# THE UTILIZATION OF CASSAVA (*Manihot esculenta*) AND QUALITY CHARACTERISTICS OF IMPROVED VARIETIES. A CASE OF MARIGAT, BARINGO COUNTY.

**EUNICE YABANN**
**(AGRI/PGF/05/08)**

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# DECLARATION

**Declaration by the Candidate**

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**Eunice Yabann**

**AGRI/PGF/05/08**

Signature………………… Date………………

**Declaration by the Supervisors**

This thesis has been presented for examination with our approval as university supervisors.

1. **Dr. Violet K. Mugalavai,**
   **School of Agriculture and Biotechnology,**
   **Department of Family and Consumer Sciences,**
   **University of Eldoret,**
   **P.O. Box 1125, Eldoret.**

   Signature……………………… Date…………………..

2. **Prof. Miriam G. Kinyua**
   **School of Agriculture and Biotechnology, Department of Biotechnology**
   **University of Eldoret**
   **P.O Box 1125, Eldoret.**

   Signature …………………….
   Date……………………….

# DEDICATION

I dedicate this project to my dear family for their financial and moral support.

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# ABSTRACT

Cassava provides vital nutrients to its consumers and is considered a food security crop for poor rural communities, particularly in arid and semi-arid regions of developing countries. The nutritional value of this crop is normally affected by many factors. In the central Rift Valley of Kenya, scientists have introduced new varieties. However, little is known about utilization and quality characteristics of new varieties, thus the need for this study. The objective of this study was to evaluate the utilization of cassava roots among the study group and to study culinary characteristics and nutritional values of the newly introduced cassava root variety. A total of 51 introduced cassava varieties were grown and all harvested at 16 months of age by Kenya Agricultural Research Institute (KARI)-Marigat. External preference mapping resulted in sensory panelists rejecting some of the cassava roots (n = 26) from further processing owing to the fact that they were woody, rotten, dark colored and fibrous. The remaining samples (n = 25), plus one sample (n = 1) picked from the local market were prepared and evaluated to determine ease of cooking. The panelists evaluated each sample and recorded their opinion in terms of surface appearance, taste, texture and overall acceptability. The attributes were scored using a hedonic scale ranging from 1-5 (where 1 = worst and 5 = very good). The varieties with a mean score of three (m = 3.0) and above in the given attribute(s) were considered acceptable. The surface appearance scored the highest means (3.80 ± 0.63) and least mean score was texture (3.20 ± 0.42). ANOVA results showed a significant mean difference in their sensory characteristics. The final test eliminated some of the cassava samples (n = 16). The remaining accepted cassava samples (n = 10) were further processed for nutritional quality determination. Proximate composition and mineral elements were measured using AOAC and HPLC. The results obtained were compared with U.S.D.A-21 reference standards. Protein levels of cassava variety R252m recorded the highest with 2.05% per 100g lower than the 3% USDA-21 reference standards. Fats ranged from 0.17% to 1.24% with only P12m cassava sample having value above the reference standards (1%). Carbohydrate (CHO) values were high in POROs with the value of 93.51% per 100gm, higher than the recommended U.S.D.A-21 standards (78%). Calcium (Ca) recorded highest in the variety P15 at 6.92% per 100g while P117o had the highest Fe content with 1.56 % per 100g. Phosphorus (P) was found in large amounts with P15m leading with 96% per 100gm. Iron (Fe), Fat, Potassium (K), and Protein had significant positive correlation with sensory qualities at $p<0.05$. (r = 0.486, 0.634, 0.513, 0.487 respectively). In conclusion variety P117o (M=4.25) and P12m (=4.25) attained the highest scores in sensory acceptability. The study recommends that there should be greater efforts to promote cassava breeding for better food, nutrition and livelihoods that will enable people to live productive lives since cassava is staple in the diet of 90% of respondents in the study area where 65% of respondents faced challenges in acquiring planting material and 21.9% had problems with disease and pests. Deliberate efforts are necessary for leveraging agricultural research towards improved production of cassava roots with better culinary, nutritional and keeping qualities. This may enable communities in vulnerable areas such as Marigat to benefit from improved cassava varieties towards attaining Kenya’s Vision 2030’s for sustainable livelihoods and development.

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| | |
|---|---|
| AOCC | Association of analytic chemistry |
| ASAL | Arid and Semi-Arid Lands |
| CGM | Cassava green mite |
| CMD | Cassava Mosaic Disease |
| DAEO | District Agricultural Extension Officers |
| HPLC | High Performance Liquid Chromatography |
| KARI | Kenya Agricultural Research Institute |
| KIRDI | Kenya Industrial and Research Development Institute |
| NGO | Non- Governmental Organization |
| SPS | Standard per Serving |
| SA | Standards for Adults |

## OPERATIONAL DEFINITIONS

| | |
|---|---|
| **Cooking Qualities** | The degree to which food is good; in this case, the cassava. |
| **Culinary** | The skills used for cooking food; the perfect taste of food in this case, the cassava. |
| **Glassy** | Difficulty to chew even after cooking for several minutes |
| **Mealy** | The Qualities of a meal which are soft, dry or crumbly. |
| **Palatability** | Having a pleasant or acceptable taste. |
| **Sensory Evaluation** | Food properties as experienced by senses, including taste, smell and touch. |
| **Utilization** | It refers to the effective use of an asset. |

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I have benefited from the wise counsel, guidance and support of many people. I am particularly indebted to the Ministry of Agriculture officers in Marigat who guided me on data collection from cassava households. I also wish to appreciate the cassava sensory evaluation panelists who developed crucial statistics for the completion of this research.

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# CHAPTER ONE

# INTRODUCTION

## 1.0 Introduction

This chapter gives an overview of the study. It presents an outline, the background statement of the problem, objectives, hypotheses that guided the study. Significance and scope of the study are also stated.

## 1.1 Background of the Study

Cassava, (*Manihot spp*), is a shrubby perennial plant that grows to a height of 6-8 feet. It is a member of the *Euphorbiaceae* family and in the genus and species *Manihot exculenta*. Cassava was introduced into sub-Saharan Africa from Brazil in the 16$^{th}$ century, becoming the main staple food in a number of countries because it could grow and produce dependable yields in places where cereals and other crops would not grow or produce well (Hann *et al*., 1987). It can tolerate drought as well as be cultivated on soils with low nutrient capacity (Hahn and Keyser, 1985). Cassava is now grown throughout Sub- Saharan Africa and is considered second in importance to maize as a human staple, accounting for more than 200 calories per day per person (Scott *et al*., 2000). Compared with other regions, capital consumption of cassava is highest in Sub-Saharan Africa, standing at 101 kg/year per adult (FAO, 2008), while estimates show that about 300 million people in sub-Saharan Africa consume cassava as a staple food (FAO, 2012). In a continent prone to food security problems, the crop has become an important food reserve. Sub-Saharan Africa produces 70-80 million tonnes of the crop annually, with the bulk of the plant grown in Nigeria, Republic of Congo, Tanzania, Uganda, Madagascar, and Angola (Nweke, 1992). In East and Southern Africa, cassava is the main staple food in Democratic Republic of Congo, the second most important crop in Uganda and Madagascar, while it is the most important crop in Burundi and Rwanda (Donald, 1998).

The cassava stem contains soft white pith and have nodes from which new plants are obtained. The roots, which are the valuable portions of the plant, grow in clusters of 4 to 8 at the stem base and can be harvested after 12 months, but can also be stored in the ground for longer periods and harvested as needed (Otim-Nape, *et al.,* 2000). Cassava roots are high in starch making them a good source of energy but are low in vitamin A and protein (Scott, *et al.,* 2000). This means that other foods should be ingested to make a nutritionally balanced diet. However, innovative projects, such as Bio Cassava Plus are actively being researched, with the aim of enhancing cassava with carotene, iron and protein (Cassava News, 2011). Cassava is classified based on the cyanoglucoside content of the tubers, which delineates the tubers as "sweet" or "bitter" cassava. The sweet form have low (<140 ppm) cyanoglucoside content while the bitter cassava contains greater than 140 ppm cyanoglucosides on dry weight basis (Falade and Akingbala, 2009). A further distinction is that while the cyanoglucosides are evenly distributed throughout the sweet variety, cyanides are majorly located in the peel in the high cyanide cassava. Cyanide is released upon peeling and grinding the roots into a paste, which can then be fermented for forty eight hours (48 hrs) before being processed, dried and roasted or ground for flour (GoK, 1994). The flour can be composited with other cereal flours and used by households for preparing various foods such as porridge and ugali (staple Kenyan food) and can also be used as a raw material for industrial processing. The sweet cassava can be peeled and boiled for about 20-30 minutes and may be eaten like other tubers such as potatoes (Adindu, 2007).

In Kenya, cassava production has undergone frequent fluctuations, largely due to diverse feeding and cultural habits that change from time to time. It has been labeled a poor man's diet, poisonous and unfit for human consumption, and food for hunger times. These might explain why cultivation of the crop is concentrated in low-income areas where poverty is a major economic problem (Kariuki, 2002).These misconceptions, largely due to ignorance and lack of information, have negatively affected cassava production in the country. Nevertheless, cassava still holds historical popularity in coast, western, eastern, and Nyanza provinces in Kenya but with less adoption in Central and Rift Valley provinces. Cassava production has also been under promotion in North Eastern province. Traditionally, cassava is produced by small-scale subsistence farmers and utilization of the crop in Kenya is limited to household use and little surplus is sold in local markets, especially during maize shortages (Kariuki, 2002).

Currently, KARI, NGOs, donors, and other universities are collaborating using modern technology to produce cassava varieties with improved compositional qualities such as early maturing, reduced cyanides, and disease and pest resistant, and with new post harvest handling and utilization mechanisms (Harlsey, 2008). With focused and sustained research and development support, this crop can make substantial contributions to the broad goals of food and nutrition security, poverty alleviation, equity and protection of the environment (Hershey, 1999). These significant opportunities will enhance sustainable cassava production in most areas of the country especially those with severe food stress due to vulnerable climatic conditions such as Marigat, Kenya.

## 1.2 Problem Statement

Food insecurity for a large segment of African populations continues to exacerbate poverty and malnutrition. High population growth and the effects of HIV/AIDS have impacted negatively on the productive labour force. Degradation of environment, poor agricultural practices, erratic rainfall patterns and the lack of an enabling economic policy has aggravated the situation. Though cassava grows well in a wide range of environmental conditions in Kenya, it remains a smallholder crop often planted on marginal land after most other crops have been sown (Mohammed, 2002). The western and coastal regions of Kenya form the backbone of the country's cassava industry. In these two zones, cassava is a significant component in the household diet, whether combined with other food crops or consumed alone.

Cassava is also a hardy crop, tolerant to poor soils and dry conditions, with flexible harvest dates (Dele, 2001), and therefore, can be a viable staple food in the dry areas of Kenya such as Marigat, Baringo County, which experiences unsuitable climatic changes. In the low lands, food insecurity is rampant (Regional Assessment Team, 2008) occasionally necessitating district leaders to call for relief food. The dire food situation in the district was dramatically captured by an article appearing in The Daily Nation of May 30$^{th}$, 2008, which reported that at least 100,000 residents faced starvation due to prolonged drought. The report showed human beings competing for wild fruits and tubers with domestic animals, especially goats and donkeys, in some areas. Although cassava might help to mitigate poverty and malnutrition among marginal communities in Kenya, such as those in Marigat district, the crop has not been widely adopted (Kariuki, 2002). A District Agriculture Office (DAO) field report suggested that minimal production of cassava crops might be due to lack of adequate disease and pest free planting materials, poor cultural practices and presence of high levels of cyanogenic glycosides in some cassava varieties (Kawano, 2003). It is therefore germane to fully understand the factors constraining the utilization of cassava in marginal areas of the country.

Sustained research on cassava by universities and research institutes are crucial in improving the quality of the crop, making it a central player in achieving food and nutrition security for the country (Kariuki, 2002).There is need to develop an early maturing, high yielding, disease and pest resistant crop. Several new varieties have been bred with high nutritional content (such as vitamin A, protein, carotene and iron), low cyanoglucoside matter, and those which can be banked and stored underground until required (Ndungu, *et al*., 2010; Cassava News, 2011). However, the culinary characteristics and nutritional values have not been determined, yet progress in these areas of research might benefit the many subsistence families especially those who rely on cassava and its products for household food security (Kawano, 2003). Thus, there was need to fill the paucity of information on the nutritional and cooking qualities of cassava varieties produced by various research institutions in the country for adoption and efficient utilization by communities especially those in dry areas.

## 1.3 Objectives

### 1.3.1 Overall Objective

The main objective of this study was to determine utilization of cassava and quality characteristics of fifty one new cassava roots produced by breeders at KARI-Marigat.

