CONSUMER PREFERENCE AND ACCEPTABILITY FOR SWEET POTATO VARIETIES IN THE LAKE ZONE OF TANZANIA

BY

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ABSTRACT

The study was carried out to evaluate consumer preference and acceptability for sweet potato in the Lake Zone. Genetic yield, farmers and consumers preference, sensory acceptability, effect of processing methods on nutritional qualities and marketing channels of sweet potato were evaluated using six sweet potato varieties; two white and four orange-fleshed local and new introduced cultivars. Results showed that there were several sweet potato varieties grown in the area mostly landraces and had yield differences. Sekondari variety had the highest yield of 4.8 t/ha and Polista the lowest 3.2 t/ha. Sekondari variety was mostly preferred in Missungwi (63.1%) while Polista variety was mostly preferred in both Meatu and Sengerema districts (60.3 and 58.9%) respectively. Reasons for preference were high dry matter content, good flavour and sweetness. Polista was highly preferred regardless of its low productivity. The results also show that the consumption of sweet potato in the Lake zone was very high, where 63.1 and 76.2% of farmers in Missungwi and Meatu respectively consumed sweet potato every day, while 63.7% in Sengerema consume sweet potato 3-5 times per week. It was observed that 69.2 and 63.7% of farmers in Missungwi and Sengerema respectively cook sweet potato by boiling whereas 51.5% of farmers in Meatu use both boiling and roasting methods. Nutrient content of fresh sweet potato varied significantly ($P \leq 0.05$) with varieties. Moisture content ranged from 55.00 to 72.44%, dry matter 27.56 to 45.00 %, total carbohydrate 23.55 to 41.09 g/100 g, total carotenoid 88.31 to 1620.07 μg/100 g and crude protein ranged from 1.39 to 2.77 g/100 g. Processing had no significant effect ($P \leq 0.05$) on ash, crude protein, total carbohydrate, calcium and zinc, while significant effect was observed in reducing sugars, iron, magnesium, phosphorous and total carotenoids. Losses in total carotenoids ranged from 37.72 to 69.13%. Traditional processing caused higher losses of more than 50% in all varieties. The main sweet potato varieties found in the market was white-fleshed (33.3%) and cream fleshed (66.7%). Market studies indicated that prices were low in the main season when the quality was good and higher in the low season when the quality was low. Problems experienced by traders were lack of capital, poor marketing, short shelf life, transportation and price fluctuations due to seasons. It is recommended that relevant stakeholders should give priority on post-harvest issues like more diversification of utilization methods, and marketing of sweet potato in the country in order to reduce losses and increase the value of the crop. In addition the breeding programme should put more emphasis on the culinary qualities as well as β-carotene content.

DECLARATION

I, Theresia John Kihinga, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is a result of my own original work and has not been submitted for a degree award in any other University.

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This dissertation is dedicated to my parents; my father late John Athanas Kihinga and my mother Petronella Kwangu Maguzu, as every step of my success depended on them.

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AIDS	Acquired Immune Deficiency Syndrome
ARI	Agricultural Research Institute
CBOs	Community Based Organizations
CD4+	Cluster of Differentiation 4 cell
CD8+	Cluster of Differentiation 8 cell
CIP	International Potato Centre
COSCA	Collaborative Study of Cassava in Africa
DNA	Deoxyribonucleic Acid
FAOSTAT	Food and Agricultural Organization Statistical Database
HIV	Human Immunodeficiency Virus
ISSR	Inter-Simple Sequence Repeat
KARI	Kenya Agricultural Research Institute
NARI	National Agricultural Research Institute
NGOs	Non Governmental Organizations
PQS	Plant Quarantine Station
RAPD	Randomly Amplified Polymorphic DNA
RNA	Ribonucleic Acid
SPVD	Sweet potato virus disease
SSR	Simple Sequence Repeats
VAD	Vitamin A deficiency
β–carotene	Beta-carotene

CHAPTER ONE

INTRODUCTION

1.1 Background information

Sweet potato (*Ipomoea batatas* Lam) is a household food security crop for many people and as such it makes a significant contribution towards their livelihoods (Walker and Crissman, 1996; Adipala *et al.*, 2000; Oduro *et al*., 2000; Anon, 2002; Tumwegamile *et al*., 2004). In the past it was grown as a food security crop for rural community and oftenly given low priority. Currently it is consumed in rural and urban areas (Rees *et al*., 1998; Oduro *et al*., 2000). In Tanzania the crop is grown in almost all regions including the Lake Victoria, Western, Southern Highlands, Eastern and Northern zones, with an average area of about 248,000 hectares. The yield data are very unreliable due to the fact that record keeping is poor and the crop is harvested on piecemeal system hence do not reflect the true production of the crop (Kapinga *et al*., 2000; Mbilinyi *et al*., 2000; Tumwegamile *et al*., 2004).

In recent years, the amount of sweet potato consumed in urban areas has increased. This is partly due to the increase in urban population and consumer positive changes towards the consumption of the crop, especially during the month of Ramadhani as well as low prices compared to other commodities. The crop is marketed and consumed in both urban and rural areas (Kapinga *et al.,* 2000; Ndunguru, 2001). Sweet potato fulfills a number of basic roles in the global food system, all of which have fundamental implications for meeting food requirements, increasing food security, and reducing poverty. Sweet potato is a cheap calorie producer, minerals, vitamin A and C (Jeong *et al*., 2000).

In Tanzania, as in other developing countries, foods of animal origin that contain vitamin A are rarely eaten on sustained basis because the majority of people cannot afford them. Thus provitamin A carotenoids from plants (green leafy vegetables, yellow/orange sweet potato roots, yellow/orange fruits and vegetables and red palm oil) constitute the main sources of vitamin A (Jeong *et al.*, 2000; Bégin and Greig, 2002; Mulokozi, 2003). Carotenoids are a group of natural pigments responsible for the yellow, orange or red colour of many foods (Niizu and Rodriguez-Amaya, 2005). Orange fleshed sweet potato contains high β-carotene content, which may potentially reduce vitamin A deficiency (Table 1). In developing countries, vitamin A deficiency (VAD) affects an estimated 75-140 million preschool-age children and accounts for 1.8% of the global burden of diseases (WHO, 2003).

Table 1: Vitamin A contribution from different foods

Crop	B-carotene per 100g of edible portion	Total vitamin A activity (RE)
Carrot (boiled)	33890-21000	648-3500
Cassava	5-35	1-6
Finger millet	25	4
Maize white	0	0
Maize yellow	360	60
Potato	2-20	Trace-3
Rice (parboiled)	0	0
Sweet potato white/cream	35	6
Sweet potato yellow/orange	300-4520	50-770
Cooking banana	60-130	10-21
Plantain	345	58

Source: FAO/WHO (1999).

Carotenoids, whether provitamin A or not have been credited with other beneficial effects on human health, enhancement of the immune response and reduction of the risk of degenerative diseases such as cancer, cardiovascular diseases, cataract, and mascular degeneration (Olson, 1999a; Niizu and Rodriguez-Amaya, 2005). The action of carotenoids against diseases has been attributed to an antioxidant property, especially, their ability to single oxygen and interact with free radicals. Also modulation of carcinogen metabolism, inhibition of cell proliferation, enhancement of cell differentiation, stimulation of cell to cell communication and filtering of blue light (Olson, 1999a,b). Vitamin A deficiency is a leading cause of early childhood death and a major risk factor for pregnant and lactating women. An impact study by Mulokozi (2003) indicated that orange-fleshed sweet potato can make a major contribution to alleviating vitamin A deficiency and indicated that the daily addition of orange-fleshed sweet potato to the diet could prevent vitamin A deficiencies in children, pregnant women and lactating mothers. Improvement of the vitamin A status of children 5-59 months old reduces mortality rate by an average of 23% in population at risk (WHO, 1999, 2003).

In Africa, mealiness or starchiness/flouriness, has been identified as an important consumer criterion. There have been several cases where cultivars with acceptable production characteristics have been rejected because they are not sufficiently mealy for African tastes. Mealiness is closely, although not completely associated with root dry matter content. When determining consumer acceptability, measure of dry matter content is a useful indicator of mealiness but it should be supported by taste tests (Rees, 2003; Tomlins *et al.*, 2005).

1.2 Justification

Until the late 1990s, although information existed on the criteria by which farmers select sweet potato varieties, very little information was documented in Tanzania on the preferences of consumers and traders. With the increase in marketing of this crop, an appreciation of the views of users become more important for breeders. In Tanzania, sweet potato tubers are primarily used for human food, and are mainly consumed freshly cooked. Information on how tubers are to be consumed is clearly vital when determining important quality criteria (Kapinga *et al.,* 2003b). Farmer selects suitable sweet potato varieties by criteria that relate both to production and post-harvest issues (Chirimi *et al*., 2000; Kapinga *et al.,* 2003a,b). However, little information is available on the preference and acceptability of the consumers and traders.

Past research on sweet potato concentrated on increasing of yield, however, experiences have shown that although research has led to many recommendations for practices to increase production of sweet potato at farm level, the rate of adoption of improved practices is low. In areas where “improved” varieties have been introduced, a low rate of uptake may indicate that the variety is in way unacceptable. These observations have led research scientists to revisit the approaches previously used, and to take more account of consumers’ preferences when developing and selecting sweet potato varieties for release (Kapinga *et al.,* 1997a).

Only limited information has been reported on consumer acceptability and sensory evaluation (Rwiza *et al.,* 2000; Anon, 2002; Tomlins *et al.,* 2003; Van Oirschot *et al.,* 2003a,b). Consumer preference and sensory testing have an important part to play in sweet potato sub-sector development (Tomlins *et al.,* 2003). Consideration of consumer preferences of low-income groups is necessary to the success of research and marketing strategies. In particular, the new varieties including orange fleshed sweet potato varieties that are being introduced for reducing vitamin A deficiency (Tomlins *et al.,* 2003). Consumer preference and acceptability tests’ measure how consumers like, prefer or accept a product, and are often used to predict sales. Sensory evaluation however aims to measure characteristics of foods by using humans (O'Mahony, 1995).

The present study has dealt with post harvest issues, looking into consumer aspects, which have not been sufficiently covered so far in the project implementation. The study was specifically elucidating the consumer culinary qualities for the various sweet potato cultivars, which were likely to facilitate acceptance and adoption. Farmers do not just value yield when selecting varieties. They may also place high value on tastes, texture as well as resistance to bad weather and pests. Therefore, learning about farmers' priorities is a key aspect of ensuring positive impacts.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to assess the consumer preference, acceptability and nutritional qualities of sweet potato varieties in Sengerema and Missungwi districts in Mwanza region and Meatu district in Shinyanga region.

1.3.2 Specific objectives

The specific objectives of the present study were;

(i) To assess the genetic yield and diversity of sweet potato varieties in Missungwi, Sengerema and Meatu districts.

(ii) To assess farmers indigenous technical knowledge on variety culinary qualities and its relationship to adoptability.

(iii) To identify farmers and consumers preferred culinary qualities for introduced high beta-carotene sweet potato varieties.

(iv) To assess nutrient content of fresh improved/local and introduced sweet potato varieties.

(v) To assess the effect of processing methods on nutritional quality of sweet potato.

(vi) To assess the marketing channels of sweet potato in urban areas.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and distribution of sweet potato

Sweet potato is the world's seventh most important staple crop, grown in over 100 countries of the world, covering an estimated total area of 9.2 million ha, with an annual global production of around 125 million tones (CIP, 2000). In Africa, the area grown to sweet potato is about 1.7 million ha and the production is about 5.5 metric tones per annum contributing to approximately 4% of the world production (FAOSTAT, 2002). Almost 95% of the total production is in developing countries. Past and current production trends suggest that sweet potato output in developing countries is increasing, for example, in Africa it is estimated that it is presently growing at about five percent per year (CIP, 2000; Scott *et al.,* 2000). It is one of the most important non-grain staple food crops providing essential minerals, vitamins and carbohydrates in the diets of majority of the people living in the tropics (Onwuene, 1978). Root and tuber crops have big complex roles to play in feeding the developing world in the coming decades. By 2020, more than two billion people in Asia, Africa, and Latin America will depend on these crops for food, feed, and income. The roots and tubers will be integrated into emerging markets through the efficient and environmentally sound production of diversified range of high-quality, competitive products for food, feed, and industry. The crops' adaptation to marginal environments, their contribution to household food security, and their great flexibility in the mixed farming systems make them an important component of a targeted strategy that seeks to improve the welfare of the rural poor and to link smallholder farmers with these emerging growing markets (Adipala *et al.*, 2000; Scott *et al.*, 2000).

Sweet potato is one among the under-exploited of the developing world's major crops (Walker and Crissman, 1996). Since the crop is considered to be 'poor persons food' can lead to the sensory and preference criteria of sweet potato to be under represented and neglected (Tomlins *et al*., 2004). The breeding initiatives for sweet potato are at a relatively early stage compared to other staple crops. Varieties grown in many regions are of low yielding, and the potential for improvements through breeding are high. While the main objectives of breeding programmes have traditionally been an increase in yield and improvement of other characteristics, the importance of post-harvest characteristics for acceptance of new varieties is being increasingly recognized (Kapinga *et al.*, 1995).

In Tanzania sweet potato are mainly grown in the Lake Zone (66%), Southern highlands (17%) and Western Zone (10%) (Kapinga *et al.*, 1995). In areas surrounding both Lake Victoria and Tanganyika, sweet potato was reported to rank second to maize among the major crops in the cassava-based intercropping systems particularly in Kagera, Mwanza, Mara, Shinyanga, Kigoma and Tabora regions (COSCA Tanzania, 1993; Kapinga *et al.*, 1995).

2.2 Genetic yield and diversity of sweet potato varieties

In East Africa the research institutes are maintaining sweet potato collections using modern conservation methods for producing healthy planting materials. The International Potato Centre (CIP) research is assessing the new methods for the conservation of sweet potato genetic resources, characterizing the cultivated collection to select a core collection in order to eradicate viruses from core accessions and evaluating them to identify sources of desired traits and this work has been done in collaboration with the research institutes in the respective country (Scott *et al.*, 2000). Participatory rural appraisals and baseline studies have been conducted in Tanzania and Kenya. Low crop yield, lack of high-yielding, early-maturing varieties, pests diseases and poor management were cited as the major constraints to production. Promotion of drought-resistant crops, kitchen-gardens and post harvest processing training were suggested as potential interventions to address rural poverty (Gichuki *et al*., 2004).

Hundreds of accessions have been morphologically characterized. Cluster analysis suggests a close relationship among the East African sweet potato. Molecular markers Inter-Simple Sequence Repeat (ISSR), Randomly Amplified Polymorphic DNA (RAPD) and Simple Sequence Repeats (SSR) are being used for diversity analysis and development of fingerprints for key varieties. A total of 58 new SSR markers from East Africa have been developed. Agronomic evaluation of the germplasm has been done in Kakamega, Kabete, Katumani and Kisii in Kenya as well as Ukiriguru and Kibaha in Tanzania. The International Centre for Potato (CIP) continued to coordinate development of varieties with high β-carotene and other agronomic traits. Research centers are multiplying clean planting materials for secondary multiplication and distribution by local Non Governmental Organizations (NGOs) and Community Based Organizations (CBOs) (Gichuki *et al*., 2004).

In early 2003, a total of 20 clones of high dry matter and high β-carotene were received in vitro from CIP-Lima. These have been multiplied in the screen house at Plant Quarantine Station (PQS) Muguga and distributed to Uganda, Tanzania and Kenya. In particular, the materials were sent to National Agricultural Research Institute (NARI) in Uganda, Kenya Agricultural Research Institute (KARI)- Kakamega and KARI Katumani in Kenya and Agricultural Research Institute (ARI) Maruku in Tanzania. Additional regions for distributions in Tanzania were Ukiriguru and Zanzibar (Kapinga *et al.,* 2004). These are currently being evaluated for adaptability in different agro-ecologies and for farmer preference culinary qualities.

A number of orange-fleshed varieties have been evaluated at different agro-ecological zones in Kenya, Tanzania and Uganda. In Tanzania, most of the clones were susceptible to sweet potato virus disease (Gichuki *et al*., 2004; Kapinga *et al.,* 2004). In Tanzania 35 accessions of sweet potato germplasm were collected in the Western and Lake Zone. The selection criteria included storage tuber yield, uniformity of tuber size, and tuber shape. Dry matter content and herbage yield were also considered. These collections were identified and distinguished by their local names, which show polymorphisms. During characterization of the collected germplasm the estimate of genetic diversity was established (Jeremiah *et al.,* 2004).

