do you store any harvested potato?

i) Yes ii) No

15. If yes which method of storage do you use?

i) Open storage □ ii) Pit storage □ iii) Clamp storage □ iv) Staggered harvesting □

Others (Specify) ……………………………………………………………………………..

16. What is the maximum storage period before spoilage?

i) 2 weeks □ ii) 1 month □ iii) 2 months □ iv) 3 months □

17. To what extent do the following characteristics of sweet potato change?

3=Very highly, 2=moderately, 1= No change

	3	2	1
Color			
Texture			
Weight			
Appearance			
Taste			

If yes, which ones?

i) Change in colour□ ii) Change in texture □ iii) Change in weight □

Yes□ No □ Yes □ No □ Yes □ No □

UTILIZATION

18. How do you consider sweet potatoes?

i) as food □ ii) as snack □ iii) as a meal □

19. Which variety do you prefer to consume?...

20. When do you eat the sweet-potato

i) Breakfast □ ii) as a snack □ iii) As a meal □

21. Do you consider sweet potatoes i) as a food □ ii) snack □

22 .Which mode of cooking do you mainly use when preparing sweet potatoes

i) Boiling □ ii) Roasting □ iii) frying □ iv) Baking□

23. Give names of dishes made using sweet potatoes as an ingredient

………………………………………………………….…………………………

SATISFACTION

24. How satisfied are you with the following practices of sweet potato farming

Attributes	5	4	3	2	1
Production					
Processing					
Utilization					

Key

5 - Highly satisfied

4 - Satisfied

3 -Moderately satisfied

2 - Not satisfied

1- Highly Unsatisfied

APPENDIX V: SWEET POTATO ORGANOLEPTIC EVALUATION FORM

Accession number……………………………………….

Evaluator's name………………………………………… Date ……………………

Trait	Score/ Rank.
Colour	
Texture	
Appearance	
Taste	
Overall acceptability	

KEY.

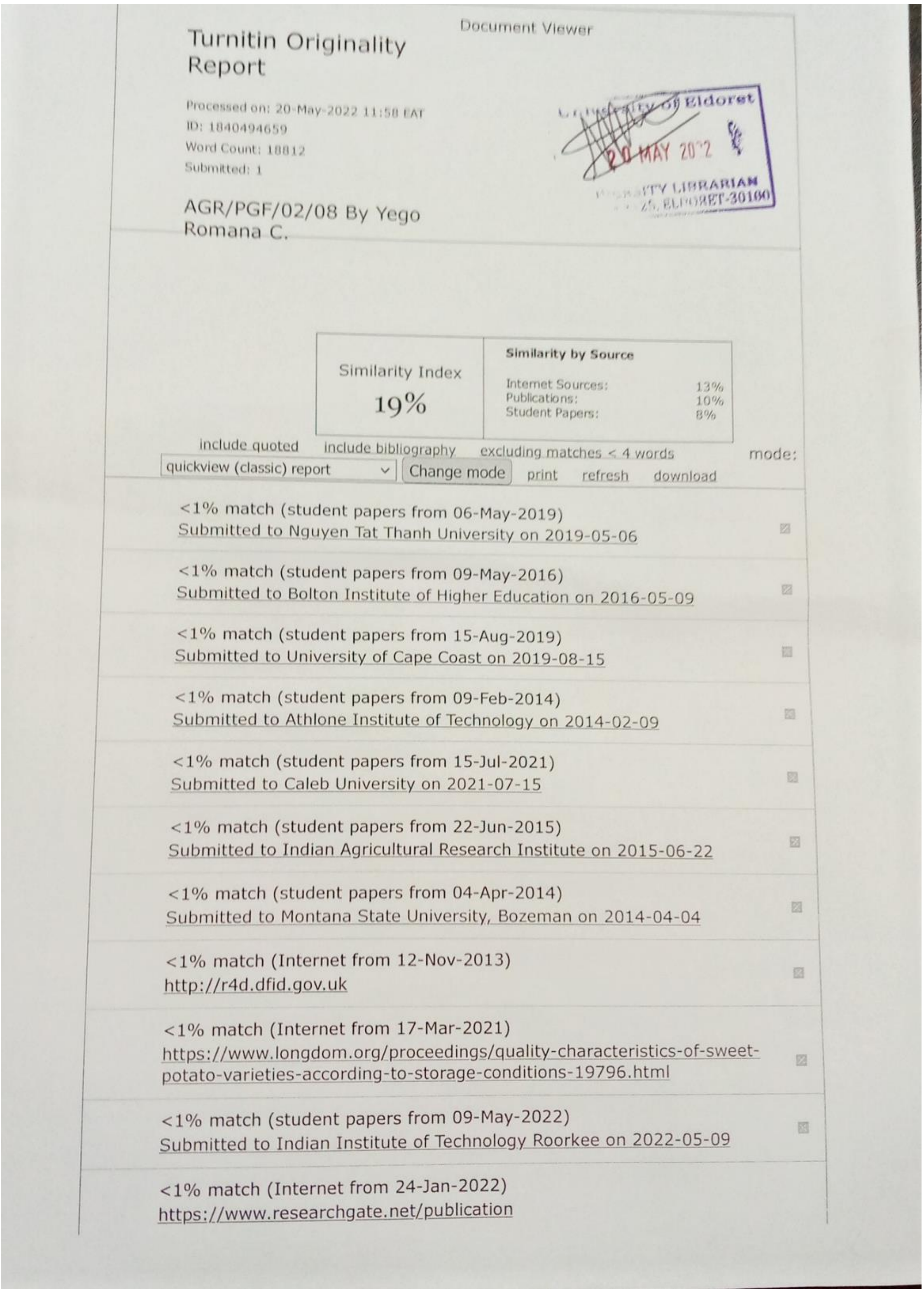
1- Mbaya Sana	1-Very bad
2- Mbaya	2- Bad
3- Inaridhisha	3-Fair
4- Nzuri	4-Good
5- Nzuri Sana	5-Very good

Comments

……………………………………………………………………………………………

……………………………………………………………………………………………

APPENDIX VI: SIMILARITY REPORT



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