### 1.3.2 Specific Objectives

1. To identify constraints and opportunities of cassava roots utilization in Marigat.
2. To determine the qualities of cooked new cassava root varieties sampled from KARI Marigat.
3. To identify the overall acceptability of boiled cassava roots harvested after 16 months.
4. To determine the nutrient composition of cassava roots with acceptable culinary characteristics.

## 1.4 Research Hypotheses

$HO_1$: The selected cassava varieties have different cooking qualities.

$HO_2$: There is a relationship between sensory characteristics and cassava nutrients.

## 1.5 Justification

Cassava is one of the most important staple food crops grown in tropical Africa. Impact studies in Nigeria have revealed that the introduction of improved varieties has provided food for 50 million people (IITA, 2009) and can do the same to Kenyan people. Cassava in areas with unreliable weather condition of semi-arid and arid areas will play a major role in alleviating the food crisis because of its efficient production of food energy year-round, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa (Hahn *et al*., 1987). Improvement of production of high quality, long duration in soil, through cassava research would greatly increase Human and Livestock nutrition (Mbika, 2002).

Adoption of improved cassava production may improve labor efficiency, incomes and living standards of urban and rural poor households who face malnutrition. Malnutrition impacts negatively on child development and public health and this reduces the capacity of rural work force, economic restoration is the priority of the

Kenyan Government but little impact has been experienced at the grass root levels. Cassava can produce high quality flours for new food recipes for rural and urban populations thus create income generating opportunities. For the purpose of development programs and interventions, all stake holders have to work as a team to fight pests and diseases and to introduce new ways of processing and using cassava products for rural and urban populations. This may enhance job creation which will result in the right to food for all. This research may be very influential especially to policy makers in facilitating intervention programs for the new cassava varieties; it will also be useful to researchers in making decisions about the characteristics to consider in the next cassava research.

## 1.6 Theoretical Framework

The Theoretical Model used to advance this study is based on expansion of sustainable livelihood framework (Department of Foreign and International Development, 1999). This framework was developed using the theories of Perkins and Zimmerman (1995). It states that " empowerment oriented interventions enhance wellness as well as target solving problems , providing opportunities for participants to develop knowledge and skills and engage professionals as collaborators instead of authoritative experts". The Sustainable Rural Livelihoods Framework Advisory Committee used the framework to understand livelihoods. The model has the following components:

*Vulnerability Context*

These are the external factors that affect people's vulnerability and these include trends, shocks and seasonal shifts. In this study, food availability is the greatest and most enduring source of hardship. Cassava and farming stress can be looked at to improve on the seasonality of food production and thus household food security.

*Livelihood Assets*

These assets are needed by the individuals to achieve sustainable livelihoods. These assets are human capital, social capital, physical capital, natural and financial capital.

**Human Capital-** these are the skills, knowledge, ability to work and good health that are needed to enable individual to pursue different livelihood strategies and achieve their livelihood objectives. Declining productivity due to poverty and climatic changes leads to decline in household income. Losses in natural capital contribute to household food insecurity.

**Social Capital-** these are the social resources upon which people draw in pursuit of their livelihood objectives. These facilitate development of knowledge through participatory research. Adoption of new cassava variety by the community may combat food insecurity in the area.

**Natural Capital-** these are natural resource stocks from which resource flows and surfaces useful for livelihoods are derived. Thus, include land, forests, air quality and biodiversity degree and rate of change. Climatic changes reduce land productivity. Due to continuous drought development of improved cassava variety can help increase productivity of resources.

**Physical Capital-** these comprise of basic infrastructure and producer goods needed to support livelihoods. For this study, participatory research enables community to assess information that equips them to establish productive resources.

**Financial Capital-** this refers to the financial resources that people use to achieve their household objectives. It is an important livelihood block as it enables an individual to adopt different livelihood strategies. Poverty leads to household food insecurity due to low rainfall that in turn limits the productivity of arable land, thus necessitates the study of drought resistant crops e.g. cassava.

*Transforming Processes and Structures*

These are institutions, organizations and policies that shape livelihoods. These determine access to various types of capital and livelihood strategies. Transforming processes in a participatory manner involves people who are skilled and who share an overall commitment to poverty elimination. For this study, the structure will be the breeders, nutritionists, extension officers and religious groups.

*Livelihood Strategies*

This is a range and combination of activities and choices that individuals make to achieve their livelihood goals. For this study, they are the sharing of knowledge on climate adaptation practices and various farming and business skills related to new cassava varieties.

*Livelihoods Outcomes*

These are the achievements or outputs of the livelihood strategies. These include improved food security, nutrition security, livelihood security and enhanced cassava utilization.

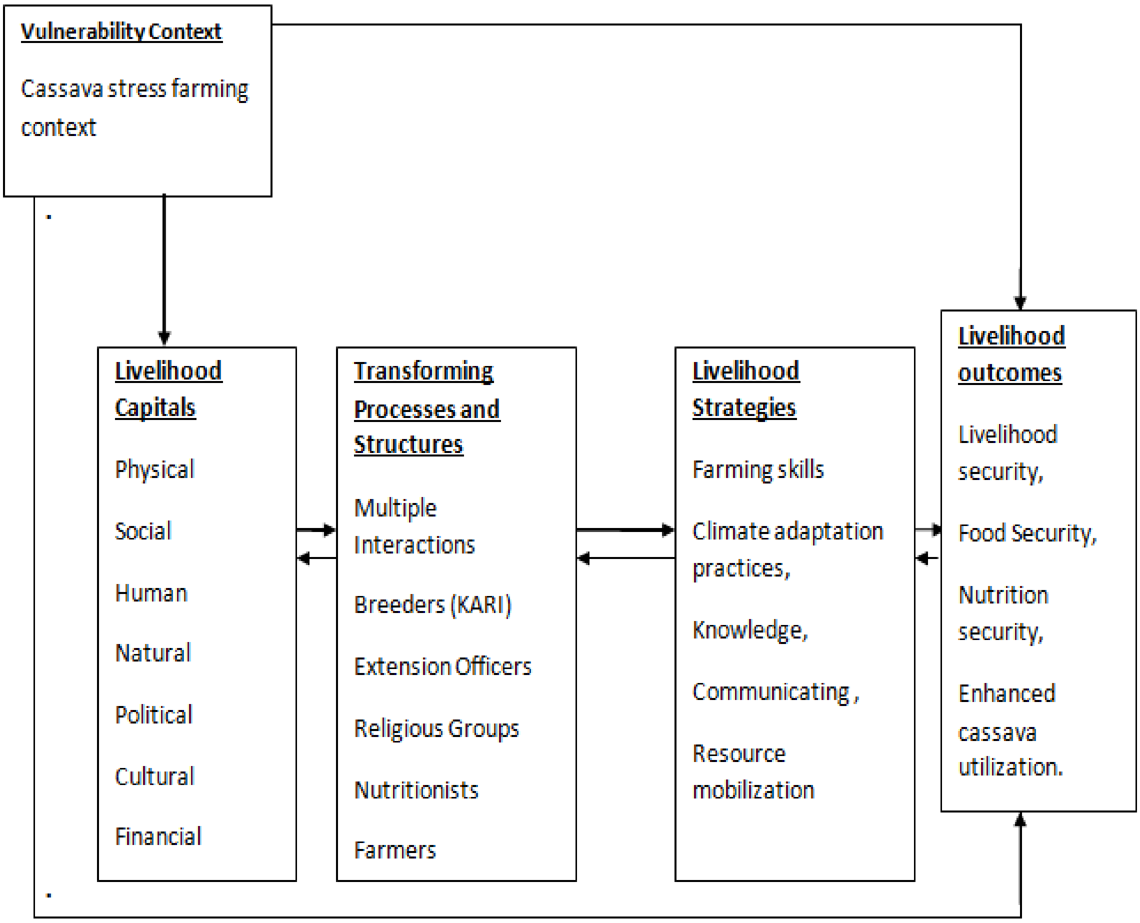


**Figure 1: Sustainable Livelihood Framework**
**Source: DFID (1999)**

## 1.7 Conceptual Framework

The conceptual framework ( Fig. 2) was adopted from DFID theoretical framework and is used to understand livelihood characteristics from which resources and services flow that contribute to household food security. Development stakeholders are the breeder's researchers, extension officers, policy makers, and non-governmental organizations that work together to bring change through participatory research approach. This type of approach improves the ability of the community to collectively make better decisions about use of resources which borrow from each other and adoption of new ideas thus improving the livelihoods through better nutrition. For this study, the structure will be KARI-Marigat, community and the researcher (nutritionist). The outputs will include more income, improved food security and increased well- being.

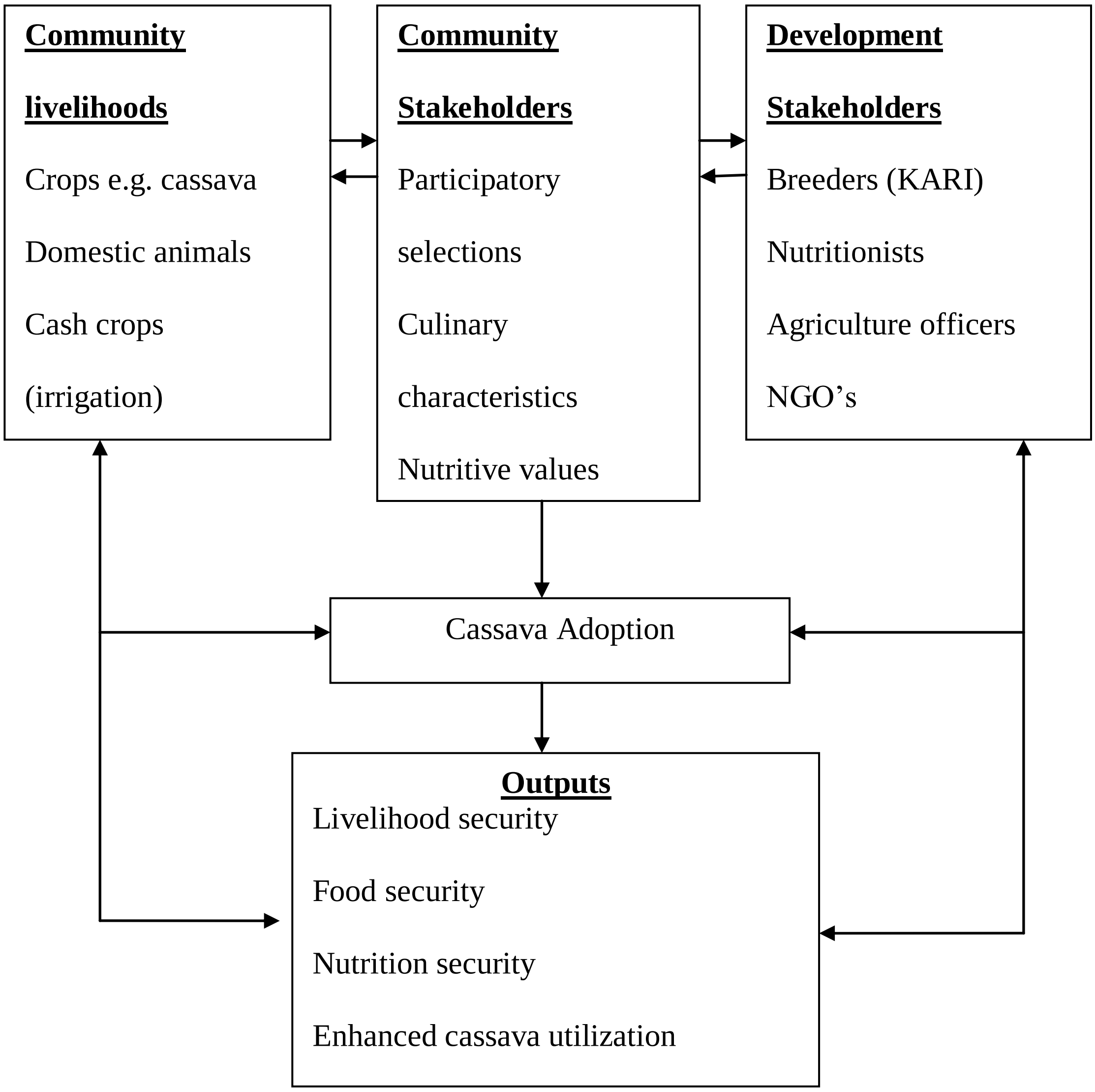


**Fig. 2 Conception Framework of Interactions between Stakeholders and Local Community (Author, 2013)**

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Cassava as a Food Security Crop

Food security can be defined as access by all people at all times to enough quality food for productive and healthy life. At household level, food security refers to the ability of the household to secure either from its own production or through purchases or both, adequate foods for dietary needs of its members (FAO, 2012). Food security therefore depends on availability and accessibility, which are determined by production and ability to purchase food (FAO, 2012). To achieve and to sustain food security, it is imperative to ensure increased production of food crops to enhance availability or facilitate and empower the people in other income-generating economic activities to guarantee affordability (IFPRI, 2008).