2.3 Sweet potato consumption and utilization

Sweet potato can be consumed and utilized in different forms as fresh tubers and dried chips. Fresh tubers and dried chips are used in industries in making starch, wine, alcohol and animal feeds (Ge *et al.,* 1992; Scott *et al.,* 2000). Sweet potato has been consumed as food for a long time in Tanzania. Previously, farmers grew sweet potato for their families' consumption and to earn some extra income, but nowdays commercial production is available for the urban markets. For human consumption, sweet potato in Tanzania has been boiled, roasted, fried or used in salads. Most of the high quality sweet potato are consumed as boiled snack and main dishes. In urban areas, particularly in Dar-es-Salaam, sweet potato are roasted or deep-fried for consumption as snack food (Ndunguru *et al.,* 1998). Consumption rises during peak harvesting season, mid March to mid August when over 70 percent of the annual crop is harvested and prices are low (Scott *et al.*, 2000; Kapinga and Carey, 2003).

Sweet potato provides a wide variety of benefits including food, employment and income (CIP, 2000). In recent years, sweet potato processing into starch (to make noodles) has emerged as a major use in China (Fuglie *et al.*, 1999). Sweet potato flour shows more limited commercial promise. It has been tested in East Africa as substitute for cassava in composite flour (Hagenimana *et al.*, 1998). Sweet potato traditionally has been produced in the subsistence sector in Tanzania, but they are moving into market economy. In 1993, Dar es Salaam market traded about 1942 metric tones of the crop and average sweet potato consumption in the household in monetary terms accounted for 33.31% in 1994 (Ndunguru *et al.*, 1994).

2.5 Nutritional qualities of sweet potato and its importance in human body

2.5.1 Carbohydrates

The main nutritional value of roots and tubers lies in their potential ability to provide one of the cheapest sources of dietary energy, in form of carbohydrates. Sweet potato is high in carbohydrates (Abu *et al.*, 2000) and can produce more edible energy per hectare per day than wheat and rice (Table 2). The energy content of sweet potato is about one-third of the weight of cereal grains, such as rice or wheat, since tubers have a high water content (FAO, 1990; CGIAR, 2000). As with all crops, the nutrient composition of roots and tubers varies from place to place depending on climate, the soil, the crop variety and other factors.

Table 2: Nutritional qualities of fresh sweet potato

Nutritional qualities	Sweet potato	
	White variety	Orange variety
Energy KJ	452.0	481.0
Moisture %	72.3	70.0
Protein (g)	1.0	1.0
Fat (g)	0.3	0.3
Carbohydrate (g)	25.1	27.1
Fibre (g)	0.8	0.8
Ash (g)	0.7	0.7
Calcium Ca (g)	21.0	36.0
Phosphorous P (g)	50.0	56.0
Iron Fe (g)	0.9	0.9
Potassium K (g)	210.0	304.0
Sodium Na (g)	31.0	36.0
Carrotene equivalent (μg)	36.0	1680.0

Source: Woolfe (1999)

The dry matter of tuber crop is made up mainly of carbohydrate, usually 60 to 90% and the fresh roots have 20-40/100 g dry matter. Plant carbohydrates include celluloses, gums and starches, but starches are the main source of nutritive energy as celluloses are not digested (FAO, 1990; Tanya *et al.*, 1997). The principal constituent of edible carbohydrate is starch together with some sugars, the proportion depending on the tuber crop. The physical properties of starch grain influence the digestibility and processing qualities of the tuber crops. The starch granules of some varieties of root and tubers are very small, which improves the starch digestibility. In addition to starch and sugar, root crops also contain some non-starch polysaccharides, including cellulose, pectins and hemicelluloses, as well as other associated structural proteins and lignins which are collectively referred to as dietary fibre (FAO, 1990). Sweet potato is a significant source of dietary fibre as its pectin content can be as high as 5% of the fresh weight or 20% of the dry matter at harvest. The role of dietary fibre in nutrition has aroused a lot of interest in recent years. Some epidemiological evidence suggests that increased fibre consumption may contribute to a reduction in the incidence of certain chronic diseases, including diabetes, coronary heart disease, colon cancer and various digestive disorders. The fibre appears to act as a molecular sieve, trapping carcinogens which would otherwise have been recirculated into the body; it also absorbs water thus producing soft and bulky stool (FAO, 1990; Tanya *et al.,* 1997).

2.5.2 Protein

The limiting nutritional qualities of sweet potato are the low protein content which constitutes about 1-3% of the fresh weight in sweet potato, but this includes 10–15% non-protein nitrogenous components (Abu *et al.,* 2000; Shewryl, 2003). The amino-acid content of root and tubers, unlike most cereals is not complemented by that of legumes as both are limiting in respect of the sulphur amino acids. In order to maximize their protein contribution to the diet, roots and tubers should be supplemented with a wide variety of other foods, including cereals (FAO, 1990). To some extent the protein content of tuber crops is influenced by variety, cultivation practice, climate, growing season and location. In tuber crops the quality of the protein, in terms of the balance of essential amino-acids present, may be compared to that of standard animal proteins in beef, egg or milk. Most of the tuber crops contain a reasonable amount of lysine, though less than legumes, but the sulphur amino-acids are limiting. The quality of proteins will depend on the severity of heat treatment during the processing of sweet potato products (FAO, 1990; Abu *et al.,* 2000; Shewryl, 2003).

2.5.3 Lipids

All the root and tuber crops exhibit a very low lipid content (Abu *et al.,* 2000). These are mainly structural lipids of the cell membrane which enhance cellular integrity, offer resistance to bruising and help to reduce enzymic browning (Owori and Agona, 2003; Rees, 2003) and are of limited nutritional importance. The content ranges from 0.12% in banana to about 1.7% in sweet potato. The lipid may probably contribute to the palatability of the root crops. Most of the lipid consists of equal amounts of unsaturated fatty acids, linoleic and linolenic acids and the saturated fatty acids, stearic acid and palmitic acid. In dehydrated products such as dehydrated potato or instant potato, the high percentage of unsaturated fatty acids in the lipid fraction may accelerate rancidity and auto-oxidation, thereby producing off-flavours and odour (FAO, 1990).

2.5.4 Vitamins

2.5.4.1 Sweet potato as a source of Vitamin A

The dietary sources of vitamin A are of two categories: vitamin A or retinol, also known as preformed vitamin A; and provitamin A carotenoids, which are the carotenoids that are biologically active as retinol. Of approximately many carotenoids found in nature, only three are important precursors of vitamin A in humans: β-carotene, α-carotene and β-cryptoxanthin. Of these, β-carotene is the major provitamin A component of most foods containing carotenoid and has the highest vitamin A activity (Mulokozi, 2003; Rodriquez-Amaya and Kimura, 2004). Since roots and tubers are very low in lipid they are not themselves rich in sources of fat-soluble vitamins. However, provitamin A is present as the pigment β-carotene in the leaves of root crops, some of which are edible. Most roots and tubers contain only negligible amounts of β-carotenes with exception of selected varieties of sweet potato. Deep coloured varieties are richer in carotenes than white cultivars especially the orange-fleshed roots (300 μg/100 g, fresh weight) (FAO, 1990; Woolfe, 1999; Low *et al*., 1997; Mulokozi and Svanberg, 2002; Mulokozi, 2003; Rodriguez-Amaya, 2003). This is one of the nutritional advantages of sweet potato because sufficient and regular ingestion of sweet potato leaves (Table 3), together with the tubers of high β-carotene varieties can meet the consumer's daily requirements of vitamin A, hence prevent the dreadful disease of xerophthalamia (FAO, 1990; WHO, 1992; Mulokozi, 2003; Rodriquez-Amaya and Kimura, 2004).

Table 3: Provitamin A carotenoid content in common vegetables (μg/100g of edible portion)

English name	Scientific name	Provitamin A carotenoids			Reference, origin of sample and chromatographic technique
		all-trans-β-carotene	cis-β-carotene	all-trans-α-carotene	
Amaranth	*Amaranthus*	8600±2780			Bhaskarachary *et al.* (1995) Hyderabad, India (HPLC)
Amaranth	*Amaranth sp.*	19120±30[b]		102260±98 [b]	Mosha *et al*. (1997) Tuskegee, USA (HPLC)
Cassava	*Manihot esculenta*	2820		0	Pepping *et al*. (1988) Nzega, Tanzania (HPLC)
Cassava	*Manihot utilissima*	9912±2503	1450±422	38±54	Hulshof *et al.* (1997) Indonesia (HPLC)
Sweet potato	*Ipomea batatas*	8990±82 d.w.[b]		990± 11d.w.[b]	Mosha *et al*. (1997) Tuskegee, USA (HPLC)

Source: Mulokozi (2003)

HPLC- high performance liquid chromatography; [b]d.w. = dry weight

Retinol is readily absorbed (70 to 90%) by the cells of the intestinal mucosa by facilitated diffusion (Mulokozi, 2003). FAO/WHO (1999) estimated and recommended and confirmed the traditional conversion factors of the vitamin A value of provitamin A carotenoids as 6 μg of all-*trans*-β-carotene in food to be equivalent to 1 μg all *trans*-retinol, i.e. a ratio of 6:1. However, more recently, higher ratios for conversion of β-carotene to vitamin A have been suggested due to poor bioavailability (Mulokozi, 2003).

Vitamin A is necessary for strong tissues and is required to maintain healthy immune system function and develop resistance to infection. It also protects the body from cardiovascular diseases and lowers the risk of stroke (WHO, 1992). The orange-fleshed sweet potato have large quantities of β-carotene, which is an essential component for vision, promote bone growth and tooth development, and helps maintain healthy hair, and mucous membrane. β-carotene protects the heart and cardiovascular system, boost immune functions, speeds recovery from respiratory infections such as colds and flu, and promotes wound healing (Tang *et al*., 1998). As an antioxidant, β-carotene can inhibit oxidative damage to cholesterol and protects against atherosclerotic plaque formation. Also higher vitamin C and β-carotene levels were associated with scores on free recall, recognition and vocabulary tests (Rodriquez-Amaya and Kimura, 2004). Another study reported that massive doses of β-carotene might improve the immune systems of people infected with Human immunodeficiency virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) (Tang *et al*., 1998; Kafwembe *et al*., 2001).

In Tanzania vitamin A deficiency is one of the major nutritional problems of public health significance. The problem affects mostly children between six months and six years and pregnant and lactating women (WHO, 1999; Mulokozi, 2003). A national representative survey conducted in Tanzania in 1997 revealed that more than 24% of children under six years and 69% of lactating women were vitamin A deficient (Ballart *et al*., 1998; WHO, 1999). Young children are at high risk of developing vitamin A deficiency due to their increased need during growth and their vulnerability to infections. Women of child bearing age are at risk because of their increased need for the vitamin, both during pregnancy and, much more, during lactation (Mulokozi, 2003). Vitamin A deficiency comes from two primary factors: inadequate intake of preformed vitamin A and vitamin A precursors (provitamin A carotenoids) and diseases (WHO, 1999; Rodriguez-Amaya, 2003).

Vitamin A concentration is lowered in HIV infection. The depletion of vitamin A seems to increase with progression of the infection leading to AIDS disease. Whether regular supplementation of vitamin A to the HIV infected individual can lead to a delayed progression to AIDS needs to be explored (Beach *et al*., 1992; Baum and Shor-Posner, 1995; Baum *et al*., 1997; Kafwembe *et al*., 2001). Antioxidants are important for people living with HIV and AIDS. HIV infection leads to higher levels of free radicals, which can increase the activity of the virus. Higher levels of antioxidants can slow down the virus and help repair some of the damaged cells (Romeyn, 2006). HIV-positive children also develop vitamin A deficiencies prior to AIDS diagnosis (Karter *et al*., 1995; Periquet *et al*., 1995). Dietary and supplemental intake of 9,000-20,000 IU appears to delay progression to AIDS, reducing the relative risk of progression by approximately 50 percent (Tang *et al*., 1998). The use of multivitamins was associated with slightly higher Cluster of Differentiation 4 (CD4+) and Cluster of Differentiation 8 (CD8+) cell counts and no overall changes in HIV levels in the blood.

Vitamin A is potentially teratogenic, high-dose vitamin A supplements can be given safely to women of child bearing age only within the first 6 weeks postpartum, when the likelihood of becoming pregnant is very low. The provision of small daily doses of vitamin A from food may be an alternative strategy for improving vitamin A status in populations at risk of deficiency (Tang *et al*., 1998; WHO, 1999; Mulokozi and Svanberg, 2002; Mulokozi, 2003). Appropriate foods provide safe amounts of vitamin A and can be given to all population groups at risk of deficiency, including women of childbearing age. Animal source foods, such as dairy foods, eggs, and liver, contain preformed retinol, which is readily absorbed in the human intestine; however, these foods are generally not affordable by population at risk of deficiency. In less-industrialized countries, 65–85% of vitamin A in the diet is estimated to be supplied by provitamin A carotenoids in vegetables and fruits (Haskell *et al*., 2004).

2.5.5 Minerals

Potassium is the major mineral in most root crops while sodium tends to be low (Table 2). This makes some root crops particularly valuable in the diet of patients with high blood pressure, who have to restrict their sodium intake. An important, often unrecognized, mineral contribution that potato can make is in its appreciable amount of iodine it contains. This could be significant in goitrous areas where iodine intake is low or marginal like in the southern highlands of Tanzania specifically in Makete district. Potassium in sweet potato help to maintain fluid and electrolyte balance in the body cells, as well as normal nerve and heart function and blood pressure (FAO, 1990).

Zinc is a component of more than 200 mammalian metallo-enzymes (McClain *et al.*, 1998). In humans, zinc deficiency can manifest as T-cell lymphopenia, decreased lymphocyte response to mitogens, depressed thymic hormone activity, a specific CD4+ T-cell population depression, decreased natural killer cell activity, (Prasad, 1993) and depressed serum concentrations of albumin, prealbumin, and transferrin. Zinc has a modulating role in blood sugar regulation, thyroid and gonadal function, adrenal hormone and prolactin production, and calcium/phosphorus metabolism, all of which are disturbed in a state of zinc deficiency (Neve, 1992). Zinc salts have been shown to have anti-viral activity, either directly or through immune-modulation, against more than 40 viruses including the HIV (Sergio, 1998).

In HIV infection, zinc plays specific roles as an anti-oxidant, immune-modulator (Tanaka *et al*., 1990) and a possible direct anti-viral agent (Favier *et al*., 1994; Sprietsma, 1999). Zinc, in vitro, has been found to inhibit cell death mediated by tumor necrosis factor, a cytokine linked to cellular apoptosis and wasting syndrome in HIV. The HIV protease enzyme, currently the topic of much research and one of the central focuses of pharmaceutical HIV suppression, is necessary to potentiate the production of new HIV-1 viruses (McQuade *et al*., 1990). The HIV virus binds to zinc ions in T-cells in order to produce pro-viral peptides which form the basis of new infectious viral particles. The HIV-1 protease enzyme then cuts the viral chains to form new infectious viral particles, which are released into the circulation and infect new immune cells. As with other proteases, including collagenase, angiotensin-converting enzyme, carboxypeptidase A, and neutral endopeptidases, zinc has both an enhancing and inhibiting activity, depending on the concentration of zinc in the surrounding tissues (Larsen and Auld, 1991). Multiple studies have shown if sufficient zinc ions are bound to the protease it will remain inactive (Zhang *et al*., 1991).

In HIV replication, viral Ribonucleic Acid (RNA) is transformed into viral Deoxyribonucleic Acid (DNA) via the enzyme reverse transcriptase. Then the enzyme integrase allows for the integration of viral DNA with host DNA. Zinc binds to the integrase enzyme via "zinc finger protein" structures and allows for optimal activity of the integrase enzyme. Inhibitors of zinc finger proteins are currently the subjects of research in HIV pharmacology (South *et al*., 1990; Rice *et al*., 1995).

2.6 Effect of processing on nutritional qualities

Like many other foods, roots and tubers are rarely eaten raw. They normally undergo some form of processing and cooking before consumption. Processing modifies the nutritive value of food. The methods of processing and cooking vary from simple boiling to elaborate fermentation, drying, slicing and field sun drying of roots as practiced in some developed countries to the large scale, multi-stage production of frozen, canned or flaked products (FAO, 1990; Woolfe, 1999). The basic purpose of these methods is to make roots and tubers and their products more palatable and digestible and to make them safe for human consumption. Processing also extends the storage life of roots and tubers, which are often highly perishable in their fresh condition. Processing also provides a variety of products, which are more convenient to cook, prepare and consume than original raw materials (FAO, 1990). The first step in processing any root crop is usually peeling. This may remove nutrients if it is not done carefully. It is sometimes advisable to peel after boiling, and to use the cooking water in order to conserve water soluble nutrients.

Processing is a prerequisite for consumption of food. Processing must first turn the food into a suitable form and give it good sensory properties (Özdemir *et al.,* 2001). Processing is also important in terms of both the content and bioavailability of nutrients and non-nutrients. Whereas processing may increase the bioavailability of bioactive compounds in foods, a reduction in processing increases their levels, (Slavin *et al*., 2000; Özdemir *et al.,* 2001). Processing may also be used to modify the bioavailability of carbohydrates, such as delaying the glycaemic responses or enhancing the solubility and fermentability of dietary fibre components (Beer *et al*., 1997; Nestares *et al*., 1999; Poutanen, 2001). Thermal processing has a huge impact on the textural attribute of the final food product, and texture is a major factor contributing to the overall quality of fruits and vegetables.