The main crops that have been produced in the country include maize, wheat, rice and sugarcane, and are called the traditional food crops. Traditional food crops remain the highest starch producers per unit area with relatively low inputs requirement compared to other crops and hence their importance in food security. For many developing countries root crops have a great potential with cassava being more significant (Donald *et al*., 1998) because it can grow and produce relatively good yields under adverse climate and soil conditions. However despite its importance as a staple crop in many developing countries, it is neglected in agricultural development policies. Cassava roots when attached to the main stem can remain in the ground for several months without becoming inedible and often farmers leave cassava plants in the field as food security against drought, famine or other unforeseen food shortages (Bokango, 2001).

Lack of clear cut food security and commercialization policies for orphan crops among countries in the East Africa root crop research network (EARRNET) region is partially to blame for the slow development of the cassava sub-sector (Kariuki, 2002). Lack of policies indicating government commitment to transformation of traditional crops including cassava into commercial crops is also a limiting factor to their development. Over the last decade research institutes have been working on overcoming the difficulties of pests and diseases in cassava production and on supplying of vegetative material and processes of roots for utilization and marketing. Kenya Agricultural Research Institute (KARI) is in the limelight for trying to develop high yielding, pest and disease resistant varieties and also collaborate with the Ministry of Agriculture to increase overall annual cassava production. The Kenya Industrial Research and Development Institute (KIRDI) has focused on development, adaptation improvement and transfer of appropriate cassava processing technologies including new product development (Mbikwa, 2002).

## 2.2 Characteristics of Cassava

Cassava roots when left attached to the main stem can remain in the ground for several months without becoming inedible and farmers often leave cassava plants in the field as  security against drought, famine or other unforeseen food shortages (Bokanga, 2001). However, incipient quality deterioration starts after the roots have reached maturity, e.g. starch content decreases while fibre increases. The roots after harvesting start actively deteriorating within 2-3 days and rapidly become of little value for consumption or industrial application (Hahn, 2007). This initial physiological deterioration is followed by microbial deterioration 3–5 days after (Rickard & Coursey, 1981). Because of the large amounts of material required for industrial processing, two to three days of pre-process storage of cassava root is inevitable, during which time physiological changes that reduce starch yield and the quality of processed cassava products occur in the raw material (Akingbala *et al*., 1989; Ihedioha *et al*., 1996), thus making pre-process storage the main problem of cassava utilization on an industrial scale.

Cassava is drought resistant and can tolerate poor soils and less farm inputs to survive. Since cassava is mostly vegetative propagated through stem cutting, it is able to withstand dry periods up to 5 months (Dele *et al*., 2001) and has no fixed planting dates or time of harvest thus rarely fails as a crop. Cassava is a multi-purpose crop whose economic value is derived from the roots as a source of starch both for human consumption and industrial purposes. The leaves are used as vegetables which are rich in vitamins and the stem used as wood fuel according to Dele et al. The crop has several attributes that have made it attractive for small scale farmers with limited resources in marginal agricultural areas. However it also has some negative attributes such as bulkiness, high perish ability and toxicity in some varieties which do not out way the benefits. The bitter cassava varieties are mainly for industrial uses.

## 2.3 Cassava Production in Kenya

In Kenya cassava processing and utilization is limited to the household level where it is basically regarded as a staple food crop. Most cassava is consumed within the household and little surplus is sold in local markets, especially during maize shortages

(Mohammed, 2002). Although cassava production statistics in the country are not comprehensive, the data available indicates that the production is declining. The yield per hectare has been decreasing over the last decade from 11 million tons per hectare in1988 to about 7 million tons per hectare in 1999 (Karuiki, 2002). However research has shown that yield as high as 72 million tons per hectare can be achieved with improved varieties and proper crop husbandry (Mbwika, 2002).

## 2.4 Constraints to Cassava Production

As a crop of resource-poor farmers and a food security crop, cassava was generally neglected by researchers (IFPRI, 2008). Until three decades ago the global knowledge base on cassava was meager. Only through the past three decades has an understanding of the crop been greatly advanced. However, the knowledge base is still much smaller than that of most cereal crops. Gaps in knowledge contribute to a number of problems or weaknesses noted (FAO, 1999). The main weakness include; Cassava is vegetative propagated using stem cuttings taken at harvest of the previous crop and stem cuttings are bulky, do not store well and are costly to cut and handle; as a root crop, cassava requires considerable labor to harvest and highly perishable and therefore must be processed into storable form soon after harvest. Lastly cassava is often relegated to marginal lands due to competition with higher-value and more respected crops. This trend is likely to continue if this crop is not further improved to adapt it to marginal conditions. Cassava often winds up in hill-lands, lands with low soil fertility, or lands susceptible to periodic or seasonal drought or flooding. Other constraints the farmers face include diseases, lack of planting materials, pests, land shortages, weeds and heavy labour all these have resulted into decline in production of cassava in Eastern and Central Africa (Bokanga, 2001).In general, stigma in cassava is partly owing to the cyanogenic glycoside, compounds that can be toxic unless removed or detoxified by food preparation processes. "Sweet" varieties are those with low cyanogenic glycoside levels that can be eaten raw or boiled like potatoes although they are often susceptible to attack by pests (Bokanga, 2001).

## 2.5 Cassava Utilization

Several opportunities exist for cassava utilization. It is reported to be consumed in 28 different forms in Cameroon alone (FAO, 1997). In urban areas of west Africa, widespread development of cassava processing methods (consisting of pounding, soaking, and drying to produce a fermented flake known as “gari” have resulted in cassava becoming an important commercial commodity. Such processing capacity does not exist in East and Southern Africa, and cassava has remained a traditional, rural starchy staple in that region. Cassava is also consumed as a snack food in various parts of the continent and widely grown for its leaves, which are used in making sauces. Once again, leaves from varieties with high cyanic acid content must be properly processed to remove the toxic compounds. Processing of cassava roots and leaves improve palatability and eliminate or reduce the level of cyanide (Cardoso *et al.*, 2005). Cassava flour is sometimes used in making bread for local consumption.

Recently, initiatives in West Africa have aimed at developing the export market potential for production of dried cassava chips used as animal feed in Europe (Makokha, 2004). This market is currently supplied by Asian production. Cassava is increasingly becoming an important food and cash crop for its multiple use and Kenya will not be exceptional in capitalizing the utility of this wonder crop. In the western part of the country, the households have much benefited from cassava as it is recorded second to maize in terms of importance as a food staple (GOK,1994). The form in which cassava roots are consumed normally depends on the country. In Kenya, cassava is either processed or eaten boiled as a snack. But the main method of utilization involves grinding of dried cassava chips/chunks in combination with various dried cereal to make composite flour that is used to prepare hard paste-ugali (Kenyan favorite dish) and uji (porridge). But in general three categories of cooking quality have been recognized among cassava varieties in Africa. (Ngeve, 1998). The roots of some varieties are non- cookable (bitter varieties) and are used only for processing; these roots will never boil soft no matter how long they are heated. In the second category the roots are said to be glassy in which case they are cooked after several minutes of heating with water but are difficult to chew. The last category is that the cassava roots are mealy in which case the cassava cook or boil easily, are floury in texture and can easily be eaten like a potato (Ngeve, 1998).

Cassava processing procedures vary depending on products, from simple processing (peel, boil and eat) to complicated procedures for processing into *gari*, for example, which involve many more steps, namely peeling, grating, pressing, fermenting, sifting, and roasting. Some of these steps reduce cyanide more effectively than others (Oyewole, 2001). Processing techniques and procedures differ with countries and localities within a country according to food cultures, environmental factors such as availability of water and fuel wood, the cassava varieties used, and the types of processing equipment and technologies available ( Hann, 1989).

## 2.6 Nutritional Quality of Cassava

Cassava is an excellent source of digestible carbohydrates and therefore high in energy, but a poor source of protein. Other vegetables must be supplemented to cassava to make a nutritionally balanced diet. The Table 2.1 shows the raw material content of cassava compared to other roots and tuber crops.

**Table 2.1 Nutritional content of some selected roots and tubers per 100gm**

| % FW | Cassava | Potato Irish | Sweet Potato | Yam |
|---|---|---|---|---|
| Dry Matter | 30-40 | 20 | 19-35 | 21-24 |
| Starch | 27-36 | 13-16 | 18-28 | 18-25 |
| Sugar | 0.5-2.5 | 0-0.2 | 1.5-5.0 | 0.5-1.0 |
| Protein | 0.5-2.0 | 2.0 | 1.0-2.5 | 2.5 |
| Fibre | 1.0 | 0.5 | 1.0 | 0.6 |
| Lipids | 0.5 | 1.0 | 0.5-6.5 | 0.2 |
| Vitamin A (mg/100g) | 17 | Trace | 900 | 117 |
| Vitamin C (mg/100g) | 50 | 31 | 35 | 24 |
| Ash | 0.5-1.5) | 1.0-1.5 | 1.0 | 0.5-1.0 |
| Energy (KJ/100g) | 607 | 318 | 490 | 439 |
| Starch Extraction Rate | 22-25 | 8-12 | 10-15 | N/A |

Source: Scott Gregory *et al*, 2000, International Potato Centre, Lima, Peru, FW-fresh weight

## 2.7 Stakeholders in the Cassava Sub-Sector

There are a number of stakeholders in the cassava sub-sector in East Africa. The primary stakeholders include farmers, traders, processors, researchers, input suppliers, policy makers and implementers, local authorities, Agriculturists, consumers, donors and Non Governmental Organizations (NGO) (FAO, 2008). In Kenya, collaboration between Kenya Agricultural Institute (KARI) and a number of NGOs, donors and universities has been taking place especially in western Kenya (Wambugu and Mungai, 2000) with the aim of improving cassava productivity and value addition.

### 2.8 Summary of literature and gaps in knowledge

It is evident that if cassava is to play a critical role in food and nutrition security, there is need to enhance collaboration among the entire stakeholders together with private sector to ensure development of specific needs of the communities. There is need to develop early maturing cassava that is resistant to diseases and that can remain in soil for a longer period of time to enable households to be food secure. While the food industries may use cassava in many preparations including, sauces, custard, powders, baby foods, Tapioca products, glucose, confectionaries, bakery products such as a jelly or thickening agents and the manufacture of adhesives and dextrin's.and this will enable households to be economically empowered thus food security.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.0 INTRODUCTION

Marigat is located in arid and semi-arid lowlands of Baringo county situated 100 km North of Nakuru. It borders East Pokot District to the north, Koibatek District to the south, Mochongai division to the east, Kabarnet division to the west, and Mukutanio division to the Northeast. The district covers approximately1244 sq kilometers. Rainfall is 337 inches annually. Marigat Division has 743.2 sq km with climate temperatures of mainly 32.3 degrees Fernheight. The land is mainly inhabited by Agro-Pastoralists (IFRC, 2008).

The long rains in Marigat are in April and early May whereas short rains come in September. Parts of Baringo County receive rain for that is utilized for the growing of crops. Twenty Percent (20%) of the area has tillable soils and other parts are rocky alluvial deposits of rock boulders (Agriculture Annual Report Marigat District Office, 2009). The population is approximately 36,692 people and about 7,964 are food insecure.

## 3.1 Study Area

Marigat is an Arid and Semi-Arid Lands (ASAL) region and is regarded as a highly food deficient area with climatic change phenomenon intensifying at an alarming rate as evident from high temperatures and rainfall irregularity and inadequate amounts. The area is regarded as food insecure (Sulo, 2005). Currently, Marigat has high records of formal food transfers and other drought supplies by the Government and other agencies such as the church and World Vision who sometimes promote work for food (DAO, 2009). Therefore, cassava, which is drought tolerant and has high potential for yield in the region, can be used to address the problem of food insecurity. The District Agricultural Extension Officers are seriously promoting traditional high value crops. These include; cowpeas, green grams, sorghum, finger millet, cassava and also sweet potatoes. The Government through this program provides seed for development and multiplication. They provide 2 kg of seed after which 4 kg should be returned after harvesting for further distribution. In rain fed areas, farmers harvest a bag of maize per acre and 2-3 bags of sorghum and millet per acre, which is not sufficient for household use. As a resilience measure, the communities settle on one meal a day so that relief food, which they rely on, can be consumed for a longer period. Cassava production is increasing through the promotion of extension services from Ministry of Agriculture and KARI Marigat Station. KARI has developed a research station in Marigat area for plant breeding purposes. Their major project is to breed cassava that is low in cyanide, early maturing, and of pest and disease resistance. The cassava under study has been grown in the area making Marigat privileged as the varieties under study if adopted, will be suitable for its soils and may improve household food and nutrition security.

## 3.2 Research Design

The study used mixed research design; Cross-sectional survey and Experimental design.

### 3.2.1 Survey Method

The cross-sectional survey was done and data collected by the use of qualitative and quantitative measures (FAO, 2008). Structured and non-structured questionnaires were administered which addressed the farmer’s demographic and socio-economic characteristics. Background information in relationship with the production, availability and utilization of cassava roots was also collected. Primary data was obtained from various stakeholders at the rural farm household level, food venders and key informants in the study area. Secondary data was collected from the Marigat District agriculture office annual reports and non-government organization within the same District. Other secondary data sources included KARI-Marigat, professional publications and the internet websites. The questionnaires were pre-tested among farmers around Iten town in Elgeyo Marakwet County that produce and consume cassava to improve on the validity and reliability.

### 3.2.2 Sampling Frame

The population was identified from the communities that live within ten kilometers from Marigat town due to harsh weather, poor road network and the long distance between households. Therefore three villages bordering Marigat town namely Kimalel, Koriema Perkerra and Marigat trading centre were purposively selected to form part of the study because of their proximity to town. Households, who produce, utilize and sell cassava roots and flour formed part of the study. The participants were sorted with the guide of extension officers from the Ministry of Agriculture Marigat. The identification of the household respondents within the ten kilometers was based on simple random sampling and willingness to participate in the study. Secondary data were collected from agriculture officers and their annual reports. The research aimed at allowing the respondents to express the intensity of their opinions on various aspects of cassava and food security. It was possible therefore in this research to compute mean scores or sum of individual ratings on various aspects of cassava crop.

### 3.2.3 Sample Size Determination for Survey Data

To make valid statistical inferences from the results obtained, it was necessary for statistical tests to have enough power, that is, the probability of finding a difference if in fact the difference existed. Small samples result in statistical tests having unacceptably low power, which inevitably results in an inability to reject a false null hypothesis (Gigerenzer, 1993). One of the objectives of this study was to determine the utilization of cassava amongst farmers in a rural area of Kenya. Because the usage of cassava was a proportion (farmers either used it or not), this study adopted the formula contained in Mugenda and Mugenda (2003), to calculate the appropriate sample size that was used. The formula is given below:

$$n_o = \frac{\mathbf{Z^2 pq}}{\mathbf{e^2}}$$

Where:

$n_0$ = the sample size

$Z^2$ = 1.96 for a 95 % confidence interval (area under a standard normal curve or a student t distribution with infinity degrees of freedom, which contains 95 % of the observations)

e = the desired level of precision/sampling error, which in this study was 5 %.

p = the estimated proportion of the attribute of interest present in the population, such as cassava utilization. Since, this proportion could not be obtained from previous studies; the study used a proportion of .5, which assumed maximum variability in the population. Thus, the estimated sample size was likely to be more conservative, that is, the sample size was likely to be more than what was required.

q = 1 – p

Thus,

$$n_o = \frac{(1.96)^2(.5)^2(.5)^2}{(.05)^2}$$

= 385 households/farmers

However, since the number of households within 10 km from Marigat town in the three villages (Kimalel, Koriema, and Perkerra) were less than 1000, the following finite population correction was done (this is because a given sample size provides proportionately more information for a small population than for a large one):

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where n is the sample size while N is the population size.
Thus,

$$N = \frac{385}{1 + \frac{(385 - 1)}{1000}}$$

$\underset{\sim}{}$278 households.

However, because of the constraints imposed by time, the long distances between households and the poor road network, this study collected data from 278 households.

## 3.3 Laboratory Experiments

### 3.3.1 Ease of Cooking

Ease of cooking of cassava roots was done using Uzoma *et al*., (2000) protocol. Ten semi- trained adult panelists familiar with cassava were recruited from University of Eldoret to observe the cassava roots and perform the sensory evaluation of N = 50 new varieties of cassava roots provided by KARI Marigat. The roots harvested at sixteen (16) months were selected and sorted before cooking. The panelists reached consensus on characteristics to observe in sorting the roots before further processing. Cassava roots that were rotten, woody, fibrous and dark with brown streaks at surface appearance after peeling were eliminated from further processing. The accepted roots were prepared according to the methods described by Oyewole and Afolami (2001). The cassava roots were peeled where the tail and head regions were removed then washed and weighed to approximately similar sizes of 100 gm. The samples were each placed in clear coded plastic bags then immersed in a 5 litre heavy weight aluminum pan with boiling water and continuously checked by use of a fork to determine ability to cook. Five samples were cooked at a time and removed when done while the cooking time was controlled to a maximum of 20 minutes for all samples. Panelists comprising male and female adults rated the cooked cassava samples according to the following characteristics:

**Mealiness of the roots:**

This is an attribute used in describing cassava roots which when boiled become soft and chewable (Ngeve, 1998). Non-cookable roots of some cassava varieties (the bitter varieties) would never boil soft no matter how long they are heated and are used only for factory processing therefore they are termed glassy. Mealy roots cook or boil easily and are floury in texture and can easily be eaten like a boiled potato.

Thus, all cassava was categorized into the three groups above reflecting the degrees of mealiness. The cooked samples were divided into small pieces and placed randomly on labeled plates. Each panelist was given a glass of water to rinse his or her mouths before the next sample. Each of the samples was rated for surface appearance (surface color); mealy (floury); taste (mouth feel and after taste); texture (feel of the tongue before chewing). Organoleptic evaluation was carried out using method of Iwe (2002) with an adjustment. Five point hedonic scale was used (where, 5 = very good, 4 = good, 3 = fair, 2 = poor, 1 = worst). A product with a mean score of three and above for a given attribute was considered acceptable and unacceptable if the mean score was less than three for that attribute. Each accepted variety was replicated for mealiness, taste and texture panelists to increase the internal validity of the study.

### 3.3.2 Sensory and nutrient analysis

Cassava root products with a mean score of three (3) and above for the given attributes were considered whereas <3 was unacceptable for further processing. The acceptability evaluation was carried out for surface color, mealiness, taste, texture. The accepted roots were washed, peeled and sliced thinly with manual chipper as recommended by Igbeka (1987) then packed 500gm in labeled brown paper sachets. The samples were then placed in an electric drier to reduce the moisture content to 12.7% safe for storage, and then milled using a maize miller as recommended by CTA, 2007. The ground samples were weighed to 200gms each and packed for nutrients analysis, which as per the Association of Analytical chemistry (1995).

#### 3.3.2.1Crude protein determination

The Kjeldhal method was used to determine crude protein. 2g of the sample flour, half of selenium catalyst tablets and a few anti-bumping agents was placed in a digestion flask. 25 ml of conc. $H_2So_4$ was added to sample and the flask shaken vigorously to obtain a wet and a well-mixed mixture. The flask was placed on digestion burner and heated slowly until the boiling ceases and a clear solution were obtained. The solution was cooled to room temperature and the digested sample was transferred into a 100 ml volumetric flask. For distillation of the sample, the apparatus was flushed out before use. 25 ml of boric acid was pippetted into a 250 ml conical flask and 2 drops of mixed indicator added. The liquid was drained from the steam trap while leaving the stop cork. The conical flask with its content was placed under the condenser in a position where the tip of the condenser was completely in the solution. 10 ml of the digested sample was measured and added to the decomposition flask. 40% of NaOH (20ml) was added to the decomposition flask. Distillation was allowed to continue for about 5 ml and the burner from the steam generator. The sample was titrated with 0.1 N HCl solution until the solution becomes colorless.

$$\% \text{ Nitrogen} = \frac{100 \times (V_A - V_B) \times N_A \times 0.01401 \times 100 \times 6.25}{W \times 10}$$

Where

$V_A$= Volume of the standard acid (ml)

$V_B$= Volume of standard in the blank (ml)

$N_A$= Molarity of HCL

W= Weight of sample (g)

F (6.25)= Non-protein (urea) Nitrogen factor

### 3.3.2.2 Moisture content analysis

Moisture content was determined according to AOAC Method 925.09, 1995. About 2g of the sample was dried in the oven at $105^0$c for 4 hours. The sample was then cooled and weighed. The moisture content of the sample was expressed as a percentage of the initial weight of the sample using the formula;

$$\% \text{ Moisture content} = \frac{\text{Weight of wet sample} - \text{Weight of dry sample}}{\text{Weight of wet sample}} \text{ x } 100$$

### 3.3.2.3 Crude fat analysis

Crude fat was determined using soxhlet extraction method AOAC Method 920.20, 1995. 2g of the sample was weighed into a thimble and the oil extracted using hexane as a solvent for 8 hours. This extract was oven dried at 105oc for about 30 minutes, cooled in a dessicator, and the weight recorded. The oil content was determined using the formula;

$$\% \text{ Crude fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \text{ x } 100$$

**3.3.2.4 Ash content analysis**

This was determined using AOAC Method 923.03, 1995. 2g of the food sample was burnt at $550^0$c for 7 hours in a muffle furnace until the difference between two successive weighing was constant. The samples were then cooled in a desiccator and weighed. The ash content will then be determined using the formula;

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \text{ x } 100$$

**3.3.2.5 Carbohydrate content analysis**

The carbohydrate content will be calculated by the difference method. The method entails adding the total values of crude proteins, moisture, crude fiber, crude fat and the ash constituents of the sample and subtracting it from 100. The value is obtained as a % of the CHO constituent of the sample.

$$\text{Carhohydrate content}(\%) = 100 - \{\text{Crude Protein } (\%) + \text{Crude fat } (\%) + \text{Ash } (\%) + \text{ Crude Fibre}(\%) + \text{ Moisture } (\%)\}$$

## 3.4 Statistical Analysis

The data was presented using both descriptive and inferential statistics. Descriptive statistics including frequencies and percentages were used to present the survey results and analyzed by use of SPSS version 20. The results were presented using tables and charts. Inferential statistics were used in the experimental results, which were subjected to Analysis of Variance (ANOVA). Chi-square was used to show the relationship between sensory characteristics and nutrient composition of the cassava varieties and relationship between sensory characteristics and various varieties of cassava.

### 3.5.1 KARI-Marigat Cassava Varieties

Figure 3 is a summary of the steps followed in the evaluation of the N = 51 cassava varieties from KARI- Marigat and one addition cassava root obtained from our local market which was being sold to the consumers for consumption. Elimination was done at stage 1 where the panelists observe for appearance and at stage 11 sensory evaluations was used. The final stage 111 was nutritional testing for the recommended varieties which were n = 10.

**FLOW DIAGRAM IN**

**STAGE I**

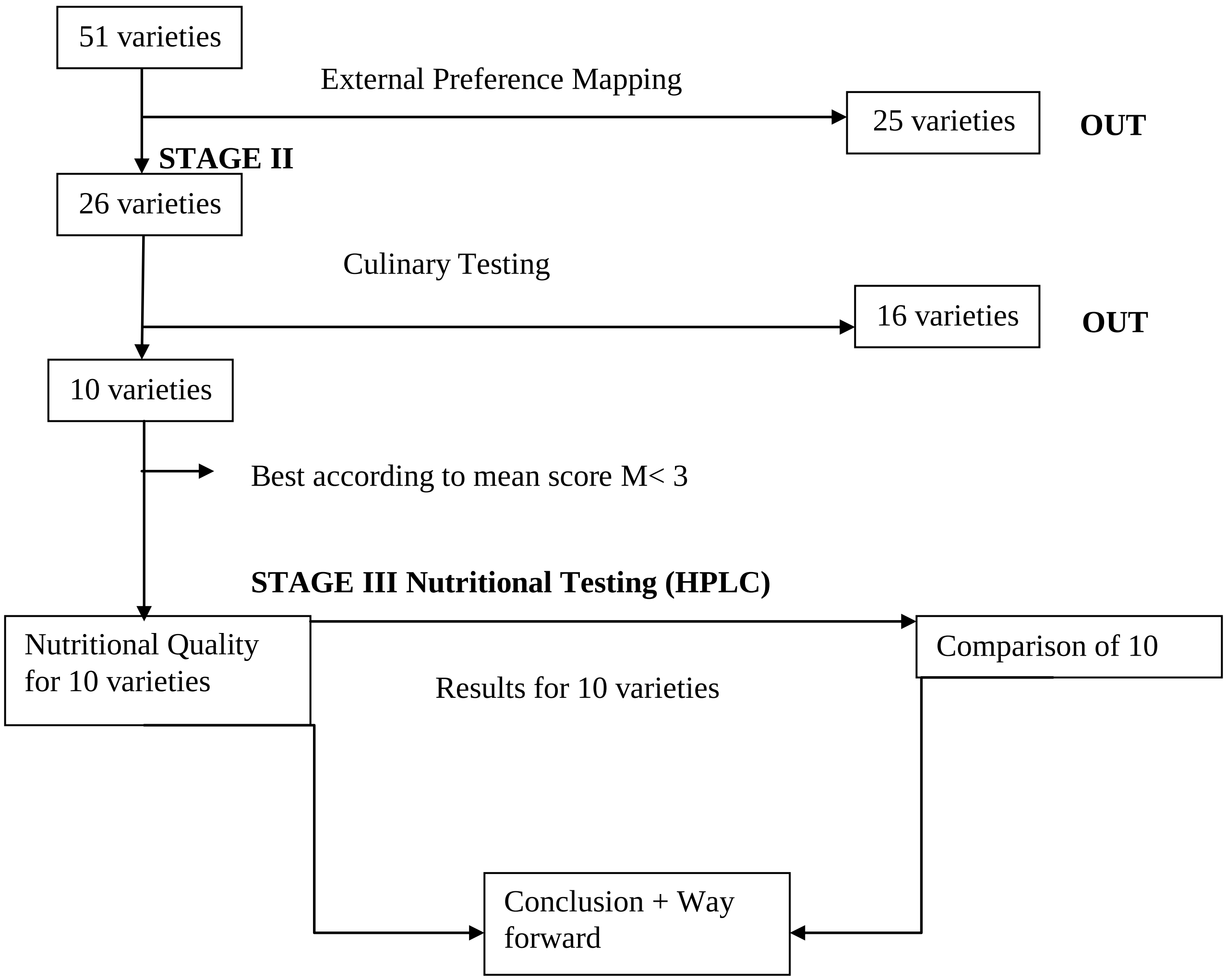


**Fig.3: Processing of cassava roots.**

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

This chapter presents the research findings. It gives descriptive information of the respondents and also the findings based on the objectives of the study. The results were presented to capture the background information and study objectives. Out of 250 questionnaires administered to the farmers in the study area, 247 (99%) were returned. The high response rate could be attributed to the way the questionnaires were laid out (structured) and the willingness of the farmers to contribute on the subject matter.