Prochaska, *et al*. (2000) found that there was a significant decrease in thermodynamic energy content in fruits, vegetables, and meat products upon processing that is independent of water content. From these findings it was reported that there were no significant change in energy content observed in cereals, sugars, grains, fats and oils, and nuts. The vitamin content of most foods was dramatically decreased by canning while smaller effects were observed upon blanching and freezing. Some forms of processing or over-processing may also adversely affect the nutritional qualities of the food (FAO, 1990). Some food processing techniques destroy enzymes and proteins that are present in all raw foods, which are responsible for the chemical and physical changes that naturally occur after harvesting. Food processing techniques also help eliminate the moisture or temperature conditions that are favorable for the growth of microorganisms.

Macronutrients, such as protein, carbohydrates, and fat, are relatively stable to radiation doses of up to 10 kilo Grays. Micronutrients, especially vitamins, may be sensitive to any food processing method, including irradiation (e.g. vitamin E levels can be reduced by 25% after irradiation and vitamin C by 5-10%). Processing and cooking conditions cause variable losses of vitamins. Losses vary widely according to cooking method and type of food. Degradation of vitamins depends on specific conditions during the culinary process, e.g., temperature, presence of oxygen, light, moisture, pH, and, of course, duration of heat treatment. The most labile vitamins during culinary processes are retinol (vegetable boiling, 33% retention) (Lešková *et al*., 2006). Under optimal conditions, vitamin losses in foods irradiated at doses up to 1 kilo Gray are considered to be insignificant. At higher doses the change in nutritional value caused by irradiation depends on a number of factors. They include the specific vitamin, the radiation dose to which the food has been exposed, the type of food, the packaging, and the processing conditions, such as temperature during irradiation and storage time. Most of these factors are also true for other food processing and preservation technologies (Nestrares *et al*., 1999; Slavin *et al*., 2000).

2.6.1 Carbohydrates

The nutritional quality of the carbohydrates and the effects of processing on that quality then becomes a concern, because both the content and the nutritional quality of food carbohydrates can be altered by processing in a number of ways. During wet heat treatment, as in blanching, boiling and canning of vegetables and fruits, there is a considerable loss of low molecular weight carbohydrates (i.e. mono- and disaccharides) as well as micronutrients, into the processing water. For example, in the blanching of carrots and swedes (rutabagas) there was a loss of 25% and 30%, respectively of these carbohydrates. With subsequent boiling another 20% was lost. In peas, green beans and Brussels sprouts the loss was less pronounced - about 12% following blanching and another 7-13% at boiling.

Raw potato starch is undigestible but digestibility increases with cooking. FAO (1990) reported that when the whole tuber is baked, as with sweet potato, virtually all the starch is hydrolysed to dextrin and sugars, mainly maltose. The concentration of reducing sugars is low, probably because of the Maillard reaction with lysine. Baking may decrease the amount of pectin in roots and the degree of esterification, thereby decreasing their fibre content.

2.6.2 Protein

Proteins are denatured by heat. In this form they are more easily digested by proteolytic enzymes. The major change in amino-acids that occurs on cooking is the Maillard reaction that makes lysine unavailable, thereby reducing the nutritive value of the roots. Loss of free amino-acids also takes place through leaching (Meredith and Dull, 1997). Herrera (1979) reported that boiling does not appreciably reduce the total nitrogen content of potato except for some loss owing to peeling. Results reported that there was 0.8 percent loss in the boiled, unpeeled tubers compared to loss of 6.5 percent in the peeled tuber, which may probably due to leaching. Nitrogen loss on roasting is also very small, apart from loss of lysine, with losses being greater in frying than baking (FAO, 1990). Furthermore, the excessive cooking that is often applied to soften the grain will decrease protein quality. The loss in protein energy ratio (PER) and weight is the result of lower protein availability as well as a loss of Iysine, which becomes inactivated through the well-known Maillard reaction shown by various investigators. Non-enzymatic browning reactions (Maillard reactions) occur between reducing sugars and amino groups in foods at processing and in storage. These reactions are temperature dependent and most extensive at intermediate water activities. They are important nutritionally as they may diminish the bioavailability of amino acids, especially lysine, thus diminishing the protein nutritional value.

Roasting is an interesting processing technique because it has the capacity to develop attractive flavours in foods so treated. It also induces important functional properties, attributes that should be compatible with nutritional value. Chemical analysis for available lysine showed the expected decrease in this amino acid, which explains the lower protein quality as roasting time increased (Nestrares *et al.,* 1999; Prochaska *et al.,* 2000).

In some traditional processing an appreciable amount of protein could be lost. For example in the preparation of "*chuno blanco*" (a process of freezing and dehhyrating potato) the protein content of the potato is reduced from 2.1% to 1.9% (FAO, 1990). Some of the loss is because of removal in the exudates, but most takes place during the soaking in water, about 50%.

2.6.3 Vitamins

Nutrients can be lost during cooking in two ways. First, by degradation, which can occur by destruction or by other chemical changes such as oxidation, and secondly by leaching into cooking medium. Vitamins are susceptible to both processes, the percentage of loss will depend partly on the cooking temperature and on whether the food is prepared by boiling, baking or roasting. Vitamin C is the most thermal labile vitamin and is also easily leached into cooking water. Air drying of thin slices of sweet potato leads to only slightly losses of vitamin C. Boiling may result in a 20 to 30 percent loss of vitamin C from unpeeled roots and tubers. If peeled before boiling the loss may be much higher, up to 40 percent (FAO, 1990). Losses are due to leaching into cooking water and the rest to destruction by heat.

Carotenoids are naturally protected in plant tissues, cutting, shredding, chipping and pulping of fruits and vegetables increase exposure to oxygen and bring together carotenoids and enzymes that catalyze oxidation. Alteration or loss of carotenoids during processing and storage of foods occurs through physical removal (e.g. peeling), geometric isomerization, and enzymatic or non-enzymatic oxidation (Rodriiquez-Amaya, 1999, 2002).

The major cause of carotenoids destruction during food processing and storage is enzymatic and non-enzymatic oxidation. Isomerization of *trans*-carotenoids to *cis*-isomers, particularly during heat treatment, alters their biological activity and discolors the food, but not to the same extent as oxidation. In many foods, enzymatic degradation of carotenoids may be a more serious problem than thermal decomposition. In home preparation, losses of carotenoids generally increase in the following order: micro waving, steaming, boiling and sautéing. Deep-frying, prolonged cooking, combination of several preparation and cooking methods, baking and pickling all result in substantial losses of carotenoids (Rodriiquez-Amaya, 1999, 2002; Rodriiquez-Amaya and Kimura, 2004).

Whatever the processing method, carotenoid retention decreases with longer processing time, higher processing temperature, and cutting or pureeing of the food. Blanching may provoke some losses of carotenoids, but the inactivation of oxidative enzymes that occurs in this type of heat treatment prevents further and greater losses during holding before thermal processing, slow processing and storage. Freezing (especially quick-freezing) and frozen storage generally preserve carotenoids, but slow thawing can be detrimental, particularly when the product has not properly blanched. Peeling and juicing result in substantial losses of carotenoids, often surpassing those of heat treatment. Traditional sun-drying, although the cheapest and most accessible means of food preservation in poor regions, causes considerable carotenoid destruction. Drying in solar dryer, even of simple and inexpensive design, can appreciably reduce losses. Protecting the food from direct sunlight also has a positive effect (Rodriiquez-Amaya, 1999, 2002; Rodriiquez-Amaya and Kimura, 2004).

2.6.4 Minerals

Minerals are usually lost through being leached into syrup during canning, most especially with potassium, calcium and magnesium (Attia *et al.,* 1994), though the minerals can be completely retained if the tubers are vacuum-packed (Elkins, 1979). The leaching loss on boiling potatoes could be minimized if the skin were retained, as reported by True *et al*. (1997) who found over 90% retention when potato was boiled for 14 minutes with skin on.

There are no leaching losses in the case of copper and zinc and so they present no problem. If vegetables are cooked in water containing salt and the cooking water discarded. This results in loss of minerals like sodium, potassium and calcium.

2.7 Farmers selection criteria for sweet potato

2.7.1 High tuber yield

The high yield tuber mainly depends on the number of storage tubers per plant. According to Kapinga *et al*. (1997a, 2003a); Adipala *et al.* (2000); Chirimi *et al*. (2000) high tuber yielding was the most frequent criterion mentioned by farmers and it was the most important attribute in the sweet potato variety selection. Yield is measured in terms of tuber size, tuber weight and number of tubers per plant for example, variety SPN/O, Mayai and Sinia were mentioned by farmers as high yielding varieties with large tuber size (Table 4). Also Odendo *et al.* (2002) reported the same, as high yield and early maturity are the top criteria for farmers in selection for maize varieties.

2.7.2 Early maturity (early bulking)

Times of maturity and tuber yields were the most important selection criteria used by farmers. Most farmers prefer early maturing varieties, which provide fast food during shortage periods in the early months of the year and release land for other crops next season, varieties Mwezigumo and Kinahaha were mentioned as very early maturing varieties (Table 4). Early maturing (early bulking) is the ability of the variety to give a reasonable number of harvestable storage roots from 3 months after planting. The early maturing varieties were mostly preferred in areas where sweet potato is a commercial crop (Kapinga *et al.,* 1995). In addition, early maturing varieties can be particularly important when there is an extended dry spell and sweet potato is a food security crop when other crops fail (Kapinga *et al.*, 1997a, 2003a; Adipala *et al.*, 2000; Chirimi *et al*., 2000). Sweet potato is mainly for home consumption, hence, taste and gastronomic appeal, early maturity and adaptability are more important than high yield. Farmers prefer varieties that are early-maturing and adapted to their marginal conditions, with fine flesh texture, aromatic and white flesh. In the past, farmers had varieties that had good yield but did not taste good.

2.7.3 Disease and pest tolerance

Farmers prefer varieties that tolerate diseases and also that are tolerant/resistance to sweet potato pests. Tolerance to insects (primarily the sweet potato weevil and *Cylas spp*) (Adipala *et al.*, 2000). Generally, as well as possessing good yields, the varieties offer a considerable range of options for a number of important traits like age to maturity. There are several early maturing varieties, which could be planted to escape infestation from pest and disease or dry periods.

2.7.4 Low fibre content

The texture of flesh tubers in terms of fibre content is an important criterion used by farmers in selecting sweet potato varieties. Sweet potato tubers with no or low fibre content are preferred. Kapinga *et al.* (1997a, 2003a); Chirimi *et al*. (2000) found that the majority of sweet potato varieties currently grown by farmers have no fibre or low fibre such varieties like SPN/O, Sinia and Kinahaha (Table 4). Farmers want their products to have good eating quality and be sold at high price

2.7.5 Tuber sweetness

Tuber sweetness is a very subjective quality, being an indication of good taste, rather than sweetness (sugar content) *per se*. In addition, a watery or fibrous tuber is never considered sweet, so that it is difficult to distinguish completely between taste and texture (Kapinga *et al.,* 1997a, 2003b; Chirimi *et al*., 2000). Adipala *et al.* (2000) reported that farmers prefer the sweet potato varieties with good eating quality such as flesh texture and taste after boiling, which vary from soft to firm. SPN/O, Karoti and Kinahaha were moderate sweet while sinia was very sweet (Table 4). Gastronomic characteristics specifically fine texture and sweet flesh are also preferred by farmers.

2.7.6 Tuber firmness/hardness

Firmness is an indicator of high dry matter content, which is a preferred attribute in sweet potato tubers (Hagenimana *et al.*, 1999; Otoo *et al.*, 2000; Kapinga *et al*., 1997a,b, 2003a,b; Tomlins *et al.*, 2003; Rees, 2003). Textural characteristics can be studied by: mechanical, sensory, histological, chemical and analytical methods (Muzanila, 1998). Sensory methods involve identification and quantification of textural characteristics of food sample by a human assessor. The five senses or receptors that are used in the perception of food are sight, touch, hearing, smell and taste (Muzanila, 1998). The texture of the food is one of the most important quality attributes that determines its acceptability, especially those foods which are derived from root and tuber crops (Muzanila, 1998). Textural properties such as 'moistness' or 'mealiness' are complex organoleptic sensations (Giese, 1995; Muzanila, 1998). Therefore, farmers can use their senses or receptors, which are sight, touch and taste in the perception of the texture of the food variety SPN/O and Sinia as mentioned as very firm (Table 4).

Table 4: Sweet potato varieties and their characteristics in different producing Zones

Variety	Zone	Characteristics
SPN/O Other names:	Eastern, Southern	White skin/Yellow flesh, High yielding, Floury, Early maturing, Large root size, Moderate sweet,

Suguti (L) Songea (SH) Simama (L, E) Tulwawima (L, SH)	Highlands, Lake Zone	Very firm, Susceptible to weevil, No fibre
Mayai	Western, Eastern	White skinned, Orange flesh, High yielding, Late maturing
Mwezigumo	Western, Lake	Very early maturing, Low yielding, Small roots, White skin/white flesh
Karoti	Eastern, Southern	Early maturing, Spreading Red skin/yellow flesh, Medium fibre content, Moderate sweet, Medium root size, Firm and Moderate drought tolerant
Sinia (SH, L) Other names: Kasinia (L)	Southern Highlands, Lake	Early maturing, Large root size, Red skin/White flesh, Very sweet, Very firm, No fibre
Kinahaha	Western, Southern	Very early maturing, Medium root size, White skin and flesh, Medium sweet, Moderate firm, No fibre

Source: Kapinga *et al.* (1995)

L= Lake, SH= Southern Highlands, E= Eastern Zones

2.8 Importance of consumer preference

Traditionally, sweet potato cultivars consumed in East Africa had a white and cream coloured flesh. Orange coloured flesh cultivars have been introduced due to their high β-carotene. The success of any newly introduced cultivars will depend not only on production characteristics, but also on its acceptability in terms of both sensory and utilization characteristics. Van Oirschot *et al*. (2003) reported that sensory differences between sweet potato cultivars are mainly determined by textural components. Consumer acceptability and sensory evaluation in East Africa has been investigated for the white-fleshed cultivars of sweet potato Van Oirschot *et al*. (2003); Tomlins *et al*. (2004) reported that the appropriate consumer preference and sensory evaluation approaches can have an impact role to play in sweet potato research, production and marketing for low-income consumers in developing countries; and for orange-fleshed sweet potato. Hagenimana *et al*. (1998, 1999); Tomlins *et al*. (2006) found that increased consumption of orange fleshed sweet potato is thought to benefit children and mother in locations where it is commonly grown and consumed. This study is looking for the newly introduced cultivars which have not been investigated in the previous studies in order to support the breeding program.

2.9 Marketing of sweet potato

Marketing of any fresh product constitutes the final stage of the journey of the food from producer to consumer (Toquero, 1992; Ndunguru, 2001). Market is defined as a place where traders and consumers meet to exchange goods and services. It is a place where consumers can express their preferences, subject to the constraints of their income by paying certain price for particular qualities and quantities of goods. In Tanzania, the marketing channels for sweet potato tubers do not involve stages such as grading and storage (Ndunguru, 2001). One channel is for tubers sold for fresh cooking at home. The other channel is for tubers sold by street vendors who sell a cooked product. Middlemen are normally responsible for bringing the products to the urban markets. In this channel, retailers who are mainly market vendors sell the crop directly to consumers (Toquero, 1992; Kapinga *et al.*, 1995, 1997b; Ndunguru, 2001).

In Tanzania sweet potato is now increasingly being marketed, and production has thus increased by 25 to 30%. Production is centered in the Lake Zone, Southern Highlands and Eastern Zone. The commercial supply chain can involve transporting roots in sacks weighing up to 250 kg several hundred kilometers, by different methods of transport (cart, bicycle, truck, canoe and boat). The marketing system, however, is poorly developed with significant losses in quality; tubers attract a significant discount (10 to 30%) when shriveled, cut or broken and even more if the tubers are rotten or damaged by insect (Tomlins *et al*., 2000b; Rees *et al*., 2001; Anon, 2002).