## 4.2 Background Information

The background information of the farmers who plant cassava was varied as shown in the Table 4.1. A total of 160 (64.8%) were male while 87 (35.2%) were female. This indicated that men headed most households in the study area, which was in accordance with the largely patriarchal nature of Kenyan families. The findings indicated a youthful population in the study area whereby 34% of the respondents were aged 31 and 40 years, 24.3% below 30 years and 22.3% were aged between 40-50 years. Farmers aged more than 50 years constituted the smallest proportion (19.4%). Up to 85.4% of the farmers were married and the least 14.6% were single. In terms of levels of education; 67.2% of the farmers had basic primary education, 19.4% had secondary education while 4.9% had tertiary education and 8.5% had no education at all. Based on employment status, 51.8% of the farmers were self-employed, whereas 39.3% were unemployed and 8.9% had formal employment. Income levels per year ranged from Kshs.1, 000 and Kshs.5, 000 for 45.3% of the farmers, and between Kshs.5, 001 and Kshs.10, 000 for 23.1%while those who earned Kshs.20, 0000 and above were 19% which indicated that rural incomes in the study area were quite low.

**Table 4. 1 Demographic Characteristics of the Respondents**

| Background Information | Variable | Frequency | Percent (%) |
|---|---|---|---|
| Gender of farmers | Male | 160 | 64.8 |
| | Female | 87 | 35.2 |
| Age of farmers | < 30 years | 60 | 24.3 |
| | 31-40 years | 84 | 34.0 |
| | 41-50 years | 55 | 22.3 |
| | >51 years | 48 | 19.4 |
| Marital Status | Married | 211 | 85.4 |
| | Single | 36 | 14.6 |
| Level education | None | 21 | 8.5 |
| | Primary | 166 | 67.2 |
| | Secondary | 48 | 19.4 |
| | Tertiary | 12 | 4.9 |
| Occupation | Unemployed | 97 | 39.3 |
| | Employed | 22 | 8.9 |
| | Self employed | 128 | 51.8 |
| Income of Farmers | 1000-5000 | 112 | 45.3 |
| | 5001-10000 | 57 | 23.1 |
| | 10001-20000 | 31 | 12.6 |
| | >20,001 | 47 | 19.0 |

N= 247

## 4.3 Cross Tabulation of Bio-data

The various categories of the respondent’s biographical information were related with each other to see if there were any relationships between them. Chi-square ($\chi^2$) tests of independence were used to establish whether there was any significant relationship between the categories. The variables were nominal and ordinal in nature and lambda (λ) test was further calculated to determine the strength of the relationships. The categories compared included the respondent's gender and their highest educational level, gender and occupation, gender and household income, age and highest educational level, and between age and occupation.

### 4.3.1 Household Gender and Education

Male farmers in the study area are likely to be better educated compared with their female counterparts. For instance, all the farmers with tertiary education were males while a greater proportion of female respondents (61.9%) had no education compared to only 38.1% of the males. However, this relationship was found to be relatively weak as indicated by a lambda of 6%. Education for all farmers can influence the socio-economic status of livelihood groups of interaction and thus the outcome may in turn affect the food security in their household.

The Chi-square test of independence between the respondent's age and profession showed a significant relationship at $\rho<0.05$ (Table 4.2).

**Table 4.2 Relationship between Respondents' Gender and Education**

| | | Respondent's highest level of education | | | |
|---|---|---|---|---|---|
| Gender of the household | | None | Primary | Secondary | Tertiary |
| Male | Frequency | 8 | 105 | 35 | 12 |
| | Percentage | 38.1 | 63.3 | 72.9 | 100 |
| Female | Frequency | 13 | 61 | 13 | 0 |
| | Percentage | 61.9 | 36.7 | 27.1 | 0.0 |
| Total | Frequency | 21 | 166 | 48 | 12 |
| | Percentage | 100 | 100 | 100 | 100 |

**($\chi^2$ = 14.64, df = 3, p =.002; $\lambda$ = .057)**

### 4.3.2 Household Gender and Occupation

The relationship between a respondent's gender and occupation was also found to be significant at p<0.05 (Table 4.3). The results suggested that very few women in the study area are likely to be in formal employment, with most of them being either unemployed or self-employed.

**Table 4.3 Relationship between Respondents' Gender and Occupation**

| Gender of Household | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | N | % | n | % | n | % |
| Unemployed | 60 | 61.9 | 22 | 100 | 78 | 60.9 |
| Employed | 37 | 38.1 | 0 | 0.0 | 50 | 39.1 |
| Self-employed | 97 | 100 | 22 | 100 | 128 | 100 |

**($\chi^2$ = 13.153, df = 2, p = 0.001,$\lambda$ = 0.06)**

### 4.3.3 Gender and Household Income

A strong relationship (lambda = 17%) was found between the respondent's gender and household income at p<0.05 (Table 4.4).

Majority (58.6%) of female-headed households earned less than Kshs. 5000 per annum compared with 38.1% for males while no female led household was found to earn more than Kshs. 20 000 per annum, which suggested that female-headed households in the study area earned inferior incomes compared with households headed by males. This indicates that education thus plays a major role in generation of household income.

**Table 4.4 Relationship between Respondents' Gender and Household Income**

| | Household income per annum (Kshs) | | | |
|---|---|---|---|---|
| Gender of Head | Male | | Female | |
| | N | % | N | % |
| 1000-5000 | 61 | 38.1 | 51 | 58.6 |
| 5001-10000 | 44 | 27.5 | 13 | 14.9 |
| 10001-20000 | 8 | 5.0 | 23 | 26.4 |
| >20000 | 47 | 29.4 | 0 | 0.0 |
| Total | 160 | 100 | 87 | 100 |

**($\chi^2$ = 55.26, df = 3, p <0.001; $\lambda$ = .17)**

## 4.4 Food Production, Availability and Accessibility

### 4.4.1 Respondents Livelihood Characteristics

The respondent's land acreage was varied as shown in the Table 4.5. Up to 72.5% had between 1 and 2 acres of land, 19.8% had between 2 and 5 acres while the same number of respondents (19.8%) had more than 5 acres. The findings indicate that the respondents owned or rented small farms to grow cassava. From the study majority 85.8% (n = 212) cultivated land but 59.1% (n = 146) allocated 1 acre or less to food crops and 15.8% (n = 39) allocated 2 acres. The least 10.9% (n = 27) recorded allocation of 3 acres or more to food crops. Livestock production was done by 14.2% (n = 35) and do not cultivate but practice nomadic farming. This shows that whereas there was variance in the acreage farmers allocated to food crops, smaller portions of their farms were used for growing food crops, mainly because they either own or rent small farms.

Most of the respondents 61.9% (n = 153) grew cassava on their farms, 47.4% (n = 117) allocated only less than one acre of land. A significant number of 38.1% (n = 94) did not plant the crop at all. Cassava was found to be intercropped with other food crops such as groundnuts and pawpaw, done by 10.1% (n = 25) and only 4.5% (n = 11) of the respondents allocate more than one acre of their land to pure stand growing. The findings indicated that respondents in the study area usually allocate small farm sizes to the growing of cassava.

**Table 4.5: Land Use Characteristics of the Respondent**

| Characteristics | Variables | Frequency | Percent (%) |
|---|---|---|---|
| Farmer's acreage | 1-2 acres | 179 | 72.5 |
| | 2-5acres | 49 | 19.8 |
| | >5 acres | 19 | 7.7 |
| Cultivate land | Yes | 212 | 85.8 |
| | No | 35 | 14.2 |
| Food crops acreage | 1 acre | 146 | 59.1 |
| | 2 acres | 39 | 15.8 |
| | 3 acres | 27 | 10.9 |
| Grow cassava | Yes | 153 | 61.9 |
| | No | 94 | 38.1 |
| Land allocated for cassava | <1 acre | 117 | 47.4 |

| Characteristics | Variables | Frequency | Percent (%) |
|---|---|---|---|
| Farmer's acreage | 1-2 acres | 179 | 72.5 |
| | 2-5acres | 49 | 19.8 |
| | >5 acres | 19 | 7.7 |
| | 1-2 acres | 11 | 4.5 |
| | Intercropping | 25 | 10.1 |
| | None | 94 | 38.1 |

**N=247**

#### 4.4.2 Food Availability

Majority of the respondents stated that they do not have enough food for their households as showed in the Table 4.6. Up to 89.5% (n = 221) did not produce enough food for their households. Most of them 66.8% (n = 165) obtained food from various sources either from other farmers within or out of the district, while only 10.5% (n = 26) produced enough food crops for their households. Twenty three (9.3%) obtained food from assistance (Food Aid) and a few of them from other sources such as families in formal employment. Most respondents 56.7% (n = 140) were found not to sell their farm products to the Marigat district municipal market, with 43.3% (n = 107) selling their farm produce to the market. The findings indicate that most of the respondents practiced subsistence farming. The respondents who sold their farm produce got varied incomes, with most of them 43.9% (n = 47) earning between Ksh 5001 and 10,000 per annum, followed by 43.9% (n = 27) who earned more than Kshs. 10,000 per annum. The latter group supplemented the sale of crops with the sale of small livestock. A sizeable proportion of farmers made little income from the sale of farm produce, with 12.1% (n = 13) and 18.7% (n = 20) earning less than Kshs1000 and between Kshs. 1001 and 5000 per annum, respectively.

**Table 4.6: Respondents Availability and Sources of Food**

| Availability of Food | | Frequency | Percent (%) |
|---|---|---|---|
| Enough food | Yes | 26 | 10.5 |
| | No | 221 | 89.5 |
| Sources of food | Assistance | 23 | 9.3 |
| | Purchases | 165 | 66.8 |
| | Others | 59 | 23.9 |
| Sale of farm products | No | 140 | 56.7 |
| | Yes | 107 | 43.3 |
| Income from sale of farm products | <Ksh 1000 | 13 | 5.3 |
| | Ksh 1001-5000 | 20 | 8.1 |
| | Ksh 5001-10000 | 47 | 19.0 |
| | >Ksh 10001 | 27 | 10.9 |
| | None | 140 | 56.7 |
| | Total | 247 | 100.0 |

**N=247**

### 4.4.3 Food Production

Respondents in the study area were found to exclusively grow their crops during the rainy seasons as shown in Table 4.7. Whilst the majority 90.5% (n = 224) grew their crops between the months of April and May during the long rains and harvested cassava tubers after a period of six months, only 9.5% (n = 23) planted crops between January and March. Planting material was a challenge as 89.9% (n = 222) of the farmers lack the seed though they prefer to plant when they get it from neigbours or KARI-Marigat. Respondents in the study area relied on rainwater to nourish their plants rather than depending on irrigation water.

It was germane to establish how the respondents in the study area sourced inputs for their farms, in order to determine how accessible they were. The study found that they obtained their inputs from varied sources, with only 8.5% (n = 21) obtaining them from DAO-Marigat and 35.2% (n = 87) sourced from neighbours whereas the majority 56.3% (n = 139) got them from other sources, such as growers in other Districts and from vendors of Kenya Seed Company.

An overwhelming proportion 89.9% of the farmers stated that cassava-planting material was not available with only 10.1% (n = 25) of them stating that they were. Most of the farmers in the study area preferred planting the sweet variety of cassava, with 65.6% (n = 162) preferring this type of cassava compared to only 4.9% (n = 12) for the bitter variety and 29.6% who preferred both varieties, which suggested that most respondents planted cassava for home consumption

Most respondents 79.4% (n = 196,) planted cassava once in a year with only 20.6% (n = 51) of them planting twice. Slightly over a half (53.4%) of the planted cassava which matured after six months, 41.7% of them had cassava that matured between four and six months while only 4.9% of the farmers had early-maturing cassava of between three and four months. The lengthy maturation period of most cassava planted in the area might explain why most farmers planted the crop only once each year.

Roughly, a half of the farmers (48.6%) took two months to complete the harvesting of the matured cassava, compared to 28.7% and 22.7% of the farmers, who used one and three months, respectively. This suggested that farmers in the area took a relatively short time to harvest cassava. Cassava was found to have distinct advantages over other crops, with 75.7% (n = 187) of the farmers perceiving cassava as an easy to maintain crop while 18.6% (n = 46) believed that the crop does well in all seasons. However, only 5.7% of the farmers believed that the crop required low inputs. The main challenge that farmers faced in the growing of the plant was lack of planting materials, which was cited by close to two thirds of the farmers 64.4% (n = 159) interviewed. The other significant challenge that faced the farmers was cassava pests, which was mentioned by 13.8% of the farmers.

**Table 4.7: Cassava Production Characteristics**

| | Variables | Frequency | Percent (%) |
|---|---|---|---|
| Planting season | Jan-March | 23 | 9.5 |
| | April-May | 224 | 90.5 |
| Access to farm inputs | DAO | 21 | 8.5 |
| | Neighbor | 87 | 35.2 |
| | Others | 139 | 56.3 |
| Availability of planting material | Yes | 25 | 10.1 |
| | No | 222 | 89.9 |
| Type of cassava preferred | Sweet | 162 | 65.6 |
| | Bitter | 12 | 4.9 |
| | Both sweet and bitter | 73 | 29.6 |
| Times in a year cassava is grown | Once | 196 | 79.4 |
| | Twice | 51 | 20.6 |
| Maturity period for cassava | 3-4 months | 12 | 4.9 |
| | 4-6 months | 103 | 41.7 |
| | > 6 months | 132 | 53.4 |
| Length of harvesting | 1 month | 71 | 28.7 |
| | 2 months | 120 | 48.6 |
| | 3 months | 56 | 22.7 |
| Advantage of cassava over other crops | Easy to maintain | 187 | 75.7 |
| | Low inputs | 14 | 5.7 |
| | Does well in all seasons | 46 | 18.6 |
| Challenges of growing cassava | Lack of planting material | 159 | 64.4 |
| | CMD cassava pests | 54 | 21.9 |
| | Others | 34 | 13.8 |
| | Total | 247 | 100.0 |

**N=247**

### 4.4.4 Utilization of Cassava

The study found that respondents utilized cassava in different ways (Table 4.8). Majority of farmers 48.2% (n = 119) ate maize as their staple food, whereas 38.1% (n = 94) considered maize and beans as their staple food. The findings of the study showed that maize was the staple food amongst the farmers. Roughly, half of the farmers 47% (n = 116) used cassava together with maize and millet while the other half 43.3% (n = 107) used it when there was no maize. A small proportion of the farmers (4.9%) used cassava as a snack.

The most popular method of preparing cassava was boiling, with 90.5% (n = 223) of the farmers preferring this method, compared to only 4.8% (n = 12) of the farmers who preferred either roasting or grinding it into flour for ugali. The farmers preferred eating cassava as a snack 47.6% (n = 118), followed by those who preferred it as meal 33.3% (n = 82) and lastly, for breakfast 19% (n = 47).

**Table 4.8: Respondents' Cassava Utilization Characteristics**

| | | Frequency | Percent (%) |
|---|---|---|---|
| As a staple Food | Maize meal | 119 | 48.2 |
| | Maize and beans | 94 | 38.1 |
| | Others | 34 | 13.8 |
| When is cassava eaten | When there is no maize | 107 | 43.3 |
| | Together with maize and millet | 116 | 47.0 |
| | Alone as a snack | 130 | 52.5 |
| | For breakfast | 47 | 19.0 |
| | As a meal | 82 | 33.3 |
| | Others | 12 | 4.9 |
| Mode of cooking | Boiling | 223 | 90.5 |
| | Roasting | 12 | 4.8 |

| | | Frequency | Percent (%) |
|---|---|---|---|
| As a staple Food | Maize meal | 119 | 48.2 |
| | Maize and beans | 94 | 38.1 |
| | Others | 34 | 13.8 |
| | For Ugali | 12 | 4.8 |

**N=247**

**Table 4.9: Mean Sensory Evaluation Scores of Cassava Roots Acceptability Status**

| Variety | Surface appearance | Mealiness | Taste | Texture | Mean (M) | SD | Remark |
|---|---|---|---|---|---|---|---|
| P12m | 5 | 4 | 4 | 4 | 4.25 | 0.50 | Retained |
| P12s | 4 | 2 | 3 | 2 | 2.75 | 0.96 | Rejected |
| P15m | 4 | 3 | 4 | 3 | 3.50 | 0.58 | Retained |
| P15s | 1 | 1 | 1 | 1 | 1.00 | 0.00 | Rejected |
| P15o | 2 | 1 | 2 | 3 | 2.00 | 0.82 | Rejected |
| P117o | 4 | 5 | 4 | 4 | 4.28 | 0.80 | Retained |
| P117m | 2 | 2 | 3 | 2 | 2.25 | 0.50 | Rejected |
| R252m | 4 | 3 | 3 | 3 | 3.25 | 0.50 | Retained |
| R252o | 2 | 2 | 2 | 1 | 1.75 | 0.50 | Rejected |
| R252s | 3 | 3 | 3 | 2 | 2.75 | 0.50 | Rejected |
| R365m | 3 | 3 | 3 | 4 | 3.25 | 0.50 | Retained |
| R365o | 3 | 1 | 1 | 1 | 1.50 | 1.00 | Rejected |
| R365s | 3 | 3 | 3 | 3 | 3.00 | 0.00 | Rejected |
| R271m | 3 | 5 | 3 | 4 | 3.75 | 0.82 | Retained |
| R271o | 2 | 1 | 1 | 1 | 1.25 | 0.50 | Rejected |
| R271s | 3 | 2 | 1 | 2 | 2.00 | 0.50 | Rejected |
| POROs | 3 | 3 | 3 | 3 | 3.00 | 0.00 | Retained |
| P114m | 2 | 1 | 1 | 1 | 1.25 | 0.50 | Rejected |
| P114o | 3 | 3 | 3 | 2 | 2.75 | 0.50 | Rejected |
| R1P44s | 2 | 3 | 2 | 2 | 2.25 | 0.25 | Rejected |
| R1P44o | 5 | 5 | 4 | 5 | 4.75 | 0.50 | Retained |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R1P42m | 4 | 4 | 5 | 5 | 4.50 | 0.58 | Retained |
| R1P42s | 5 | 4 | 4 | 4 | 4.25 | 0.50 | Retained |
| R3P51m | 2 | 1 | 1 | 1 | 1.25 | 0.50 | Rejected |
| R1P81m | 2 | 1 | 1 | 1 | 1.25 | 0.50 | Rejected |
| R182m | 1 | 1 | 1 | 1 | 1.00 | 0.00 | Rejected |

**N=26**

A summary of n=10 cassava varieties that were retained are given in Table 4.10.The results indicated that of the accepted varieties, the characteristics of the surface appearance was generally the best with a M = 3.80 and std dev = 0.63 while texture was the lowest (M = 3.20, std dev = 0.42). The characteristic of mealiness and taste were in between these extremes and were largely similar with M = 3.30.Varieties ranked highest with similar scores were P12m and P117o (M = 4.25 and std dev = 0.82) whereas the three varieties R365m, R271m and controlled POROs scored lowest equal values of M = 3.0 and std dev = 0.00.

**Table 4.10: Sensory Evaluation Scores of Cassava Roots Retained after Cooking**

| Variety | Surface appearance | Mealiness | Taste | Texture | Mean (M) | Standard Deviation |
|---|---|---|---|---|---|---|
| P12m | 5 | 4 | 4 | 4 | 4.25 | 0.50 |
| P15m | 4 | 3 | 4 | 3 | 3.50 | 0.58 |
| P117o | 4 | 5 | 4 | 4 | 4.25 | 0.82 |
| R252m | 4 | 3 | 3 | 3 | 3.25 | 0.50 |
| R365m | 3 | 3 | 3 | 3 | 3.00 | 0.00 |
| R271m | 3 | 3 | 3 | 3 | 3.00 | 0.00 |
| POROs | 3 | 3 | 3 | 3 | 3.00 | 0.00 |
| R1P44o | 4 | 3 | 3 | 3 | 3.25 | 0.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| R1P42m | 4 | 3 | 3 | 3 | 4.75 | 0.50 |
| R1P42s | 4 | 3 | 3 | 3 | 3.25 | 0.50 |
| Mean | 3.80 | 3.30 | 3.30 | 3.20 | 3.40 | 0.33 |
| Std. Dev. | 0.63 | 0.67 | 0.48 | 0.42 | 0.42 | |

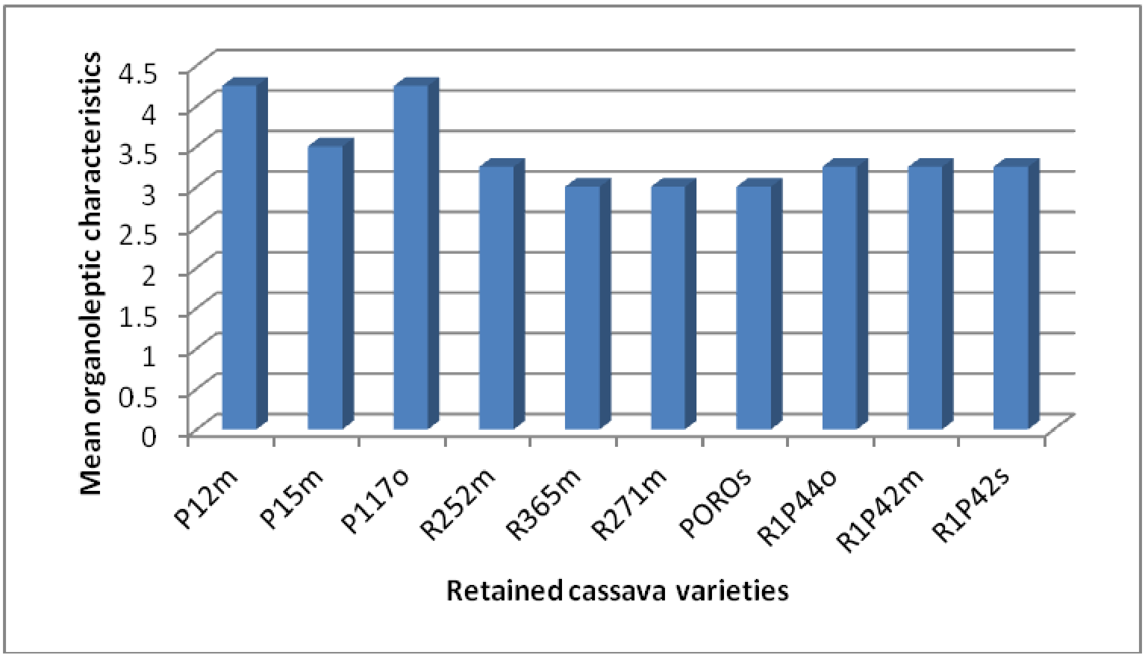


**Fig.4: Sensory characteristics of the retained cassavas**

The figure above is a pictorial presentation of the mean culinary characteristics of the retained cassava varieties.

The results indicated that varieties P117o and P12m had the highest mean scores on the sensory characteristics among the retained varieties, followed by variety P15m while the control stock, POROs, together with varieties R27m and R365m had the lowest scores on the tested characteristics.

The mean scores obtained from the cassava varieties that were accepted were also determined as shown in Table 4.11. The overall mean values of the sensory characteristics ranged from M = 3.00 to M = 4.25 which indicated that acceptance threshold was mean for the sample selected. Comparing the means of the sensory characteristics, surface appearance score the highest mean score followed by taste and least was texture.