In general, the marketing of these crops is poorly organized, and they are not receiving much attention from research and development bodies (Mbilinyi *et al*., 2000; Scott *et al.*, 2000). Sweet potato is rarely the focus of policy initiatives aimed at spurring agricultural development. More often than not, the crop attracts little interest from policymakers (Scott *et al.,* 2000). The marketing systems for sweet potato tubers, however, are poorly developed with high levels of tuber damage (Mtunda *et al*., 2001; Ndunguru, 2001; Rees *et al*., 2001). A survey done in Mwanza in the Lake Zone, Tanzania noted a significant reduction in the quality of sweet potato tubers sold in the markets, which had implications for market value. Sweet potato tubers quality are highest during the main season when prices are relatively low and quantities high. Quality is lowest in September and October when sweet potato have overstayed their optimum harvesting time and become watery. Therefore, the relationship between product value and quality does not appear to be constant throughout the year (Thomson *et al*., 1997; Ndunguru *et al*., 1998). Before sweet potato tubers are transported to the market, they are harvested and stuffed in sacks for transportation. Harvesting is normally done by farm implements which cause injuries to the tubers. These injuries also affect quality of sweet potato tubers and hence their market values (Kapinga *et al.,* 1997a, b; Ndunguru, 2001; Rees *et al*., 2001). Losses in market value of sweet potato in Tanzania can be up to 13%, which result from broken and cuts, that may occur during packaging and harvesting, weevil attack leads to the greatest reduction in value, with average discount of around 30-40% as reported in study done by Tomlins *et al*. (2000b).

In most urban markets in Tanzania sweet potato tubers are purchased in sacks or bamboo baskets and then sold to consumers in heaps. Heaps are sold at a fixed price, which differ in total weight depending on factors such as size (small, medium, large) and quality of the tubers (Kapinga *et al.,* 1997b; Tomlins *et al*., 2006). A survey done by Ndunguru *et al*.

(1998) in Dar-es-Salaam and Lake Zone showed that the quality of sweet potato is variable and does not relate to market price. The survey indicated that farmers and traders do not perceive quality to have an influence on price of sweet potato tubers. However, consumer would want to buy products that will give them maximum satisfaction in terms of both quality and quantity (Ndunguru, 2001).

2.9.1 The importance of market information

Market information on agricultural products is important in order to gain an understanding about market situation on a particular product (Kapinga *et al.*, 1997b; Ndunguru, 2001; Rees *et al.*, 2001). Farmers need market information in order to know prices and the market requirements for their products in terms of quality and quantity. They also want to have information on the existing infrastructures such as transport and storage facilities for smooth handling of the produce. Similar to farmers, traders and manufactures also need information on the products in terms of availability, quality and prices in order to make decisions on the suitability of marketing the crops (Kapinga *et al.*, 1997a,b; Ndunguru, 2001).

Sound market information can enable producers to make effective production decisions, take advantage of new market opportunities, improve spatial distribution, etc. (Marter, 2005). The importance of such information relates in part to its value in reducing (but not removing) risk e.g., to avoid selling at a time of market over supply. It can also inform alternative locations of sales (or purchases) further along market chains (although these may be offset by costs, including labour/marketing time, and additional risks). Negotiation with traders can be facilitated e.g., at farm-gate level through knowledge of prices in destination markets. Information also enables more effective decisions on storage (where perishability is not an over-riding issues) e.g., in respect to relative costs and risks against seasonal price variation. It can also inform similar decisions with respect to off-season production (Marter, 2005).

2.9.2 Marketing problems

Poor market infrastructure

Farmers are finding it increasingly difficult to compete in national and regional markets due to their poor access to such infrastructure as roads, storage facilities, power and transportation (Best *et al*., 2005). Many farmers have to travel long distances on foot to markets; there is poor market accessibility. Most farmers sell their sweet potatoes to middlemen and local markets. Transportation of sweet potato tubers to the markets is a major problem. Due to the lack of care harvesting and loading, and lack of good packaging methods, losses in transit over bumpy roads and in subsequent handling are high. This means the shelf life of roots in the market is short, a week or ten days at most (Kapinga *et al.*, 1995; Mtunda *et al*., 2001; Rees *et al*., 2001).

Bulkiness/perishability

Sweet potato tubers are bulky in nature and perishable therefore need to reach the final consumers within a week of harvest (Kapinga *et al*., 1997a). Their weight, low value-to-volume ratio in fresh form and propensity to incur shrinkage as well as pest and disease damage after harvest discourages transport and drives up marketing costs (Scott *et al*., 2000; Mtunda *et al*., 2001; Rees *et al*., 2001).

Prices in urban markets

The prices in urban markets increases dramatically during the month of Ramadhan. The prices of sweet potato in the retail markets of the city do not seem to follow the laws of supply and demand, as one would expect. During the month of Ramadhan, both the supply and prices of sweet potato increase dramatically. However, during the peak seasons of sweet potato, which is from April to August the supply is very high, quality is good but prices are low, unless it has coincided with Ramadhan where the prices will be high. During the rest of the year there is often scarcity of sweet potato in the market, but the prices remain constant (Kapinga *et al.*, 1995; Ndunguru, 2001). The urban marketing system is informal, and does not involve standardized grading, sorting for more than a few days, or any system for diffusion of information on supply and price (Kapinga *et al.*, 1995; Ndunguru, 2001). Most farmers receive no information about changes in the value of their products, whereas traders have reasonably rapid access to such trade-based information. This skew in access to basic market information has been cited as a major impediment to empowering farmers to negotiate for better prices and thus to build market confidence and trade links (Best *et al*., 2005).

Policy and institutional constraints

Sweet potato is rarely the focus of policy initiatives aimed at spurring agricultural development. More often than not, the crop attracts little interest from policymakers (Scott *et al*., 2000). According to the Tanzania Agricultural Policy, 1997 the sweet potato has been grouped in other sub-staple crop, which includes irish potatoes, bananas and plantains. Whereby the emphasis is given to the research to concentrate on producing better yielding varieties so as to increase production of products preferred by the market. Also to encourage and support the establishment of market centers for the crops and in collaboration with private sector establish market conduct for the commodity group.

Farmers who cultivate sweet potato are typically among the poorest farmers /households in the region or country (Mtunda *et al*, 2001; Rees *et al*., 2001). They rarely have collective representation before policy-making bodies, and their lack of commercial status, the crop is not imported or exported to any appreciable extent.

In nearly all sweet potato producing countries, the various participants in the sector- growers, processors, traders, and researchers operate in isolation. No forum brings these various interest groups together, develops a common strategy, and organizes to push for its implementation with policymakers, bankers, industrial and export lobbies, among others (Scott *et al*., 2000). Farmers in many countries are poorly organized. This lack of scale means that trade suffers from poor quality, low volume, and weak link and is often uncompetitive because of the consequent high transaction costs.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

3.1.1 Location and description of the study area

The research was conducted in Sengerema and Missungwi districts in Mwanza region and Meatu district in Shinyanga region. One village from each district was selected for this study, Igurumuki from Sengerema, Nyanhomango from Missungwi and Mwanyahina from Meatu (Table 5). Meatu district is one of the eight districts of the Shinyanga region, with high production of sweet potato, utilization and processing. It is bordered to the north by the Bariadi district, to the west by the Maswa and Kishapu districts, to the east by the Arusha region, to the southeast by the Manyara region and to the south by the Singida region. Missungwi is bordered to the west by Mwanza city, Kwimba district to the East, Magu district to the North, Shinyanga region to the South, and to the Southwest by the Geita and Sengerema districts. This area produce, utilize, process and market sweet potato in large amount compared to other districts in the region. Sengerema district is one of the eight districts in Mwanza region, with high sweet potato production and it has access to market. It is bordered to the north and east by Lake Victoria, to the south by the Geita district and to the southeast by the Missungwi district.

The districts were chosen purposely due to their potential and diversity of sweet potato production, utilization and genetic variation of varieties. Also they are study site for the project titled, “Assessment of genetic diversity, farmer participatory breeding and sustainable conservation of East African sweet potato germplasm”, which is the sponsor of this study.

Table 5: Number of consumers interviewed from each district

District	Village	Number of consumers		Total
		Male	Female	
Meatu	Mwanyahina	65	61	126
Sengerema	Igurumuki	51	73	124
Missungwi	Nyanhomango	55	75	130
Total		171	209	380

3.2 The population

There were 248 949 people in Meatu district, 501 915 in Sengerema and 257 155 in Missungwi district with an average household size of 6.3, 5.9 and 5.8 respectively (Tanzania Census, 2002). The dominant ethnic groups in the districts are Sukuma and Zinza, and both have similar language but retain their original tribal identity, traditions, beliefs and rites.

3.2.1 Study population

The study population included a representative sample of households that are sweet potato growers, consumers and traders in Meatu, Sengerema and Missungwi districts.

3.3 Sampling procedure and sample size

3.3.1 Sweet potato consumers

A sampling plan was drawn out such that the number of consumers (n) selected in each village, were such that n/N represented a figure greater/equal to 5% of the village population. Boyd *et al*. (1981) stated that this is the minimum sample size to set a representative sample. Where n is the number of selected consumers and N is the total population in the village. For the purpose of this study a sample size of 126, 124 and 130 (total 380) consumers were randomly selected and interviewed from Mwanyahina (Meatu district with a total population of 2249), Igurumuki (Sengerema district total population of 2113) and Nyanhomango (Missungwi district total population of 2410) respectively based on the above formular. Households were selected based on the advice of local leaders and extension workers. Only households known to grow and consume sweet potato were interviewed.

3.3.2 Sweet potato traders

Market survey was done in Kirumba and central market in Mwanza city where sweet potato are marketed. The two main sweet potato markets were selected for this study. Clusters of traders of sweet potato were defined using data from the market master of Mwanza city. Clusters comprised of men and women of different age groups and ethnicity. Using sampling techniques of counting (Scott *et al*., 2000), eight traders were sampled from the clusters for interview. Sample were systematically selected, that is every second named trader from a list given by the market master was interviewed using a structured questionnaire to get the information on sweet potato marketing, selling prices, seasonality, varieties supplied in the markets and problems facing the marketing of sweet potato.

3.4 Data collection

Data collection involved primary and secondary data. The primary data included the field surveys on consumer preferences and marketing information while the laboratory data were nutrient composition of fresh and processed sweet potato. The secondary data included information on genetic yield and diversity of sweet potato, varieties grown in the area and farmers' attributes in selecting sweet potato varieties.

3.4.1 Primary data collection

Data were collected from the field and laboratory. Fieldwork involved a survey, which used a Participatory Rapid Appraisal (PRA) and interviews using structured questionnaires. Laboratory data included the nutrient composition of raw/fresh and processed sweet potato samples collected from the three districts during the survey.

3.4.1.1 Field survey

A survey in the 3 districts was carried out by interviewing sweet potato consumers using a pre-tested questionnaire. The questionnaire was pre-tested by interviewing sweet potato producers and consumers near the Ukiriguru Agriculture Centre. The questionnaires were designed to capture the consumers' information, on preference, consumption pattern, utilization and culinary qualities (Appendix 1).

Consumers interviewed in this study were 126 from Mwanyahina (Meatu district), 124 from Igurumuki (Sengerema district) and 130 from Nyanhomango (Missungwi district). In total 360 consumers were interviewed from the 3 districts.

3.4.1.2 Laboratory work

Nutrient composition of the 6 fresh sweet potato varieties from the 3 districts was determined for carbohydrate, moisture, dry matter, crude protein, crude fat, ash, reducing sugars, minerals and total carotenoid. The analyses were carried out in triplicate.

3.4.1.2.1 Sample collection

A total of 6 varieties of sweet potato (4 varieties from each district) were used in this study (Table 6). Samples of sweet potato varieties were collected for laboratory analysis carried out in the Department of Food Science laboratory at the Sokoine University of Agriculture. The fresh samples were stored at room temperature (22 ± 1˚C) before processing. Processed samples were stored in the freezer at –21 ± 0.5˚C until analysis.

Table 6: Varieties of sweet potato evaluated in each district

District	Variety	Flesh colour
Meatu	Carrot Dar	Orange
	Mafuta	Orange
	Sekondari	Cream
	Polista	White
Sengerema	Japon	Orange
	Mafuta	Orange
	Sekondari	Cream
	Polista	White
Missungwi	Carrot Dar	Orange
	Japon	Orange
	Zapallo	Orange
	Sekondari	Cream

3.4.1.2.2 Sample preparation

Raw sweet potato were peeled using a kitchen knife, cut into cubes of about 2.5 cm, washed by using distilled water and then ground using motor and pestle. The samples were then subjected to chemical analysis immediately after preparation especially for total carotenoid analysis. This minimized the chance of enzymatic oxidation.

Fresh sweet potato samples were then subjected to different processing methods which correspond to traditional processing as well as improved processing methods as follows:

1. Traditional (sun drying)

Fresh sweet potato were peeled, sliced using kitchen knife to slices of about 0.5 cm thickness, then sun dried for three days. Dried samples were packed in polythene bags and kept at room temperature (22 ± 1˚C) for storage until analysis.

2. Improved processing methods

- Moist heat (boiling), fresh sweet potato samples were peeled, washed with distilled water, sliced to pieces of 3-5 cm then boiled for about 30-45 minutes. The samples were left to cool and packed in air-tight containers then stored in chest freezer (-21. ± 0.5˚C) before analysis.
- Dry heat (oven), fresh sweet potatoes were placed in a pre heated oven at 60°C and baked for about 45- 60 minutes. Samples were left to cool and packed in airtight containers then stored in the chest freezer (-21. ± 0.5˚C) before analysis.

3.5 Laboratory analysis

Proximate analysis of both fresh and processed samples were determined as follows:

3.5.1 Determination of moisture content

The moisture content of fresh and processed sweet potato samples was determined in triplicate samples following the AOAC method No. 925.10 (AOAC, 1995). The sweet potato samples were then dried at 105° C overnight, then weighed. The average moisture content was calculated using the following formula:

$$\text{Percent moisture} = \frac{(W_2 - W_1) - (W_3 - W_1)}{(W_2 - W_1)} \text{ x } 100$$

Where:

W_1 = Weight of crucible

W_2 = Weight of sample in a dish

W_3 = Weight of sample in a crucible

i.e. $$\text{Percent moisture} = \frac{\text{Loss in weight after drying}}{\text{Initial weigt of sample}} x100$$

3.5.2 Dry Matter (%)

Dry matter was calculated based on moisture content according to Egan *et al.* (1981), that is;

Percent dry matter = 100 % - percent moisture

3.5.3 Crude protein determination

Crude protein of sweet potato samples was determined using the semi micro Kjeldahl method as described in the AOAC (1995) method No.920.152. About 0.5 g of sweet potato samples were weighed in triplicate and digested.

Total Nitrogen (N) and crude protein in the sweet potato samples were worked out as follows:

$$\text{Percent } N = \frac{(14x0.1)xA}{W} x100$$

Where:

A = the titre of acid used in milliliters

W = original weight of the digested sample

N = Total Nitrogen

Percent crude protein = Percent N x Factor (6.25)

3.5.4 Crude fat determination (Ether Extract)

Crude fat content of sweet potato samples was determined by the soxhlet method as described in AOAC (1995) methods No. 960.39. Sweet potato samples were ground in a motor and pestle in order to increase the surface area for the extraction. About 5 g of the sample were subjected to the soxhlet continuous ether extract for 5 hours.

The percent crude fat was calculated as follows:

$$\text{Percent crude fat} = \frac{(W_3 - W_1)}{W_2} x100$$

Where:

W_1 = Weight of sample

W_2 = Weight of flask

W_3 = Weight of flask and sample

3.5.5 Ash content determination

Ash content of the tested samples was determined by AOAC official method No. 940.26 (AOAC, 1995). About 5 g of the test sample was weighed in a pre-weighed crucibles. The samples were then ignited in carbolite muffle furnace (530 2RR, England) at 550° C for six hours.

The ash content was calculated as bellow:

$$\text{Percent ash} = \frac{(W_3 - W_1)}{W_2} x100$$

Where:

W_1 = Weight of crucible

W_2 = Weight of sample

W_3 = Weight of sample in a crucible

3.5.6 Carbohydrate

The total carbohydrate content was determined by difference, according to AOAC (1995) that is, 100% - other proximate chemical compositions, using the following formula;

Total carbohydrate = 100 – (% CP +% EE + % CF + % Ash content + % MC)

Where:

CP = Crude protein

EE = Ether extract

CF = Crude Fibre

MC = Moisture content

AC = Ash content

3.5.7 Reducing sugars

Reducing sugars were determined by Luff-Schoorl method as described by Egan *et al.* (1981). Reducing sugars were calculated directly from the table relating titration (T) and sugar content (G).

$$\begin{matrix}\text{Amount of reduceing sugar} \\ \text{in original sample mg/g}\end{matrix} = \frac{\text{Reducing sugar (mg) from Table}}{\text{Weight of sample (g)}} \ x \ \frac{\text{Total vol of extract}}{\text{Vol. Extract}}$$

The amount of reducing sugars in mg/g was then expressed in percentage (g/100)

3.5.8 Mineral analysis

The minerals content of fresh and processed samples were carried out by AOAC (1995) method No. 968.08. Mineral contents (Ca, Fe, P, Mg and Zn) for sweet potato samples were determined by using Atomic Absorption/Flame Emission Spectrophotometer (AA

630-12). Absorbencies of various cations were read at 422.7 nm, 248.3 nm, 285.2 nm, 884 nm and 213.9 nm for calcium, iron, magnesium, phosphorous and zinc respectively.