**Table 4.11: Results Showing the Mean Scores of Each Hedonic Score (± SEM)**

| Variety | Surface appearance | Mealiness | Taste | Texture | Mean |
|---|---|---|---|---|---|
| P117o | 4 | 5 | 4 | 4 | 4.25 ± 0.50 |
| P12m | 5 | 4 | 4 | 4 | 4.25 ± 0.50 |
| P15m | 4 | 3 | 4 | 3 | 3.50 ± 0.58 |
| POROs | 3 | 3 | 3 | 3 | 3.00 ± 0.00 |
| R1P42m | 4 | 4 | 5 | 5 | 4.50 ± 0.58 |
| R1P44o | 5 | 5 | 4 | 5 | 4.75 ± 0.50 |
| R1P42s | 5 | 4 | 4 | 4 | 4.25 ± 0.50 |
| R252m | 4 | 3 | 3 | 3 | 3.25 ± 0.50 |
| R365m | 3 | 3 | 3 | 4 | 3.25 ± 0.50 |
| R271m | 3 | 5 | 3 | 4 | 3.75 ± 0.82 |
| Mean ± | 3.16 ± 0.72 | 2.60 ± 0.26 | 2.64 ± 0.71 | 2.41 ± 0.29 | |

The data was then subjected to subjected to ANOVA test to determine if there were significant differences in each score of each of the sensory qualities against the cassava varieties. The ANOVA table showing differences in the hedonic characteristics of the cassava sensory quality evaluation is shown in Table 4.12. From the ANOVA results it showed that there were significant mean difference between the sensory characteristics and the cassava varieties at 5% level of significance as shown in Table 4.12. There were significant differences in the values of the surface appearance, mealiness and taste among the cassava varieties investigated. However, the cassava varieties were similar in their textures. Generally the overall mean values of the scores were also found to be significantly different among the cassava varieties. This therefore accepts the null hypothesis that states: $H_o$ = There is significant difference in cooking qualities of the selected cassava roots. Cassava varieties harvested at the same time and under the same conditions may differ substantially in the quality due to number factors including genetic conditions, resistance to environmental condition and other intrinsic factors resulting in differences in the sensory qualities. These differences are reflected in the rejection and acceptance of some of the cassava varieties. These differences resulted in retention of 10 cassava varieties and rejection of the remaining fifteen.

**Table 4.12: ANOVA results of relationship between sensory characteristics and cassava varieties.**

| | | Sum of Squares | df | Mean Square | F | P-value |
|---|---|---|---|---|---|---|
| Surface | Between Groups | 35.741 | 9 | 3.971 | 3.895 | 0.037* |
| appear | Within Groups | 17.333 | 17 | 1.020 | | |
| Variety | Total | 28.074 | 26 | | | |
| Mealiness | Between Groups | 17.241 | 9 | 1.916 | 2.538 | 0.0433* |
| Variety | Within Groups | 12.833 | 17 | 0.755 | | |
| | Total | 20.074 | 26 | | | |
| Taste | Between Groups | | | | | |
| Variety | | 18.583 | 9 | 2.065 | 2.492 | 0.0383* |
| | Within Groups | 14.083 | 17 | 0.828 | | |
| | Total | 22.667 | 26 | | | |
| Texture | Between Groups | 7.833 | 9 | 0.870 | 1.153 | 0.682 |
| Variety | Within Groups | 12.833 | 17 | 0.755 | | |
| | Total | 20.667 | 26 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mean Variety | Between Groups | 17.453 | 9 | 1.939 | 2.672 | 0.039* |
| | Within Groups | 12.339 | 17 | 0.726 | | |
| | Total | 19.792 | 26 | | | |

***Significant at p<0.05**

### 4.5 Nutritional Characteristics

The proximate composition considered during the study was varied with respect to the USDA-21 standards as summarized in Table 4.13. CHO values for the cassava were high and ranged from 84.00 units to 93.51 % per 100 g, which were all higher than the recommended USDA-21 levels for all varieties with the variety under control POROs leading in CHO and could have been due to difference in harvesting period. This therefore indicates that in terms of provision of energy, the current varieties of cassava were good despite the fact that they stayed underground for sixteen months. The protein levels ranged from 1.25% to 2.05% per 100 g, which was lower than the USDA-21standard requirement of 3% per serving. The low and sometimes large variation in protein content of cassava could be contributed to by genetic makeup, growing environment or length of stay in the soil. POROs when compared with the other nine varieties in protein levels, it was ranked the least with 1.25% per 100g. This is an indication of the release of improved protein bred varieties by the researchers. Fats ranged from 0.17% to 1.24% with only one cassava sample having values above the USDA-21 standards (P12m, 1.24% and USDA-21-1%). Dietary fibre and ash contents values were in traces reflecting that the varieties of cassava in the study area are low in fiber and ash contents. Proximate composition of the variety picked from local market (POROs) had either lower or similar values with the KARI varieties. However, it had an exception of CHO values which emerged leading due to different growing environments. Unlike the KARI bred cassava varieties which were specifically bred for sixteen months to determine palatability and nutrients level after that length of time for possibility use to alleviate poverty in dry areas like Marigat.

**Table 4.13: Proximate Composition of the Accepted Cassava Varieties**

| Nutrient (%/100g) | P12m | P15m | P117o | R252m | R365m | R271m | POROs | R1P44o | R1P42m | R1P42s | SPs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Protein | 1.85 | 1.75 | 1.95 | 2.05 | 1.85 | 1.65 | 1.25 | 1.45 | 1.45 | 1.55 | 3.00 |
| Fat | 1.24 | 0.21 | 0.22 | 0.17 | 0.18 | 0.15 | 0.18 | 0.17 | 0.18 | 0.34 | 1.00 |
| CHO | 84.00 | 87.34 | 88.72 | 88.98 | 90.67 | 88.81 | 93.51 | 90.88 | 87.78 | 89.01 | 78.00 |
| D/Fibre | 0.05 | 0.08 | 0.06 | 0.05 | 0.06 | 0.08 | 0.03 | 0.04 | 0.09 | 0.07 | 3.70 |
| Ash | 0.09 | 0.135 | 0.09 | 0.11 | 0.09 | 0.12 | 0.04 | 0.08 | 0.09 | 0.09 | 1.3 |

Sps= Standard per servings (USDA-21) for adults.

D/fibre= Dietary fibre

The mineral element composition of the cassava varieties are shown in Table 4.14. Ca in the varieties ranged from a low of 3.00% to a high value of 6.92 % per 100g with variety P15m with the highest value of 6.92%. Control variety POROs had second last value of 3.25% indication of KARI varieties were high in Ca. Fe ranged from 0.53% to 1.56 % per100g with P117o leading in the value. All varieties except R271m (0.53%) had higher Fe values than the USDA-21 standards (0.6%). These positive findings show that researchers bred improved varieties. Traces of Mn were seen at values ranging from 0.33% to a high of 2.36% per 100g with P117o still leading with 2.36%. Values of P ranged from 0.014% to 0.0774%. The content of K in the cassava was found in large amounts and ranged from 56% to 96%. Control variety POROs tailed with 56% and P15m still leading with 96% and same. All the mineral elements in the cassava were found to be below the USDA-21 standards except Fe. The observed values for proteins and other minerals contents suggest that the researchers have bred and released varieties with improved mineral values in Kenya.

**Table 4.14: Mineral Element Composition of the retained Cassava Root Varieties**

| Nutrient (%/100g) | P12m | P15m | P117o | R252m | R365m | R271m | POROs | R1P44o | R1P42m | R1P42s | SPs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ca | 5.04 | 6.92 | 4.67 | 5.04 | 5.07 | 6.61 | 3.25 | 3.00 | 5.47 | 4.63 | 33.0mg |
| Fe | 1.04 | 1.14 | 1.56 | 1.23 | 1.42 | 0.53 | 0.61 | 1.10 | 0.72 | 1.08 | 0.6gm |
| Mn | 1.50 | 0.33 | 2.36 | 0.45 | 1.77 | 1.50 | 0.80 | 0.14 | 2.10 | 0.65 | 43.3mg |
| P | 0.07 | 0.03 | 0.06 | 0.04 | 0.04 | 0.77 | 0.01 | 0.03 | 0.02 | 0.04 | 558mg |
| K | 83.00 | 96.00 | 93.00 | 60.00 | 80.00 | 84.00 | 56.00 | 66.00 | 72.00 | 85.00 | 3.9mcg |

Sps= Standard per servings (USDA-21) for adults.

The correlation between sensory quality and proximate composition of the cassava varieties are shown in Table 4.15. Protein and fat had significant positive correlation with sensory qualities (p values 0.487, 0.634 respectively). CHO were highly negatively correlated and significant at $p < 0.05$ with sensory qualities (p value = 0.691). This indicates that as values of protein and fats increase, the sensory quality of the cassava improves while an increase in the content of carbohydrates reduces the overall sensory quality of the cassava. On the contrary, there were large quantity of CHO which can degrade the quality of the cassava should it increase. Dietary fibre and ash did not affect the sensory quality of the cassava indicating that cassava quality may be less determined by these variables.

The correlation between sensory quality and mineral element composition of the cassava varieties are shown in Table 4.15. Only Fe and K had significant positive correlation with sensory qualities while Ca, Mn and P were not significantly correlated with sensory qualities. This has confirmed the null hypothesis that: $H_o$= there is significant correlation between sensory qualities and mineral elements of cassava roots at $p < 0.05$. This indicates that as content of Fe and K increase, the sensory quality of the cassava improves. As shown in the results below the cassavas were deficient in Fe and K than the recommended levels and therefore any increase in these two mineral elements will probably improve the overall quality of the cassava.

**Table 4.15: Spearman Rank Correlation between Sensory Evaluations and Nutrient**

**Values. N = 10**

| Nutrient | Pearson Correlation | Sig. (2-tailed) |
|---|---|---|
| Protein | 0.487 | 0.048* |
| Fat | 0.634 | 0.049* |
| CHO | -0.691 | 0.027* |
| Dietary Fibre | -0.079 | 0.827 |
| Ash | 0.179 | 0.621 |
| Ca | 0.074 | 0.839 |
| Fe | 0.486 | 0.045* |
| Mn | 0.301 | 0.398 |
| P | -0.274 | 0.444 |
| K | 0.513 | 0.020* |

*. Correlation is significant at the 0.05 level (2-tailed).

# CHAPTER FIVE

## SUMMARY

### 5.1 Introduction

This chapter contains discussion, results and conclusions their practical implications and recommendations. These are based on the findings in chapter four and on the literature review. Discussions of results are presented in section 5.2, summary are made in section 5.3, conclusions in section 5.4, while recommendations are in section 5.5.

### 5.2 Discussion

This study found that farmers faced difficulties in sourcing for cassava planting materials, with a considerable proportion of them opting to obtain the materials from their neighbours. This constraint may be to large extent due to the nature of the cassava planting material. Cassava, unlike other common crops such as maize and beans, is propagated vegetatively, using stem cutting taken at harvest of the previous crop (Plucknett, Phillips and Kagbo, 2000). Stem cuttings are bulky, cannot be stored for long and are costly to cut and handle. Thus, a farmer cannot walk into an agronomical shop and ask for a cassava cutting, which was developed earlier. This limits most farmers to obtaining the cuttings from their neighbours, a cultural practice which may not be desirable as the planting materials obtained may not be of the best quality. Another downside to using vegetative propagation is that multiplication rates for new improved varieties are slow, which retards their adoption. Plucknett *et al* (2000) also found out this in their study. There is therefore a need to develop seeds as the chief propagating materials for cassava, which might overcome the difficulties experienced by farmers with cuttings.

As found in other studies, notably those of Bokanga (2001) and Kariuki (2002), this study also found that pests infesting the cassava crop were a constraint that reduced its productivity. Although this study did not specifically set out to identity the pest species infecting the crop, those that have been found to be endemic in Africa include cassava mealybug (*Phenacoccus manihoti*), striped mealybug (*Ferrisia virgata*), and cassava green spider mite (*Monony chellustanajoa*). Others have been found to be cassava scales (*Aonidomy tilusalbus*), and vertebrate pests such as birds, rodents, monkeys, pigs and domestic animals such as cattle, goat and sheep (Belletti, Smith and Lapointe, 1999). These pests damage and cause yellowing of leaves, suck sap, inject toxins, reduces length of internodes, resulting in smaller tubers, poor quality planting materials and in cases of severe attack, death of the plant. Because of their lower cyanogenic glycoside content, the sweet cassava varieties are more vulnerable to pests compared with their bitter counterparts (Plucknett, 1995). Given that the majority of farmers in the study area plant the sweet variety, the problem of pests might be a major one.

Farmers were found to own small land sizes and even to allocate smaller portions to growing of cassava. Given that land is a finite asset, little can be done about expanding the farmers' holdings. However, if the farmers were to find that growing cassava has more tangible benefits than growing other crops or keeping animals, they might be motivated to dedicate more of their land to growing cassava. Thus, it is important for researchers to develop better cassava varieties that can draw more farmers to the growing of the crop. The presence of high cyanogenic glycosides in some varieties implies that they cannot be readily eaten unless elaborate preparative procedures have been conducted (Plucknett *et al*, 2000). This might limit the number of farmers willing to plant such varieties. Although the "Sweet" varieties are more popular and can be eaten raw or boiled like potatoes because of low cyanogenic glycoside level, they are often more susceptible to attack by pests (Bokanga, 2001). Thus, it is pertinent for researchers to develop cassava varieties with lower cyanogenic glycosides but which are resistant to pest attack.

The study found that distinct opportunities exist for the crop, which might be leveraged upon to promote the adoption of the crop in hunger-prone areas of the country. The crop is easy to maintain, can grow in all seasons, and can be planted twice in a year, advantages that have been found by others such as Dele *et al* (2001). Soil nutritional requirements of cassava per unit of dry matter yield are much lower than of most other crops, except for potassium because the crop is a very efficient user of soil nutrients (Howeler, 2001). The crop also offers unique opportunities of being stored that of being left underground after maturity, to be mined by the farmer whenever they wish. Compared with other common crops such as maize that must be harvested soon after maturing to prevent rotting and destruction by birds, underground storage of cassava will protect it from consumption by herbivorous animals. Given that the crop in the study area, as in many parts of the country, is used virtually as a fresh human food, there are huge opportunities of expanding the crop into an efficient industrial crop for factory processing, such as in animal feed and starch processing.

Cassava is usually harvested 9 -12 months after planting (Plucknett *et al*, 2000), hence this study deliberately used roots harvested after 16 months to test for cooking and nutritional characteristics, partly to determine the storing qualities of cassava varieties developed at KARI station in Marigat. The study found that n = 26 out of n = 51 (about 54% of the total cassava varieties) cassava roots were rotten, woody, and fibrous or having dark brown streaks after peeling and off-white standard color. This suggests that roughly half of the new varieties developed by KARI could not be stored for a very long while the other half could. Given that the control variety (POROs) had been harvested after about ten months of planting, the results indicate that KARI is partially successful in the development of longer underground-staying cassava varieties.

The study used four qualities to determine the cooking qualities of the cassava varieties: surface appearance, mealiness, taste and texture. Of the n = 25 retained varieties, n = 10 of them (that is, 40%) were found to have acceptable cooking qualities, as measured by the average of the four qualities tested. However, if we consider the N = 51 varieties we started with, those with acceptable cooking qualities were only about 18%. This again suggests that KARI has had both successes and failures in developing cassava varieties that satisfy the gastronomical tastes of people. From the rating of the cassava varieties on the four quality characteristics, the results indicate that KARI-developed varieties were very good in their surface appearance with respect to their color (M = 3.16) while with lower values in respect to their mealiness (ease of cooking) and taste (mouth feel and after taste) M = 2.60 and 2.64 respectively. However, texture (M = 2.41), (the feel of the tongue after chewing) was least favoured. The study found that varieties like P117o (M = 4.25) and P12m (M = 4.25) had good sensory characteristics while others like POROs (M = 3.00), R252m (M = 3.25) and R365m (M = 3.25) were less favoured an indicaton that the was significant differences in overall acceptability of the sampled cassava roots. That the control, POROs, had the lowest score on the tested characteristics further indicated that KARI has been successful to some extent in developing more accepatable cassava varieties. Of the 51 tested varieties, the overall acceptability was found to be just about 18%, suggesting that KARI needs to make alot of progress in improving the cassava varieties, especially with respect to their texture, taste and mealiness.

Nutritional tests on the retained n = 10 cassava roots generally revealed low levels of protein, fat, dietary fibre, and ash compared to the recommended USDA-21 levels. However, carbohydrate values were higher in all the retained varieties relative to the recommended USDA-21standards per serving. This suggested that KARI has not achieved alot of success in developing varieties with a balanced nutritional content. This is because the conventional cassava varieties are usually high in CHO content but low in proteins and fats (Plucknett *et al,* 2000). A study by Chavez, Sanchenz, and Ceballos (2005) reported large difference in protein content of roots ranging from 0.95% - 6.42% per 100g an indication of possibility to improve protein through breeding. The varieties developed by KARI will be useful in supplying energy requirements to farmers and domestic animals because of high CHO content. A person requires enough energy for daily activities. In addition to fuelling activities, the research suggests that CHO can also promote recovery when consumed after exercise and is known to keep ones central nervous system functioning at optimal levels. However, cassava is poor in supplying protein and fats. Given the high protein deficiency in developing countries, it will be germane for KARI to develop varieties that are more fortified in proteins. Excepting for Fe, all the mineral elements (Ca, Mn, P and K) in the cassava varieties were found to be below the recommended standards. Although they are found in a small amount, their absence in the human body can cause hidden hunger. All these minerals have crucial functions in the health of a human being, it will be important for KARI to develop varieties with higher content of these elements. A comparison of the nutritional values of the control (POROs) and varieties developed by KARI revealed that except for CHO, POROs nutritional values for the major compounds were among the lowest; suggesting that KARI varieties may be used to improve food security hence increased wellbeing of Marigat community.

## 5.3 Summary of results

The overarching aim of this study was to identify opportunities and constraints of cassava utilization in Marigat district, Baringo County and to determine the quality characteristics of fifty newly bred cassava roots grown at KARI Marigat. The specific objectives of the study were to identify constraints and opportunities of cassava roots utilization in Marigat, determining the cooking qualities of the new cassava root varieties bred for longer ground storage and sampled from KARI-Marigat, identifying the overall acceptability of sampled cassava roots after boiling, and measuring the nutritional value of cassava roots that had acceptable quality characteristics.

Majority of the farmers in the study district did not produce enough food, forcing them to either purchase or seek for aid to meet their needs. Most of their farm produce was for subsistence and those managing to sell their farm produce on the market mostly earning paltry annual incomes of less than Kshs10 000. A significant proportion of the populace had not planted cassava while those who did mostly allocated less than one acre for the crop. This study found that the wide utilization of cassava was hampered by several constraints: difficulties in sourcing for planting materials, the existence of pests for the crop, and the high cyanogenic glycosides in some varieties. However, the study also found distinct opportunities existing for the crop: easy maintenance, ability of the crop to grow in all seasons and possibility of upstaging maize and beans as the staple food to back up cassava.

Fifty one cassava roots, including a control picked from the market, were subjected to a series of culinary tests. In the first stage, n = 26 varieties, which were rotten, woody, and fibrous or having dark brown streaks after peeling and off-white standard color, were eliminated. The remaining n = 25 plus n = 1 from local market cassava varieties were cooked and characterized for sensory qualities of surface appearance, mealiness, taste, texture and overall acceptability. Ten (including the control) out of the n = 26 cassava varieties, with an overall acceptability mean of at least M = 3, were retained. The surface appearance was generally rated the best characteristic of the accepted varieties, followed by mealiness and taste, while their texture was the poorest. Varieties P117o (M = 4.25) and P12m (M = 4.25) had the highest scores on the general acceptability of sensory characteristics among the retained varieties while the control stock, POROs (M = 3.0) together with varieties R27m (M = 3.0) and R365m (M = 3.0) had the lowest scores.

Nutritional tests on the retained n = 10 cassava roots generally revealed low levels of protein, fat, dietary fibre, and ash compared to the recommended USDA-21standards per serving levels. However, CHO values were higher in all the retained varieties relative to the recommended USDA-21 levels. The cassava roots had higher levels of iron than the recommended standards whereas calcium, manganese phosphorus and potassium were found to be lower than the USDA-21 recommended standards.

## 5.4 Conclusions

This study identified opportunities and constraints of cassava utilization in Marigat district, Baringo County and determined the quality characteristics of fifty new cassava roots grown at KARI Marigat. The conclusions from this study were:

Wide utilization of cassava was hampered by difficulties in sourcing for planting materials, the existence of pests for the crop, small farm sizes and the even smaller land area allocated for the crop, and the high cyanogenic glycosides (very bitter taste) in some varieties as reported by the farm households. However, distinct opportunities are extant for the crop. These include easy maintenance, ability of the crop to grow in all seasons, possibility of upstaging maize and beans as the staple food, planting the crop twice in a year and banking the crop underground.

Cassava varieties developed by KARI have very good surface colour, medium acceptance with respect to their mealiness and taste while they are recorded poor with regard to texture.

Of the N = 51 tested varieties, the overall acceptability was found to be just about 18%, suggesting that KARI needs to make alot of progress in improving the cassava varieties, especially with respect to their texture, taste and mealiness.

KARI developed cassava varieties with high CHO and Fe content, but low levels of protein, fat, dietary fibre, ash, Ca, Mn, P, and K compared with recommended USDA-21 standards per serving.

## 5.5 Recommendations

As the study indicates, cassava can be used in every meal as raw, boiled, fried or mixed with other cereals. Emphasis by the researchers should therefore be on improved varieties that are early maturing and resistant to pests, diseases and texture spoilage with longer duration in the ground to ensure all year food supply to the households. The high macronutrient and micronutrient cassava variety should be adopted for use in National improvement programmes to reduce malnutrition and other nutrition related problems in food deficient areas.

There is need for the Government to adopt a policy on cassava as a food security and industrial crop as it can grow in most types of soil and these include;

- Policy on post-harvest and agro processing handling for better utilization
- Working with community during breeding to avoid introduction of unsuitable varieties.
- Production of breeds that are more palatable with length of ground storage capability/characteristics
- Extension services should include introduction of newly bred varieties of cassava to reduce on maize dependency
- Changing cropping patterns to include intercropping cassava with legumes that are highly nutritious with high climate stress tolerance.

**Further Research:**

- Acceptability of maize and cassava flour in household diet for food security in Marigat
- Development of cassava products for school feeding programs in ASAL region.
- Effect of intercropping cassava with legumes with high climate stress tolerance.

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# APPENDICES

## Appendix I: Consent form to participate in a Research Study

**Title:** Comparative analysis of cassava roots as affected by age at harvest: A case of Marigat District.

**Investigator:** Eunice Yabann (MCN Student)

School of Agriculture and Biotechnology

Department of consumer sciences

Chepkoilel University College

**Purpose:** This study is an academic requirement for a Master of Science in Community Nutrition and the Research findings may be used for policy making to enhance food security in dry areas.

**Procedure:** Laboratory experiments and field survey will be conducted. Questionnaires will be used by the sample participants to answer simple questions.

**Benefits:** This research will benefit the community to grow quality crop and enhance food security. There are no risks involve in all participants.

**Confidentiality:** All information obtained is strictly for research purposes only.

**Consent:**

I agree to participate in this study

Signature: ___________________ Date:___________________

**Appendix II: Interview guide for key informants (Agriculture Officers)**

**INSTRUCTIONS:** The interviewer will read out the questions to the respondents and record the responses.

1. What are the sources of food in the area?
2. Which is the staple diet of the community?
3. What types of crops are grown in the area?
4. Is cassava one of the food crops in the area?
5. If no, why does the community not grow the crop? If yes land is allocated for the crop?
6. Is cassava planting material easily available?
7. How do the households utilize cassava roots and leaves?
8. What are the challenges of cassava production in the area?

**Appendix III: Questionnaire**
**Survey Questionnaire No.……**

**GENERAL INFORMATION, DEMOGRAPHIC, AND SOCIO-ECONOMIC CHARACTERISTICS**

**(Tick one or fill in place provided)**

1. Household head

a) Gender__ Male__ Female

b) Age____

c) Marital status__ Married__ Single__ Separated___ Widowed

d) Level of education__ None__ Primary__ Secondary__ Tertiary

e) Occupation__ Unemployed__ Employed__ Self employed__ N/A

f) Household income) Ksh__

**FOOD PRODUCTION, AVAILABILITY AND ACCESSIBILITY**

1. How many acres of land do you own__________ or rent______
2. Do you cultivate any? a)Yes b)No
3. If yes how many acres do allocate to food crops?___________ acres
4. Is food produced in your farm enough for household? a) Yes b) No
5. If No, how do you obtain food for your household?

   a) Assistance b) purchases c) others---------------

**CASSAVA PRODUCTION, CHALLENGES AND UTILIZATION**

1. Do you grow Cassava on your farm? a) Yes b) No
2. If yes, how much of the land do you allocate for growing Cassava? ----acres
3. Is Cassava planting material available? a) Yes b) No
4. If yes which type of cassava do you prefer? a) sweet _b) bitter
5. How do you prepare Cassava for food? a) Boil and eat as snack_b) dry grind for flour c) Others ___________
6. When do you prepare Cassava for the family?

   a) When there is no maize b) Together with maize and millet?

   c) Prepare it alone as a snack c) Others_________________
7. What challenges do you face in the production and utilization of Cassava?_________________________________
8. What is your perception of cassava as a food crop?

**Appendix IV: Boiled cassava roots sensory evaluation form**

**Clone number……………………...**

**Evaluators name…………………….**

| **Traits** | **Score/Rank** |
|---|---|
| Surface Appearance | |
| Mealiness | |
| Taste | |
| Texture | |
| Overall Acceptability | |

**SCORES RANK**

5-Very good 4-Good, 3-fair, 2-bad 1-worse

………………………………………………..

**Appendix V: Cassava Plants**

**(Source: Author, 2013)**

**Appendix VI: Alluvial soils in the study area**

**(Source: Author, 2013)**

**Appendix VII: Topography of the study area**

**(Source: Author, 2013)**