The mineral content (mg/100g) were calculated as below:

Mineral content mg/100g = $\frac{R\ x\ 100ml\ D.F}{S\ x\ 1000}\ x100$

Where:

R = Reading in ppm

100 = Volume of sample made (ml)

$D.F$ = Dilution factor

1000 = Conversion factor to mg/100g

S = Sample weight

3.5.9 Total carotenoid content determination by spectrophotometer

Total carotenoids content of sweet potato were determined by extraction method using acetone (Rodriguez-Amaya and Kimura, 2004). Two grams of sweet potato samples were placed in a mortar and 3 g of hyflosupercel (celite) was added, then ground in 50 ml cold acetone. Samples were filtered with suction through a sintered glass funnel. Then 40 ml of petroleum ether was added in a 500 ml separatory funnel with teflon stop-cock and also acetone was added. Fifty ml petroleum ether were collected in a volumetric flask, the solution were passed through a small funnel containing glass wool and anhydrous sodium sulfate (15 g) to remove residual water. Then absorbance of the sample was read at 450 nm in spectrophotometer.

Total carotenoids were calculated using the following formula;

Total carotenoid content (μg/g) = $\frac{A \, x \, volume\,(ml)\, x\, 100}{A_{1cm}^{1\%} \; x \; Sample\ weight\,(g)}$

Where:

A = absorbance at 450 nm

$Volume$ = total volume of extract (50ml)

$A_{1cm}^{1\%}$ = absorption coefficient of β–carotene in petroleum ether (2592)

Then multiplied by 100 to give the carotenoid content in μg/100g.

3.6 Sensory evaluation of fresh and processed samples

Consumer tests were conducted in the three selected districts namely, Meatu, Sengerema and Missungwi. In each district the most preferred varieties from the project trial were used (Table 6). Tubers of these varieties were obtained from farmers of the project, and were cooked using a standardized method, which simulated the most common cooking method in the area.

3.6.1 Preparation of cooked samples

Sweet potato roots were peeled and cut into roughly equal sized portions (3-5 cm), washed with distilled water and then the pieces were boiled using distilled water for about 30-45 minutes; they were boiled until the texture, assessed by a fork, was considered right for eating. Each sample was labeled with a three-digit random number so that the consumers did not know which varieties they were testing (Appendix 1).

3.6.2 Sample presentation to consumers

Sensory evaluation of sweet potato was conducted using a 5-point hedonic scale (where 1= dislike very much/very bad and 5= like very much/very good). Sweet potato was assessed for attributes colour, smell, flavour, fibre, texture, flouriness and overall acceptability (Appendix 1). The samples were presented in random order placed into 3-digit coded plates for evaluation. Consumers were given instruction on how to evaluate the samples. Distilled water was provided to consumers to cleanse their palates between samples. In a given session consumers were asked to rate the sweet potato attributes of four samples (Appendix 1).

3.7 Marketing of sweet potato

Traders were interviewed using a structured questionnaire from Kirumba and Main market in Mwanza city where sweet potato are marketed (Appendix 2). Eight traders were interviewed in both markets. Information gathered was on varieties supplied and their sources, prices and seasonality.

3.8 Secondary data

Secondary data were obtained from libraries, internet, District Agricultural Offices, and project reports. Secondary data on genetic yield and diversity of sweet potato, sweet potato varieties grown, farmers' attributes in selecting sweet potato varieties were obtained from the assessment of genetic diversity, farmer participatory breeding and sustainable conservation of East African sweet potato germplasm study (Jeremiah *et al.*, 2004).

3.9 Data Analysis

Descriptive data were analyzed using SPSS Version 11.5 for WINDOWS (SPSS Inc. Chicago), chemical parameters and sensory data were analyzed by MSTATC computer software programs for analysis of variance (ANOVA).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter summarizes the findings on the importance of consumer preference in developing and selecting sweet potato varieties. Results presented in this chapter include sweet potato genetic yield and diversity, varieties grown, selection criteria, culinary qualities, consumer preferences in relation to varieties, consumption patterns, utilization, processing and storage, nutritional qualities, effect of processing on nutritional qualities and marketing.

4.2 Genetic yield and diversity of sweet potato varieties

The average yield for sweet potato varieties studied as reported by Jeremiah *et al.* (2004) are indicated in Fig.1. About 6 varieties namely Sekondari, Mafuta, Carrot Dar, Polista, Japon and Zapallo were used in this study. The varieties Sekondari, Japon and Zapallo had the highest yield while Polista had the lowest yield. The varieties have been reported to differ in terms of yield (Jeremiah *et al.*, 2004). However, Safo-Kantanka *et al*. (2000); Sonda *et al*. (2003); Gichuki *et al.* (2004), observed a close relations among East African sweet potato varieties. The differences could be attributed by differences in agro ecological zones as some environments favor the growth and production of the crop such as good rainfall pattern and fertile soils and also by farmers' management capabilities. Simwambana *et al*. (1999); Guoquan and George (2000) reported that yield differences could be due to poor rainfall distribution in which dry spell could cause a low mobilization of soil nutrients. In this study, areas like Meatu district had experiences of poor rainfall distribution compared to Sengerema district, however, dry weather favours tuber bulking

(Tsuno, 1981). Many differences are under genetic control, but their expression may be altered dramatically when plants are grown under different environments.

Sweet potato is grown by every household in the Lake Zone and the area under sweet potato cultivation differ from one household to another, depending on the use and need of the crop (Kapinga *et al*., 1995; Sonda *et al*., 2003). Farmers grow several sweet potato varieties, mostly landraces. However, the results from this study showed that Sekondari, Japon and Zapallo varieties had the highest yield although, it was reported by Jeremiah *et al.* (2004) that the production of sweet potato in these areas is still low, this could be attributed to the presence of sweet potato virus disease, weevils, continuous use of same varieties despite tuber yield degeneration and critical shortage of planting materials of superior varieties.

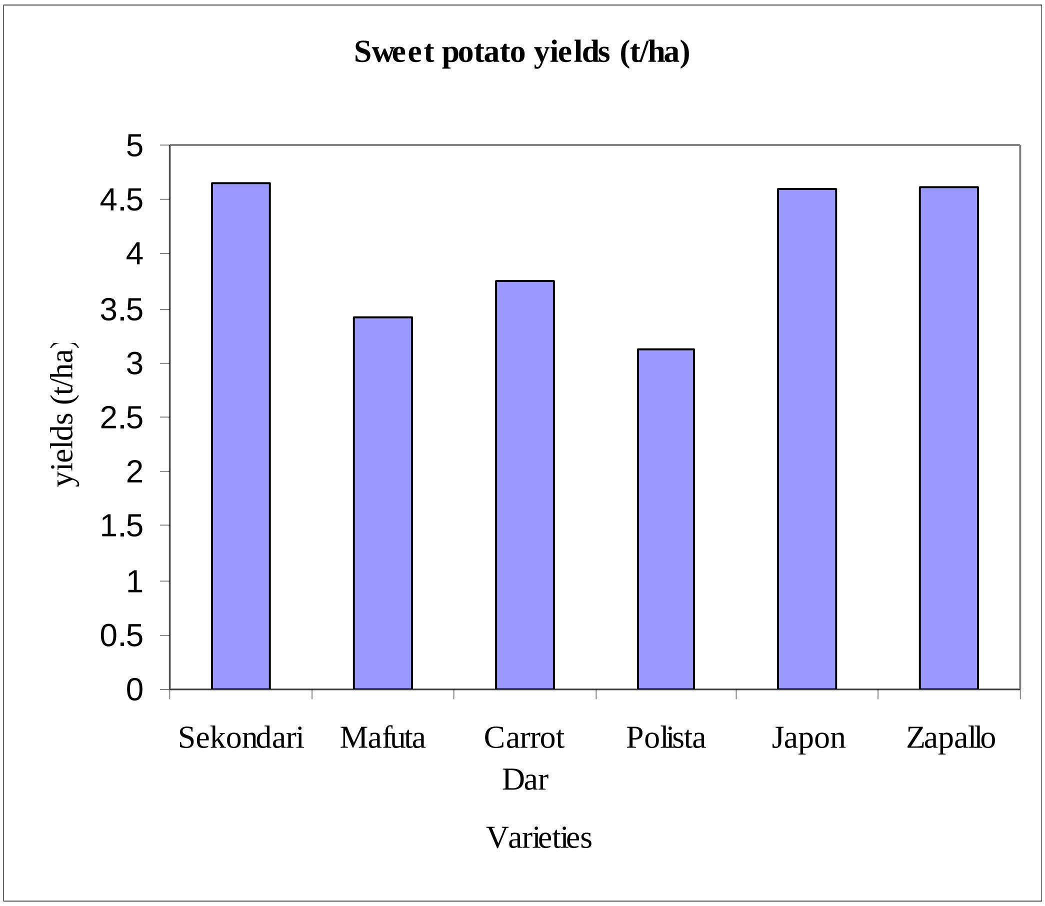

Figure 1: Yield of sweet potato in the Lake Zone t/ha

Source: Jeremiah *et al.* (2004)

4.2.1 Types of sweet potato varieties grown

Sweet potato varieties grown and their characteristics are presented in Table 7 and 8 respectively. White and creamy fleshed varieties are mostly dominant in both districts than yellow/orange varieties, the reasons for this preference could be due to farmers perception that white-flesh was a good indicator of high starch/dry matter content (Kapinga *et al.*, 2003a; Kulembeka *et al.*, 2003; Sonda *et al.*, 2003).

Table 7: Sweet potato selection of local varieties in Sengerema, Missungwi and Meatu district

Rank	Varieties per district		
	Sengerema	Missungwi	Meatu
1	Sekondari	Sekondari	Polista
2	Polista	Mwanamisalaba	Sekondari
3	Budagala	Mwaniki wa mjini	Tausi
4	Suguti	Mwanamulwa	Semosi
5	Sinia	Nyangeta	Kasinia
6	Vitunguu	Mwanabushole	Ng'wanalupujo
7	Sungusungu	Mamaheri	Mongeni
8	Mwezigumo	Mwanakabote	Nzegamatoro
9	Nguruka	Mwanagogo	Beki
10	Blanketi	Ngikuluobundaga bugolo	Kikundi

There were many sweet potato varieties grown in the Lake Zone. Hart (1991); Kapinga *et al*. (1995) reported that there were hundreds of names for sweet potato cultivars given by farmers. For example in Bukoba alone (Kagera region) over 57 varieties/cultivars were mentioned, in Maswa district (Shinyanga region), over 100 varietal names were collected. This indicates that names of sweet potato varieties vary with locations (Table 4), for example variety SPN/O is known as Suguti in the Lake Zone and Songea in the Southern Highland. Simama in the Lake Zone and Eastern Zone, Tulwawima in the Lake Zone and Southern Highlands. Some varieties bear names of their phenotypic characteristics such as earliness, or yielding capacity, for example Mwezigumo implies very early maturing (Kapinga *et al*., 1995). A good cultivar identified by one farmer may soon end up on a different farm and be given a different name at the new location. In this study only the first 10 preferred sweet potato varieties were considered (Table 10).

Table 8: Types of sweet potato varieties grown per village

Sweet potato characteristics (flesh colour)	Villages and % of sweet potato grown		
	Mwanyahina (Meatu district) N=86	Nyanhomango (Missungwi district) N=78	Igurumuki (Sengerema district) N=82
White	53.3	32.7	46.7
Cream	16.7	26.7	26.7
Purplish white	13.3	-	3.3
Yellow	13.3	16.7	10.0
Orange	-	-	13.3
Others	3.3	-	-

4.2.2 Selection criteria of sweet potato varieties by farmers

The most important attributes used by farmers to select a certain variety were high tuber yield, early maturity, low fibre, sweetness, high tuber firmness, tolerance to pests and diseases (Table 9). Farmers prefer varieties that were early maturing, and high yielding, especially for the case of piecemeal harvesting. According to farmers the advantage of early maturity was that it avoided drought period particularly in areas with long dry spells. Most of the white/cream-fleshed sweet potato met these characteristics (Kapinga *et al.*, 1997a). Results from this study revealed that varieties Sekondari, Polista and Mwanamisalaba were highly preferred by farmers (Table 7), these varieties met some attribute characteristics mentioned earlier. However, Polista variety had the lowest yield but ranked high, the reasons were good sensory attributes like root firmness, which indicated high dry matter content, good texture with low or without fibre, good flavour and taste of the variety.

Table 9: Criteria for selection of sweet potato varieties

Pre harvest criteria	Post harvest criteria
• High yielding	• Sweetness
• Early maturity	• Low fibre content
• Disease tolerance	• High tuber firmness
• Insect tolerance	• High dry matter content
• Drought tolerant	• Good storability
• Good in-ground storability	• Good flesh colour
• Tender leaves	• Marketability
• Potential to be grown in all seasons	• Large tuber size

Early maturing varieties are harvested three months after planting, due to this characteristics a farmer can plant two or more crops in a year because of its short maturity (Adipala *et al.,* 2000; Otoo *et al*., 2000). Rusch (1999) reported that the potential early maturity was reflected in the proportion marketable tubers, varieties having high proportion of marketable tubers from planting to harvesting were regarded as early maturing. Also it was found that sweetness to farmers was very subjective quality, since they considered it as an indication of good taste rather than sweetness (sugar content) *per se.* However, farmers' views need to be taken into account when selecting sweet potato varieties for breeding purposes (Van Oirstchot *et al*., 2000).

4.3 Culinary qualities of sweet potato

4.3.1 Consumer preference in relation to varieties

Knowledge of the important characteristics of consumer preference of sweet potato varieties is very essential before starting sweet potato production and marketing. Results obtained in this study on consumer varietal preference are presented in Table 10 and Appendix 4. Results in Table 10 indicate the highly preferred varieties in each district and Appendix 4 indicates the highly preferred varieties by gender. Sekondari variety was mostly preferred in Missungwi followed by Carrot Dar. Farmers associated their preference to high starch/floury content and sweetness. In Meatu and Sengerema Polista was highly preferred followed by Sekondari, however, Polista had the lowest yield compared to other varieties (Fig. 1 and Table 7). The main reason given was good flavour, therefore, consumers select the varieties by looking for other factors like sensory attributes rather than production. In addition Sengerema mentioned good taste while Meatu mentioned starch/floury being one of the reasons for preference (Table 10 and Appendix 3). Men preferred Sekondari as their first choice followed by Polista. While women first preference was Polista followed by Sekondari (Appendix 4). Their reason for high preferences was high starch/floury content and good flavour (Appendix 5). Sweet potato with no or low fibre content are mostly preferred by farmers. Tuber firmness/hardness is an indication of high dry matter content, which is a preferred attribute in sweet potato tubers. However, most of the sweet potato varieties grown by farmers had medium to slightly firm tubers as confirmed in studies by Kapinga *et al*. (1995, 1997a,b, 2003a,b); Chirimi *et al*. (2000); Otoo *et al.* (2000); Rees (2003); Tomlins *et al.* (2003). These results suggest that more attention should be given to sweet potato in the breeding scheme in order to increase chances of varietal adoption.

The nutrient compositions of the storage tubers of the varieties were assessed in terms of dry matter and sugar contents. The starch attribute, refers to the texture of the tuber, and is sometimes described as mealiness or flouriness, which is a complex attribute since it is related to the dry matter of the tubers. Sugar, or sweetness of the tuber is considered as an important taste attribute. It can also be a complex characteristic, not necessarily related directly to sugar content (Tomlins *et al*., 2003). The acceptability of sweet potato varieties was influenced by location and gender. These findings are in agreement with the earlier reports by Low *et al*. (1997); Hagenimana *et al*. (1999); Tomlins *et al.* (2005) that women generally have access within the household to the majority of vitamin A-rich food sources, including the orange-fleshed sweet potato, and can decide whether to prepare them for consumption at home or to sell them.

Table 10: Preference of sweet potato varieties in Meatu, Sengerema and Missungwi districts

Variety	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Sekondari	82	63.1	29	23.0	32	25.8
Mafuta	NA	NA	3	2.4	9	7.3
Carrot Dar	29	22.3	18	14.3	NA	NA
Polista	NA	NA	76	60.3	73	58.9
Japon	14	10.8	NA	NA	10	8.1
Zapallo	5	3.8	NA	NA	NA	NA

4.3.2 Consumers evaluation in relation to culinary qualities

In general, the results obtained from Meatu (Table 11) showed significant ($P \leq 0.05$) variations among the varieties assessed except in Sekondari and Carrot Dar varieties. The Polista variety was rated superior in all attributes which were colour, good smell, flavour, texture and floury, although its production was low. Also it had scored higher in overall acceptability, while Mafuta variety scored lower in all attributes as well as in overall acceptability (Table 11). The same trend was observed in consumer preference in relation to varieties where Polista was highly ranked followed by Sekondari. These results indicate that consumers considered other factors such as culinary qualities. However, significant differences ($P \leq 0.05$) were observed in some attributes of sweet potato varieties. Colour differed significantly ($P \leq 0.05$) in Sekondari and Mafuta varieties, while Carrot Dar and Polista did not differ. Flavour differed significantly ($P \leq 0.05$) from each variety. Smell and texture differed significantly except with Sekondari and Carrot. Starch/floury content evaluation did not differ significantly ($P \leq 0.05$) in all varieties except in Polista. In general all varieties scored high in all attributes, except Sekondari and Mafuta varieties. Studies by Rwiza *et al.* (2000); Quirien *et al*. (2002); Tomlins *et al.* (2003) reported that sensory characteristics were obviously important for cultivar selection.

Table 11: Sensory evaluation of cooked sweet potato in Meatu

Variety	Colour	Smell	Flavour	Texture	Starch/floury	General acceptability
Sekondari	3.08^{b}	3.92^{b}	3.99^{c}	3.73^{b}	3.50^{b}	3.96^{b}
Mafuta	3.58^{c}	3.68^{c}	3.69^{d}	3.50^{c}	3.32^{b}	3.62^{c}
Carrot Dar	4.46^{a}	4.06^{b}	4.24^{b}	3.90^{b}	3.35^{b}	4.03^{b}
Polista	4.39^{a}	4.45^{a}	4.65^{a}	4.22^{a}	4.66^{a}	4.70^{a}
Mean	4.05	4.03	4.14	3.84	3.71	4.08
Se ±	0.07	0.07	0.07	0.07	0.08	0.06
CV %	19.33	19.22	18.24	19.86	24.91	16.91

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).
Subjective ranking: 1= dislike very much/very bad and 5= like very much/very good

Consumer scores of the varieties evaluated in Missungwi district are indicated in Table 12. Like in Meatu district, the same trend for some aspects of consumer, were also observed in Missungwi, but some differences between the areas were observed. In Missungwi Sekondari variety scored higher in general acceptability as for the farmers selection criteria where, Sekondari variety was their first choice, also the same variety had the highest yield compared to other varieties, but it was the only white-fleshed variety presented in the evaluation, as it was indicated that farmers prefer mostly the white-fleshed sweet potato varieties compared to the orange fleshed ones (Kapinga *et al*., 2003a; Kulembeka *et al*., 2003; Sonda *et al.*, 2003).

Table 12: Sensory evaluation scores by consumers in Missungwi district

Variety	Colour	Smell	Flavour	Texture	Starch/floury	General acceptability
Carrot Dar	3.93[b]	3.93[b]	4.11[b]	3.89[b]	3.51[bc]	4.05[b]
Zapallo	3.87[b]	3.88[b]	3.89[c]	3.86[b]	3.27[c]	3.89[b]
Japon	3.85[b]	3.93[b]	3.94[bc]	3.89[b]	3.58[b]	3.93[b]
Sekondari	4.47[a]	4.56[a]	4.54[a]	4.39[a]	4.75[a]	4.72[a]
Mean	4.03	4.07	4.12	4.01	3.78	4.15
SE ±	0.07	0.07	0.08	0.08	0.09	0.07
CV %	21.07	20.79	20.93	22.02	27.21	18.11

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).
Subjective ranking: 1= dislike very much/very bad and 5= like very much/very good

Table 13 indicates the results for consumer evaluation in Sengerema district. Like in other two districts, the same trend for some aspects of consumer evaluation, were also observed in this district, but some differences were also observed, since the varieties were not the same across the district the preferences also were different. Varieties differed significantly (P≤0.05) in general acceptability but Sekondari and Polista varieties were the same and scored highest, while the remaining varieties scored the same. Sekondari and Polista scored high in all attributes (Table 13). Starch/floury differed significantly (P≤0.05) from each variety except Japon and Mafuta. With respect to colour, Sekondari and Mafuta varieties did not differ as well as Japon and Polista, but the two groups differed significantly (P≤0.05). In general acceptability, white-fleshed sweet potato tubers ranked first in all districts followed by orange-fleshed tubers as reported by Kapinga *et al*. (2003a,b); Kulembeka *et al*. (2003); Sonda *et al.* (2003). Consumers are primarily concerned with taste, coarse and hard texture and dry matter/starch content and not with colour *per se* (Tomlins *et al*., 2003; Van Oirschot *et al.*, 2003; Tumwegamire *et al*., 2004). However, other studies by Hagenimana *et al*. (1999); Tomlins *et al.* (2006) reported that the new cultivars which are orange fleshed are more acceptable than the traditional cultivars which are white/creamy, which contrast with the earlier reports and the present study, where consumers associated the orange-fleshed sweet potato cultivars with sensory attributes like watery texture, pumpkin flavour and orange colour.

Table 13: Sensory evaluation of sweet potato varieties in Sengerema district

Variety	Colour	Smell	Flavour	Texture	Starch/floury	General acceptability
Sekondari	4.29[a]	4.44[a]	4.53[a]	4.26[a]	4.41[b]	4.61[a]
Japon	3.78[b]	3.74[b]	3.78[b]	3.61[b]	2.63[c]	3.52[b]
Polista	3.87[b]	4.32[a]	4.58[a]	4.28[a]	4.67[a]	4.60[a]
Mafuta	4.21[a]	3.87[b]	3.56[c]	3.60[b]	2.47[c]	3.39[b]
Mean	4.04	4.09	4.11	3.94	3.55	4.03
Se ±	0.08	0.08	0.07	0.07	0.08	0.07
CV %	22.31	21.45	20.19	19.94	23.57	18.47

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).
Subjective ranking : 1= dislike very much/very bad and 5= like very much/very good

Good flavour and taste were another factor for preference of sweet potato as mentioned by consumers. Consumer testing has been involved in evaluation of suitable methods for rapidly assessing preference and acceptability in rural and urban locations (Rwiza *et al.*, 2000; Tomlins *et al.*, 2003). The characteristics that consumer preferred mostly were, starchy/floury (high dry matter) of the tuber, secondly, that they have good taste, followed by good cooking qualities, low fibre, good storage potential and good appearance (Kapinga *et al.*, 1995, 2003a,b; Chirimi *et al.*, 2000; Tomlins *et al.*, 2000a).

4.4 Consumption pattern for sweet potato

Most of the consumers in the study area used sweet potato every day (Table 14). Missungwi and Meatu had the highest percentage of consumers who used sweet potato every day, while in Sengerema most people use sweet potato 3-5 times per week. The reasons for this consumption pattern could be due to the fact that Sengerema district had diversity of crop production compared to Meatu and Missungwi. The environment in Sengerema (high rainfall and fertile soils) favours the cultivation of varieties of food crop while Meatu and Missungwi experienced shortage of rainfall for most of the seasons. It was found out that both males and females consume sweet potato every day (Appendix 6). Studies done by Kapinga *et al*. (1997a); Ndunguru (2001) found out that frequency of consumption varied with season and availability of sweet potato in the markets especially for urban consumers. At peak season, more people consumed sweet potato than in low season. During the fasting month for Moslems (Ramadhan), sweet potato were consumed more frequently particularly in the preparation of futari.

Traditionally, sweet potato cultivars consumed in East Africa had a white or cream coloured flesh but new orange coloured flesh cultivars have been introduced that are high in β-carotene that the body uses to produce vitamin A (Tomlins *et al*., 2006). Tumwegamile *et al*. (2004) reported that there has been a steady increase in both acreage and consumption levels of orange-fleshed sweet potato, for example, orange-fleshed varieties are estimated to occupy 1-2% in the Lake zone of Tanzania, 5-10% in Central Uganda, 10-15% in Western Kenya and 15-20% in Southern Mozambique. The success of newly introduced sweet potato cultivar will depend not only on production characteristics, but also on its acceptability to consumers in terms of both sensory and utilization characteristics. From this study it was observed that the consumption of orange-fleshed sweet potato varieties in Tanzania especially in the Lake zone is still low. The reasons could be due to the culinary attributes preferred by the people in the study area. Consumers preferred sweet potato varieties with high dry matter contents while most of the orange-fleshed sweet potato varieties had low to very low dry matter contents. So there is a need for promoting varieties with demanded culinary qualities for more utilization and consumption such as the orange-fleshed sweet potato varieties. Nutrition education and intervention strategies aimed at improving population diets need to consider sensory response to foods. A field study reported that in Western Kenya, orange-fleshed sweet potato were acceptable to both producers and consumers (Hagenimana *et al*., 1999). Studies by Hagenimana *et al*. (1999); Tomlins *et al*. (2006) confirmed that African mothers could readily accept orange-fleshed sweet potato varieties, thus implementation strategies concentrate on women because of their central role in the production and marketing of sweet potato and other food crops used in the family diet (Tumwegamile *et al*., 2004).

Table 14: Consumption pattern for sweet potato in Meatu, Sengerema and Missungwi districts

Frequency of sweet potato consumption	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Every day	82	63.1	96	76.2	45	36.3
3-5 times per week	47	36.2	30	23.8	79	63.7
Once per week	1	0.8	0	0.0	0	0.0

4.4.1 Cooking methods for sweet potato

Results from this study indicate that consumers in Missungwi and in Sengerema use boiling method for preparing their sweet potato tubers (Table 15 and Appendix 7), this could be due to less diversification in utilization of the sweet potato tubers in rural compared to urban areas where people use it in different forms such as futari, different recipes of snacks etc. Boiling and roasting were more used in Meatu than in other districts. Consumption rates could be influenced by many factors such as availability of alternative foods, eating preferences and local food customs (Kapinga *et al.*, 1995). However, the major cooking methods used in the area were boiling and roasting. The same findings were reported by Kapinga *et al.* (1995); Owori and Agona (2003); Tomlins *et al.* (2003, 2006). Kapinga *et al.* (1995, 1999) reported that sweet potato in Tanzania were boiled, roasted, fried or used in salads. While Ndunguru *et al*. (1998) found that in urban areas like Dar es Salaam sweet potato are roasted or deep fried for consumption as snack food. Most consumers boil or cook sweet potato alone. However, in Sengerema farmers mix with legumes such as beans, cowpeas and green grams. Consumers prefer to mix their sweet potato dishes with other ingredients in order to increase nutritional value of their food stuffs.

Table 15: Cooking methods of Sweet potato in Meatu, Sengerema and Missungwi districts

Cooking methods	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Mostly boiling sweet potato alone	80	69.2	61	48.4	79	63.7
Mostly boiling and roasting	30	30.8	65	51.6	45	36.3

4.5 Utilization of sweet potato

Sweet potato was mainly used as the main dish especially in Sengerema and Missungwi while in Meatu most consumers used it as main dish and breakfast (Table 16 and Appendix 8). This trend was common during the sweet potato season when most farmers had sweet potato in their fields. Consumption pattern differed from one location to another, it was used as a main dish but in different time within the day, could either be used as lunch or dinner depending on the household preference and availability of other food crops. As a main dish it was mainly accompanied with relishes, however, the type of relishes vary with location and availability, for example people who live near the lake shore preferred to use it with fish and sardines while in other area they used beans, green vegetable, milk, roasted groundnuts etc.

Table 16: Utilization of sweet potato in Meatu, Sengerema and Missungwi districts

Utilization pattern	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Main dish	96	73.8	42	33.3	100	80.6
Breakfast/snack	4	3.1	33	26.2	2	1.6
Supplement	1	0.8	4	3.2	4	3.2
Main dish and breakfast	29	22.3	47	37.3	18	14.5

4.6 Processing and storage of sweet potato

Most of the respondents process sweet potato for preservation and storage (Table 17). Perishability, bulkiness and seasonality nature of sweet potato roots were the major constraints on the marketing, availability and storage of the crop. Processing was used to address these constraints. The products processed in this study were "*michembe"* and "*matoborwa"* (Table 17). *Michembe* is a product obtained by peeling, slicing and sun drying sweet potato, while *matoborwa* is boiled before slicing and sun drying. "*Michembe"* were more processed in Missungwi (94.6 %) and Sengerema (82.38%), whereas Meatu they process both "*michembe"* and "*matoborwa"* (69.82%). Kapinga *et al.* (1997) reported that this technique of processing sweet storage tubers were first developed by Sukuma and Nyamwezi tribes in the Lake and Western zones. These techniques have now spread to the other zones. Wherever these tribes settled, sweet potato processing techniques were introduced. For instance, in the Southern Highlands Mwambene *et al*. (1992) reported that sweet potato processing was very common in the Usangu Plains that was mainly inhabited by the Sukuma people. The processed products could be kept up to 13-24 months without spoilage, depending on the type of the product and the climatic conditions. However, "*matoborwa"* could be stored for even longer time than that. These processed products were stored in "*vihenge"* (big storage baskets), tins, and gunny bags and in other types of containers (Kapinga *et al*., 1997). Meatu had more processed products due to dry spell conditions hence food insecurity is frequently experienced.

Processed products are mostly used during the food shortage especially during the rainy seasons when farmers start preparing their fields for the new crops. Hart (1991) observed that when preparing a meal with processed sweet potato, women prefer to cook the two types mixed together to lower the sweetness of "*matoborwa*" but this was commonly in areas where they process both products like Meatu. Food shortage was mainly caused by poor storage of the harvested crops as well as poor planning whereby farmers sell their food crops after harvest without considering storage for the coming months before the next harvest. And sometimes food shortage was caused by bad weather whereby farmers' experienced drought and rainfall shortage.

Table 17: Processed products of sweet potato in Meatu, Sengerema and Missungwi Districts

Processed products	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Michembe	123	94.6	36	28.6	102	82.3
Michembe and matoborwa	1	0.8	88	69.8	1	0.8
Not processing	6	4.6	2	1.6	21	16.9

4.7 Nutritional qualities of fresh sweet potato tubers

The results for nutrient composition of different varieties of sweet potato are shown in Table 18 and 19. The results from this study indicated that, the moisture content in fresh sweet potato varieties ranged from 55.00-72.44% where as the dry matter was between 27.56 and 45.00%. Of the varieties analyzed Polista had the highest dry matter content while Japon had the lowest amount. Mafuta and Sekondari had almost the same amount of dry matter content. Dry matter content is an indication of tuber firmness as reported by Otoo *et al.* (2000); Kapinga *et al.* (1997a,b, 2003a,b) that most of the varieties grown by farmers had medium to slightly firm tubers. Also farmers believed that white-fleshed sweet potato varieties had more dry matter content compared to other sweet potato varieties, (Kapinga *et al*., 2003a; Sonda *et al.*, 2003). Although Polista had more dry matter content and the lowest yield, it was the most preferred variety. In this study the total carbohydrate ranged between 23.55 and 41.09 g/100 g. Plant carbohydrates include celluloses, gums and starches, but starches are the main source of nutritive energy as celluloses are not digested (FAO, 1990). The principal constituent of edible carbohydrate is starch together with some sugars, the proportion depending on the root crop. Polista had more total carbohydrate contents compared to other varieties and Japon had the lowest since it had the highest amount of moisture content. Dry matter can vary between roots, and also for different parts of the same root. In addition the growth environment can have significant effect (Rees, 2003).

The results in Table 18 showed that there was variation of reducing sugars between the varieties. Varieties like Japon and Zapallo had the highest reducing sugars (139.1 g/100 g) while Polista had the lowest (100.8 g/100 g). This variation could be attributed to varietal differences, crop variety, cultivation practice, climate, growing season, location, soil, processing and storage.

The total carotenoid ranged from 88.31-1620.07 μg/100 g, it was noted that Carrot Dar variety had the highest total carotenoid and Polista had lowest amount. The flesh colour of the varieties with high content of total carotenoids was deep orange to orange observed like in varieties Carrot Dar, Zapallo, Mafuta and Japon, while the low total carotenoids content was found in yellow to cream-fleshed varieties such as Sekondari and Polista. These results compare with the findings reported by Low *et al*. (1997); Mulokozi and Svanberg (2002); Mulokozi (2003); Rodriguez-Amaya (2003); Niizu and Rodriguez-Amaya (2005).

Crude protein content of sweet potato varieties in the present study ranged between 1.39-2.77 g/100 g (Table 18). It has been reported that the limiting nutritional qualities of sweet potato were the low protein contents, which constitutes about 1-3% of the fresh weight, (Woolfe, 1999). There was no much variation in protein content in various sweet potato varieties analyzed (Table 18). However, sweet potato is not a good source of protein suggesting that it has to be supplemented with rich protein foods like fish, sardines etc, cereals and vegetables. To some extent the protein content of root and tuber crops is influenced by variety, cultivation practice, climate, growing season and location (Woolfe, 1999; Yashimoto *et al*., 2000). Animal crude proteins are generally known to have high biological value than plant crude proteins but plant foods, when rightly combined with other foods can satisfactorily meet the protein needs of adults (Ejoh *et al*., 2003).

Sweet potato are very poor source of fat and from the results of this study it ranged from 0.03-0.92 g/100 g (Table 18). There was variation of fat content in different sweet potato varieties. All the root and tuber crops exhibit a very low lipid content. Since roots and tubers are very low in lipid they are not in themselves rich sources of fat-soluble vitamins, except for red/orange/yellow-fleshed sweet potato varieties which are rich in beta-carotene (Pro-vitamin A). The lipid may probably contribute to the palatability of the root and tuber crops (FAO, 1990; Ejoh *et al.*, 2003).

There was no variation in ash content in all varieties of sweet potato (Table 18), however, there was variation in individual mineral content (Table 19). Mineral content varied from one variety to another for example Carrot Dar and Mafuta had the highest amount of calcium (29.96 and 29.32 mg/100 g) respectively, while Sekondari the lowest (24.26 mg/100 g). Also Carrot Dar had the highest amount of iron (0.78 mg/100 g) and Japon the lowest (0.61 mg/100 g). Polista had the highest amount of magnesium (14.01 mg/100 g) and Mafuta the lowest (13.21 mg/100 g). Sekondari had the highest amount of phosphorous (48.61 mg/100 g) and Polista the lowest (46.57 mg/100 g), and Japon had the highest (0.37 mg/100 g) and Zapallo the lowest (0.29 mg/100 g) amount for zinc.

Potassium is the major mineral in most root and tuber crops while sodium tends to be low (FAO, 1990).

Table 18: Nutrient content of fresh sweet potato varieties (g/100g edible portion) dry basis

Varieties	Moisture content	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Total carotenoid (µg/100g)
Carrot Dar	62.52[d]	0.98[a]	2.55[a]	0.68[c]	124.80[c]	33.38[b]	1620.07[a]
Japon	72.44[a]	0.98[a]	2.61[a]	0.03[f]	139.10[a]	23.55[e]	247.27[c]
Zapallo	67.40[b]	0.98[a]	1.39[c]	0.92[a]	134.20[ab]	29.29[d]	298.26[b]
Mafuta	65.02[c]	0.99[a]	2.09[b]	0.77[b]	124.80[c]	31.13[c]	297.12[b]
Polista	55.00[e]	0.98[a]	2.77[a]	0.14[e]	100.80[d]	41.09[a]	88.31[e]
Sekondari	64.09[c]	0.98[a]	1.54[c]	0.16[d]	129.60[bc]	33.17[b]	192.89[d]
Mean	64.41	0.98	2.15	0.45	125.57	31.93	457.32
SE ±	0.90	0.00	0.29	0.00	4.28	1.06	3.76
CV %	1.97	0.23	19.01	1.56	4.82	4.70	1.16

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Table 19: Mineral content of fresh sweet potato varieties (mg/100g of edible portion) dry basis

Varieties	Calcium	Iron	Magnesium	Phosphorous	Zinc
Carrot Dar	29.96[a]	0.78[a]	13.30[bc]	47.24[c]	0.30[b]
Japon	25.72[c]	0.61[d]	13.24[bc]	48.05[b]	0.37[a]
Zapallo	27.37[b]	0.65[c]	13.28[bc]	47.00[d]	0.29[b]
Mafuta	29.32[a]	0.73[b]	13.21[c]	47.01[d]	0.29[b]
Polista	28.00[b]	0.75[ab]	14.01[a]	46.57[e]	0.29[b]
Sekondari	24.26[d]	0.72[b]	13.51[b]	48.61[a]	0.32[ab]
Mean	27.43	0.71	13.42	47.41	0.31
SE ±	0.64	0.02	0.20	0.06	0.04
CV %	3.32	4.35	2.10	0.18	19.98

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Table 20: Effect of processing on nutrient content for the variety Carrot Dar (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.98[a]	2.55[a]	0.68[a]	124.80 [a]	33.38[a]	29.96[a]	0.78[a]	13.30[a]	47.24[a]	0.30[a]
Moist heat	0.98[a]	2.46[a]	0.68[a]	72.02[d]	33.47[a]	28.98[a]	0.68[b]	12.13[b]	44.28[b]	0.29[a]
Dry heat	0.97[a]	2.46[a]	0.68[a]	96.01[c]	33.47[a]	28.97[a]	0.60[c]	12.12[b]	44.35[b]	0.30[a]
Traditional	0.97[a]	2.47[a]	0.67[a]	120.00[b]	33.49[a]	28.89[a]	0.65[bc]	12.01[b]	44.35[b]	0.30[a]
Mean	0.97	2.48	0.67	103.22	33.45	29.19	0.68	12.38	45.05	0.30
SE ±	0.01	0.12	0.01	1.41	0.57	0.70	0.03	0.04	0.06	0.07
CV %	0.32	7.10	2.28	1.94	2.41	3.39	5.59	0.45	0.19	33.32

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Table 21: Effect of processing on nutrient content for variety Japon (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.98[a]	2.61[a]	0.03[a]	139.10[a]	23.55[a]	25.72[a]	0.61[a]	13.24[a]	47.00[a]	0.37[a]
Moist heat	0.97[a]	2.53[a]	0.03[a]	78.80[c]	24.02[a]	24.39[a]	0.50[b]	12.26[b]	44.00[b]	0.37[a]
Dry heat	0.97[a]	2.50[a]	0.03[a]	91.21[b]	24.05[a]	24.82[a]	0.53[b]	12.34[b]	44.02[b]	0.37[a]
Traditional	0.97[a]	2.52[a]	0.03[a]	99.10[b]	24.05[a]	24.60[a]	0.52[b]	12.34[b]	44.01[b]	0.37[a]
Mean	0.97	2.54	0.03	127.04	23.91	24.88	0.54	12.54	44.76	0.37
SE ±	0.01	0.04	0.01	6.16	2.66	0.84	0.01	0.07	0.01	0.01
CV %	0.34	2.26	26.47	6.86	15.71	4.78	1.55	0.81	0.02	4.29

Mean values followed by the same letters within the column do not differ significantly at $p \leq 0.05$ according to Duncan Multiple Range Test (DMRT).

Table 22: Effect of processing on nutrients content for variety Zapallo (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.98[a]	1.39[a]	0.97[a]	208.10[a]	30.45[a]	27.37[a]	0.65[a]	13.33[a]	47.00[a]	0.29[a]
Moist heat	0.98[a]	1.35[a]	0.95[a]	110.40[c]	29.69[a]	26.99[a]	0.52[b]	12.42[b]	44.21[b]	0.28[a]
Dry heat	0.98[a]	1.34[a]	0.95[a]	129.70[b]	29.68[a]	27.00[a]	0.53[b]	12.43[b]	44.21[b]	0.28[a]
Traditional	0.98[a]	1.34[a]	0.95[a]	134.20[b]	29.68[a]	26.89[a]	0.54[b]	12.44[b]	44.18[b]	0.28[a]
Mean	0.98	1.25	0.95	144.60	29.44	26.31	0.56	12.67	44.87	0.28
SE ±	0.01	0.12	0.06	6.06	2.20	0.61	0.02	0.03	0.05	0.01
CV %	0.52	13.24	9.60	5.92	10.57	3.27	3.78	0.29	0.17	3.45

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).

Table 23: Effect of processing on nutrient content for variety Mafuta (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.99[a]	2.09[a]	0.77[a]	184.00[a]	31.13[a]	29.32[a]	0.73[a]	13.21[a]	47.01[a]	0.29[a]
Moist heat	0.99[a]	2.00[a]	0.76[a]	81.64[c]	31.23[a]	28.30[a]	0.62[b]	12.18[b]	44.17[b]	0.29[a]
Dry heat	0.98[a]	2.02[a]	0.76[a]	124.80[b]	31.12[a]	28.78[a]	0.61[b]	12.22[b]	44.11[b]	0.29[a]
Traditional	0.98[a]	2.01[a]	0.76[a]	124.80[b]	31.25[a]	28.22[a]	0.63[b]	12.27[b]	44.18[b]	0.29[a]
Mean	0.98	2.03	0.76	128.81	31.18	28.65	0.65	12.47	44.86	0.29
SE ±	0.01	0.05	0.02	3.00	0.86	0.64	0.01	0.07	0.05	0.01
CV %	0.09	3.38	3.27	3.30	3.91	3.15	3.15	0.77	0.16	1.02

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).

Table 24: Effect of processing on nutrient content for the variety Polista (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.98^{a}	2.77^{a}	0.14^{a}	189.00^{a}	42.09^{a}	28.00^{a}	0.75^{a}	14.01^{a}	46.57^{a}	0.29^{a}
Moist heat	0.98^{a}	2.55^{a}	0.14^{a}	100.80^{d}	41.31^{a}	27.53^{a}	0.61^{b}	12.38^{c}	43.57^{b}	0.29^{a}
Dry heat	0.98^{a}	2.54^{a}	0.14^{a}	120.00^{c}	41.32^{a}	27.01^{a}	0.63^{b}	12.47^{bc}	43.67^{b}	0.29^{a}
Traditional	0.97^{a}	2.56^{a}	0.14^{a}	139.20^{b}	41.31^{a}	27.32^{a}	0.62^{b}	12.50^{b}	43.73^{b}	0.29^{a}
Mean	0.98	2.60	0.14	137.26	41.50	27.46	0.66	12.84	44.33	0.29
SE ±	0.01	0.35	0.01	7.89	1.19	1.12	0.02	0.05	0.08	0.01
CV %	0.08	19.23	10.05	8.13	4.04	5.77	4.89	0.54	0.25	1.20

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).

Table 25: Effect of processing on nutrient content for variety Sekondari (g/100g of edible portion) dry basis

Processing method	Ash	Crude protein	Crude fat	Reducing sugars	Total CHO	Calcium	Iron	Magnesium	Phosphorous	Zinc
Raw	0.98^{a}	1.54^{a}	0.16^{a}	179.00^{a}	33.17^{a}	24.26^{a}	0.72^{a}	14.01^{a}	46.61^{a}	0.32^{a}
Moist heat	0.98^{a}	1.45^{a}	0.16^{a}	104.01^{d}	33.31^{a}	23.52^{a}	0.62^{b}	12.58^{b}	44.22^{b}	0.31^{a}
Dry heat	0.97^{a}	1.46^{a}	0.16^{a}	115.20^{c}	33.30^{a}	23.36^{a}	0.63^{b}	12.53^{b}	44.24^{b}	0.31^{a}
Traditional	0.97^{a}	1.47^{a}	0.15^{a}	129.60^{b}	33.31^{a}	23.07^{a}	0.62^{b}	12.51^{b}	44.25^{b}	0.32^{a}
Mean	0.98	1.48	0.15	127.96	33.27	23.55	0.65	12.90	44.58	0.31
SE ±	0.01	0.05	0.04	2.55	0.70	0.79	0.01	0.04	0.07	0.02
CV %	0.24	5.23	21.41	3.06	2.98	4.77	2.30	0.41	0.21	9.80

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).

4.8 Effect of processing on nutrient content of sweet potato varieties

The methods of processing and cooking range from simple boiling to elaborate fermentation, drying and grinding to make flour, depending on the varieties of roots and tubers (FAO, 1990). Heat treatment increases the nutritional value of the food and improving digestibility. By comparing the results from the fresh samples on chemical composition before and after processing they indicate how much the processing methods affected the chemical composition of sweet potato samples (Table 20-25).

4.8.1 Protein

The protein content of the fresh sweet potato varieties in this study ranged from 1.39 to 2.77 g/100 g and after processing by different methods it varied between 1.34 to 2.50 g/100 g (Table 20-25). There were no changes in the protein content of sweet potato with processing. These results are in agreement with the findings reported by Ameny and Wilson (1997); Otoo *et al.* (2000) who indicated that heat processing such as boiling may not reduce protein content. However, they contrast with earlier observations reported by Ejoh *et al.* (2003) that there was slightly reduction in protein content when different preparation treatments were applied. Which could be due to denaturation of protein on heat treatment. This falls within the range of 1.3 to 10% reported by FAO (1990) and Otoo *et al.* (2000).

4.8.2 Carbohydrates

The results of the present study showed that processing of sweet potato varieties by different methods had no effect on carbohydrate content (Table 20-25). However, FAO (1990) and Özdemir *et al.* (2001) reported that processing of foods affects carbohydrate and micronutrient content and bioavailability in different ways with either desirable or adverse effects on the nutritional value. During wet heat treatment, as in blanching, boiling and canning of vegetables and fruits, there is a considerable loss of low molecular weight carbohydrates (i.e. mono- and disaccharides) as well as micronutrients, into the processing water. For example, in the blanching of carrots and swedes (rutabagas) there was a loss of 25 and 30%, respectively of these carbohydrates. With subsequent boiling another 20% was lost. In peas, green beans and brussels sprouts the loss was less pronounced about 12% following blanching and another 7-13% at boiling (FAO, 1990).

The average reducing sugars content of sweet potato processed by different methods are shown in Tables 20-25. The results showed that processing had significant effect ($P \leq 0.05$) on reducing sugars, the reduction ranged from 4-56%. Cooking by moist heat (boiling) in all varieties caused higher percentage loss in reducing sugar content than the other processing methods, while traditional processing caused the lowest percentage of losses. Muzanila (1998) also observed reduction in sugars in processed cassava by wet method. Leaching of nutrients and Maillard reactions could be the main reasons for this reduction (Muzanila, 1998; Ejoh *et al.,* 2003). Prochaska, *et al.* (2000) found that there were no significant change in energy content observed in cereals, sugars, grains, fats and oils, and nuts. Significant differences ($P \leq 0.05$) were also observed in all processing methods in varieties Carrot Dar, Polista and Sekondari, with exception of varieties Japon, Zapallo and Mafuta where dry heat did not differ with the traditional processing. Contrary to the study by Tomlins *et al*. (2003) which indicated that the sugar content of roots increases during cooking, as the process promotes the breakdown of starch.

4.8.3 Fat

The results obtained from this study showed that sweet potato are poor sources of lipids. Processing treatments had no significant effect ($P \leq 0.05$) on fats (Table 20-25). These findings are in contrast with Özdemir *et al.* (2001) who reported that processing especially roasting leads to changes in the fats (free fatty acids) in hazelnuts, but this changes could be attributed by high temperatures and time used for processing.

4.8.4 Minerals

Results on the effect of processing on minerals on different sweet potato varieties are presented in Table 20-25. Processing by moist heat (boiling), dry heat (roasting) and traditional (sun drying) had no effect on ash, calcium and zinc. However, there was slight decrease on other minerals like iron, Magnesium and phosphorous. Decrease in mineral content after processing were reported earlier by Attia *et al.* (1994); Nestrares *et al*. (1999); Yashimoto *et al*. (2000) who found out that cooking of chickpeas reduced calcium by 20%, soaking with or without subsequent cooking reduced phosphorous by 10-15%, that is somewhat more than the 8.5% reduction found by Attia *et al.* (1994) and to the use of different varieties reported by Yashimoto *et al*. (2000). In the present study, the losses (5-6%) were slightly smaller than those found by other authors, and there were no significant difference in processing methods as well as varieties. Heating had no effect on calcium content. Cooking had no significant effect on phosphorous content (Nestrares, *et al*., 1999). From this study it was also found that processing reduced magnesium by 7-12%. The same trend was observed with iron where the reduction was between 13-23%. Minerals like sodium, potassium and calcium are lost when food is cooked in water containing salt and when cooking water was discarded. However, the availability of food iron is not altered by the cooking or by baking (FAO, 1990).

4.9 Effect of processing on total carotenoids

The average amount of total carotenoid contents and losses in processed sweet potato are presented in Table 26, the percent losses ranged from 35.72 to 69.13% when processed in different ways. The lowest amount of total carotenoid was found in traditional processing (55.11 – 69.13%). The processing methods differ significantly ($P \leq 0.05$) in total carotenoid contents in different sweet potato varieties as compared to fresh tubers. Prolonged heat treatment can destroy the fat-soluble vitamins and the water-soluble vitamins thiamine, pantothenic acid, folic acid, and biotin (FAO, 1997; Negi and Roy, 2000; Ejoh *et al*., 2003). Generally, processing leads to losses in vitamin A (Mosha *et al*., 1997; Rodriquez-Amaya, 1997; Mulokozi, 2003; Rodriguez-Amaya and Kimura, 2004)). However the amount of total carotenoid contents differ with varieties the more deep orange colour the more content (Mulokozi, 2003; Kapinga *et al.*, 2004). The variation in β-carotene content within similar root and tuber crops may be due to cultivar differences and /or stage of maturity, geographical site of production, agronomic practices applied to plants prior to harvest, temperature and harvesting time and harvesting and post harvest handling (Rodriguez-Amaya and Mercadante, 1991; Mulokozi, 2003).

Table 26: Effect of processing on Total carotenoids (µg/100g edible portion) dry basis

Processing method	Total carotenoid (µg/100g)					
	Orange fleshed sweet potato varieties				White fleshed	
	Carrot Dar	Japon	Zapalo	Mafuta	Polista	Sekondari
Raw	1620.00[a]	247.30[a]	298.30[a]	297.10[a]	88.31[a]	192.90[a]
Moist heat	957.90[b] (40.87)	153.70[b] (37.85)	142.50[b] (52.23)	151.50[b] (49.02)	43.24[b] (51.04)	124.00[b] (35.72)
Dry heat	865.50[b] (46.57)	148.40[b] (39.99)	139.40[b] (53.27)	148.00[b] (50.19)	41.76[b] (52.71)	122.90[b] (36.29)
Traditional	532.70[c] (67.12)	110.90[c] (55.16)	116.10[c] (61.08)	113.20[c] (61.89)	29.52[c] (66.57)	59.54[c] (69.13)
Mean	994.03	165.08	174.08	177.45	50.71	124.84
SE ±	4.55	4.93	2.29	3.99	0.65	0.89
CV %	0.74	4.43	1.92	3.18	1.57	1.00

Mean values followed by the same letters within the column do not differ significantly at p≤0.05 according to Duncan Multiple Range Test (DMRT).
Figures in bracket indicate (%) percent loss after processing

The results of this study compare with the study done by Rodriquez-Amaya (1997); Negi and Roy (2000); Mulokozi (2003); Rodriguez-Amaya and Kimura (2004) who found that traditional methods of processing followed by sun drying caused significant losses in β-carotene content compared with other methods like solar drying, boiling, baking, freezing and blanching. Also Hagenimana *et al*. (1999) reported that boiling resulted in a reduction of total carotenoid content, which varied depending on the cultivar. With the use of sun drying, peeling, mincing and juicing the carotenoids are exposed to heat, oxygen and light, all of which can catalyse oxidation and isomerization reactions (Rodriguez-Amaya, 2001). The extensive losses of carotenoid in open sun dried product is possibly due to oxidative degradation, which is said to be one of the principal causes of carotenoid loss (Mosha *et al*., 1997). The extent of degradation depends on the availability of oxygen and is stimulated by light, enzymes and co-oxidation with lipid hydroperoxides (Rodriguez-Amaya, 2001). The major cause of carotenoid destruction during food processing and storage is enzymatic or non-enzymatic oxidation. Isomerazation of trans-carotenoids to the cis-isomers, particularly during heat treatment, alters their biological activity and discolours the food, but not to the same extent as oxidation. In many foods, enzymatic degradation of carotenoids may be a more serious problem than thermal decomposition (Rodriguez-Amaya and Kimura, 2004). Sun drying was, therefore, considered to be the major factor in carotene losses (Mulokozi and Svanberg, 2002).

Many carotenogenic foods are seasonal and preservation at peak harvest is necessary to minimize losses. Processing and storage of foods should, however, be optimized to prevent carotenoid losses (Rodriquez-Amaya, 1997, 1999, 2002). Thermal processing has been reported in some studies to cause substantial losses of provitamin A carotenoid content (Padmavati *et al*., 1992; Chen and Chen, 1993). A study by Khachik *et al.* (1992) reported that the level of carotenes under mild cooking conditions remain unchanged.

Studies conducted to assess the effect of sun drying on total carotenes of green leafy vegetables have reported losses ranging from 58 to 98% (Maeda and Salunkhe, 1981; Mosha *et al.*, 1997; Negi and Roy, 2000). Water is known to have a protective effect on the autoxidation of carotenoids (Ramakrishnan and Francis, 1979). Generally, drying techniques involving heat, light and open-air systems can be damaging to carotenoids as a result of oxidation, isomerization and /or free radical formation (Mulokozi and Svanberg, 2002; Mulokozi, 2003). Loss of vitamin A during drying varies from 10 to 20 percent. Carotenoid losses increased with temperature (Andrangi and Laborde, 2004).

Despite a reduction in carotene content observed in this study due to cooking, heat processing is reported to have the potential to increase the bioavailability of carotenoid in cooked foods (Van het hof *et al.*, 2000). Whatever the processing method, carotenoid retention decreases with longer processing time, higher processing temperature, and cutting or pureeing of the food. Reducing the processing time, like rapid processing at high temperature (Rodriguez-Amaya and Kimura, 2004) lowering the temperature, and shortening the time lag between peeling, cutting, or pureeing and processing, significantly improve retention of carotenoids.

4.10 Marketing of sweet potato

Results from this study showed that the main varieties of sweet potato supplied and marketed in Mwanza markets were white and cream flesh colour with red skin colour, there were no orange fleshed sweet potato found in the market (Table 27). Reasons for preference for these sweet potato varieties were high starch/floury content and sweetness of the roots. The results of this study were in agreement with other study reported by Ndunguru (2001) who observed that reddish and purple skinned varieties were preferred and sell at an average premium of 10% above the price of yellow ones. However, FAO (1997) reported the findings from a study done in Kenya, Meru district that, perishability of white-skin potato is a major reason for consumer preference of the red skinned varieties.

Table 27: Varieties of sweet potato marketed in Mwanza

Market location	Sweet potato varieties preferred by traders		Number of traders N=8
	White varieties (%)	Cream & white varieties (%)	
Mwaloni	33.3	66.7	6
Main market	0	100	2

The main source of sweet potato mentioned by both traders were Uzinza in Sengerema district and the main varieties supplied at the market for the whole season were Polista and Sinia, which have red skin colour. Mbilinyi *et al.* (2000); Mtunda *et al*. (2001) found that there were several areas within the country where sweet potato production is focused primarily towards providing tubers for the marketing in the urban centers such as Mwanza and Dar es Salaam. The reasons for preference of these varieties are mainly longer shelf life and resistance to transportation effects. Since there were poor handling practices during transport and short-term storage in the markets, the conditions under which roots are kept are non-ideal and during transportation, roots were subjected to mechanical damage. Temperatures may be very high under tropical conditions where generally humidity is low. Consignments often have to be transported long distances, and shelf life has been reported as much shorter of only 2-3 weeks (Kapinga *et al.,* 1997; Rees *et al.,* 2001). It is perceived that an increase in shelf life could greatly enhance the market potential of sweet potato (Kapinga *et al*., 1997; Ndunguru *et al.,* 1998; Mtunda *et al*., 2001; Tomlins *et al*., 2000, 2006).

4.10.1 Selling prices and seasons of sweet potato

Table 28: Prices of sweet potato during peak and low seasons

Production level	Months	Buying price (Tsh/bag)
Peak period	March- August	5000- 8000
	January- February	6000- 10000
Low season	September-December	9000- 16000

Size of the bag ranged between 120-140 kg

It was found out from this study that sweet potato tubers are marketed at high prices in low season when the quality is low and prices are lower at high season when quality is high. The prices dropped dramatically when in season due to high supply (Table 28). Quality is lowest in September and October when sweet potato have overstayed their optimum harvesting time and become rather watery (Ndunguru *et al.,* 1998; 2001). Prices are low when supply is high and vice versa (Ndunguru *et al.,* 2000; Tomlins *et al*., 2006). Studies also show that there is a positive relationship between quality and market value of the crop marketed in the urban areas. Under this situation, producers and traders of sweet potato cannot realize better returns for their livelihoods if the produce cannot fetch high prices in the market and be available in the quality demanded by the market (Ndunguru *et al.,* 1998; Mtunda *et al.,* 2001; Tomlins *et al*., 2006).

Kapinga *et al.* (1997); Ndunguru (2001); Rees *et al.* (2001) reported that production of sweet potato in the Lake zone is guided by weather. The main planting season is normally the same time for all farmers around the regions. Harvesting of main crop is usually done during April to September. Sweet potato harvested during this time are good in quality and better for market. During this period the Mwanza markets are oversupplied with sweet potato tubers that make prices to fall significantly despite of their good quality. On retail basis, fresh sweet potato are normally marketed in heaps at prices ranging from 100 to 300 Tsh, depending on the size of the heap or season. A heap is a pile of sweet potato which comprised of 5 to 7 tubers of different sizes and quality attributes. One heap weighed between 1.2 and 1.5 kg. A heap of 100 Tsh comprised of small and broken roots while a heap of 300 Tsh had big tubers with good quality as found in the study by Ndunguru (2001).

4.10.2 Problems experienced during marketing of sweet potato

The major problems of marketing sweet potato mentioned by the traders in this study were lack of capital, poor marketing, short shelf life of the produce, transportation from the source to the market which leads to great damages of the tubers and seasonality of the crop. The increase in prices and decline in availability of sweet potato in the markets is due to the seasonal variation as mentioned above. Rees *et al.* (1998, 2001) reported the effect of damage on tuber shelf life of sweet potato, as the serious constraint to marketing. It was found further that deterioration under normal marketing conditions was due to weight loss and rotting although the rate of deterioration differed between locations and seasons as well as storage conditions. It was also noted that superficial damage, and poor handling lead to high level of losses in the sweet potato marketing systems, hence loss of opportunity for marketing, which had great economic implications (Mtunda *et al*., 2001; Rees *et al.*, 2001). Although traders lowered prices to expedite selling they still experienced high losses.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From this study it was observed that there were wide diversity of sweet potato varieties grown in the area with varied yields, however, the production is still low. Therefore, there is a need for improved varieties with high yielding potential in order to boost the production.

This study provides evidence that consumer culinary qualities have to be taken into consideration on varietal selection and adoption rather than agronomic factors only. It was observed that varieties had significant effect on culinary qualities. Polista variety was highly preferred regardless of its low yielding capacity, farmers/consumers consider mostly the sensory and culinary qualities in selecting a variety. Preference by gender was not different since men and women prefer varieties with the same culinary characteristics. This suggest that more promotion campaign, awareness creation and mass education carefully targeting each group should be given more emphasis on the newly introduced orange-fleshed sweet potato varieties since they contain high β-carotene content which is important for the children and pregnant mothers health as well as people with HIV/AIDS. Since some varieties like Carrot Dar had the highest amount of total carotenoid they could be used as a good source of vitamin A to feed children under five years of age, pregnant mothers as well as people living with HIV/AIDS since they have major role in the body immunity and CD4+.

Also processing had no significant effect on some nutrients like ash, protein, fat, carbohydrate and some minerals like calcium and zinc, while significant difference was observed in total carotenoids. Total carotenoids decreased with processing methods especially traditional processing which involves peeling, slicing and direct sun drying had more effect compared to other methods such as boiling and baking.

5.2 Recommendations

Based on the results of this study it is recommended that:

(i) The Ministry of Agriculture should give priority on post-harvest issues like more diversification of utilization methods, and marketing of sweet potato in the country in order to reduce losses and increase the value of the crop.

(ii) Creating awareness to farmers on the importance of orange-fleshed sweet potato varieties as a source of vitamin A for children under five years of age, pregnant and lactating mothers and people living with HIV/AIDS.

(iii) The success of any newly introduced cultivars does not only depend on production characteristics, but also on its acceptability to consumers in both sensory, culinary and utilization characteristics. Therefore, the breeding programme should also put more emphasis on these culinary qualities in addition to β-carotene content.

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APPENDICES

Appendix 1: Consumer preference of sweet potato varieties in Missungwi, Sengerema and Meatu districts

A. General information

1. District 1. Missungwi 2. Meatu 3. Sengerema
2. Name of interviewer__________________________ Date of interview____________
3. Name of interviewee________________________________
4. Age of interviewee (yrs)________________________
5. Marital status
    1.Married
    2.Single
    3.Widower
    4.Divorced
    5.Separated

6. Gender
    1.Male
    2.Female

B. Consumer information

7. How often does your family eat sweet potatoes (number of times per week, during sweet potato season)
    1.Every day
    2.3-5 times per week
    3.Once per week
    4. Never

   If never why?---

8.What are the methods of cooking normally used? (Tick all that are applicable)
    1.Boilling
    2.Steaming
    3.Roasting
    4.Frying

9. Is it mixed with other ingredients (ie.Futari)?
    1.Yes
    2.No

10.If yes, what are they
    1.Beans
    2.Cassava
    3.Groundnuts

11.Who prepare/cook your sweet potato
1.Women
2.Men
3.Children
4.Both

12. How do you utilize your sweet potato. (Tick all that are applicable)
1.Main dish
2.Break fast/snack
3.Supplement
4.Others

13. Do you process/ preserve sweet potatoes
1.Yes
2.No

14. If yes, what are the products?
1.Michembe
2.Matoborwa
3.Others (specify).

TASTE TEST

Name of evaluator ______________________________________
Name of espondent__________________________________Sex/Gender________________
Age of respondent____
Date_______________________________ Village_____________________________
District____________________________________

Attributes	Varieties			
	207	559	180	329
Colour				
Smell				
Flavour				
Fibres				
Texture				
Flouriness (Starch)				
Overall impression				

Subjective score
1 = Very bad; 2 = Bad; 3 = Moderate; 4 = Good; 5 = Very good

PAIR WISE RANKING

Variety	Variety			
	207	559	180	329
207	X			
559	X	X		
180	X	X	X	
329	X	X	X	X
Total score per variety				
Rank				

Reasons for high ranked variety
1______________________________
2______________________________
3______________________________

Reasons for low ranked variety
1 ______________________________
2______________________________
3 ______________________________

Appendix 2: Questionnaire for traders

1. Market location_______________________________
2. Name of trader________________________________
3. Age of trader (yrs)__________________________
4. Gender/Sex
   1. Male
   2.Female

5. Category of trader
   1.Middlemen
   2.Broker
   3.Retailer
   4.Whole seller
   5.Others (specify)…………………………………………..

6. Where are the sources of sweet potato
   1.____________________________________
   2.____________________________________
   3.___________________________________
   4.____________________________________

7. What are the varieties supplied or sold in the market

Rank	Variety name	Yellow/orange	White
1			
2			
3			

8. What are the buying and selling prices

Quantity (wt in kg)	Buying price	Selling price
Sack		
Heap		
Others (specify)		

9. Does season/weather influence supplies and prices
   1.Yes
   2.No

10. If yes, how
   1____
   2____
   3____

11. What determine price
    1.Size
    2.Quality
    3.Quantity
    4.Size, quality and quantity
    5.Others

12. What are the qualities of the product supplied with season

Quality	Seasons	
	High	Low
Good		
Moderate		
Bad		

13. What are the volumes handled daily and weekly

Amount (sacks)	Daily	Weekly
Less than 1		
1-5		
6-10		
More than10		

14. Who are the major buyers/customers
    1.Whole sellers
    2.Retailers
    3.Processors
    4.Inter regional traders
    5.Others

15. Which are the most preferred varieties

Type	Reasons	Type	Reasons
Orange/yellow		White flesh	

16 What are the major problems faced
    1 ____
    2____
    3____
    4____

Appendix 3: Reasons for high preference of sweet potato per district

Attributes for ranking	Missungwi		Meatu		Sengerema	
	N=130	%	N=126	%	N=124	%
Good colour	22	16.9	12	9.5	11	8.9
High starch/ floury content	41	31.5	42	33.3	41	33.1
Good flavour	22	16.9	31	24.6	44	35.5
Good texture	2	1.5	10	7.9	3	2.4
Good smell	2	1.5	12	9.5	1	0.8
Sweetness	41	31.5	19	15.1	24	19.4

Appendix 4: Preference of sweet potato variety by gender

Varieties	Male		Female	
	N=171	%	N=209	%
Sekondari	64	37.4	79	37.4
Mafuta	7	4.1	5	2.4
Carrot Dar	25	14.6	22	10.5
Polista	62	36.3	87	41.6
Japon	10	5.8	14	6.7
Zapallo	3	1.8	2	1.0

Appendix 5: Reasons for high preference of sweet potato by gender

Attributes for ranking	Male		Female	
	N=171	%	N=209	%
Good colour	24	14.0	21	10.0
High starch content	57	33.3	67	32.1
Good flavour	44	25.7	53	25.4
Good texture	6	3.5	9	4.3
Good smell	6	3.5	9	4.3
Sweetness	34	19.9	50	23.9

Appendix 6: Pattern of sweet potato consumption by gender

Frequency of sweet potato consumption	Male		Female	
	N=171	%	N=209	%
Every day	102	59.6	121	57.9
3-5 times per week	68	39.8	88	42.1
Once per week	1	0.6	0	0.0

Appendix 7: Cooking methods for sweet potato by gender

Cooking methods	Male		Female	
	N=171	%	N=209	%
Boiling	103	60.2	127	60.8
Boiling and roasting	68	39.8	82	39.2

Appendix 8: Utilization of sweet potato by gender

Utilization pattern	Male		Female	
	N=171	%	N=209	%
Main dish	104	60.8	134	64.1
Breakfast/snack	21	12.3	18	8.6
Supplement	3	1.8	6	2.9
Main dish and breakfast	43	25.1	51	24.4