INFLUENCE OF QUALITY ATTRIBUTES ON THE MARKET VALUE OF FRESH SWEET POTATO TUBERS AND PROCESSED CASSAVA

BY

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Abstract

Cassava (*Manihot esculenta Crantz*) roots and sweet potato *(Ipomoea batatas (L) Lam)* tubers are important staple food crops in several areas of Tanzania. Studies were conducted in Mwanza and Dar es Salaam markets in order to assess the factors that influence the quality and market value relationship of fresh sweet potato tubers and processed cassava roots.

Consumers and traders in Mwanza preferred sweet potato tubers which are wholesome and free from infestation. White processed cassava root products were preferred by traders and consumers in Mwanza.

Valuation assessment made on sweet potatoes showed that, broken, cut and weevil infested tubers sold were at 12.1, 14.2 and 36.6 percent discount respectively. Average valuation discount of processed cassava roots were 10 to 15 for yellow, 20 to 25 for greenish and 35 to 40 percent for dark product.

Causes of losses in quality of sweet potato tubers were due to operations related to handling and transportation. Occurrence of broken tubers, skinning injury and cuts increased significantly with handling and transportation ($P \leq 0.001$). The largest loss in quality occurred between the lakeshore and the port at Mwanza when sacks were loaded and unloaded from the ship and handled at the port.

Broken sweet potato tubers and skinning injury increased significantly ($P \leq 0.001$) during handling and transportation from Gairo to Da es Salaam

Impact shock loggers provided a low cost method for comparing the handling of sacks during transportation. Shock impact record increased with increase in the height form which sweet potato sacks were dropped (R^2 adjusted = 0.875). Multiple linear regression analysis indicated that the number of impact in the category between 0.2 and 2 g significantly correlated with skinning injury (P=0.001), (R^2 adjusted =0.651) and broken tubers (P=0.001), (R^2 adjusted = 0.407) respectively.
Weight loss during storage increased significantly (P=0.01) with shock impact and skinning injury. Dropping sacks of sweet potato tubers significantly ($P \leq 0.01$) increased the occurrence of broken tubers

The use of cardboard boxes filled with fewer tubers instead of overfilled polypropylene sacks and adoption of improved management procedures in the handling and transport are recommended.

Declaration

I, Grabiel Tito Ndunguru do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own original work and has not been submitted for a degree award at any other University.

Signature: ....

Date: 22nd November, 2001

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Dedication

To the one who always believes in me – my wife Angelika and children; Tito, Dominic, Karitas and George

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Abbreviations and Symbols

CIRAD	Centre de Decooperartion Internationale en Recherché Agronomique pour le Developpement
CIRAD – SAR	Departement des Systemes Agroalimentairies et Ruraux
CIP	International Potato Centre
CIAT	Centrol Internacional de Agricultura Tropical
COSCA	Collaborative Study on Cassava for Africa
DFID	Department for International Development
(g)	Acceleration
g	Gram
GATT	General agreement on Trade and Tariffs
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
kg	kilogram
NRI	Natural Resources Institute
TBS	Tanzania Bureau of Standards
TFNC	Tanzania Food and Nutrition Centre
TZS	Tanzania shillings
UNCTAD	United Nations Centre for Trade and Development
USA	United States of America
U.K	United Kingdom

CHAPTER 1

INTRODUCTION:

1.0 General information

Cassava (*Manihot esculenta Crantz*) roots and sweet potato *(Ipomoea batatas (L) Lam)* tubers form a significant component of the staple food supply in the tropics (Grace, 1977). Root and tuber crops also play an important role in the agro-economics of most African countries, contributing significantly to basic food requirements in urban and rural areas as well as having some non- food uses. These crops are drought resistant and are also important to both rural and urban food supplies. They are importance in food security at all levels and create a balance between local food production imports. However, until recently, very little information has been collected on the consumption patterns and marketing systems of these commodities as they are considered to be of low economic value. Their importance far outweighs what the production and trade figures indicate. However, these crops have generally not been developed into diverse processed and culinary forms, partly as a result of limited research and development (FAO, 1994). In general, the marketing of these crops is poorly organized (Griffon, 1995) and they are not receiving much attention from research and development bodies. They are grown in a subsistence context, resulting in an inadequate supply to markets. Inconsistency in quality appears to be a major factor constraining expansion of the sector. Unfortunately, these crops have been denied the infra-structural support needed for their full promotion and development. Such support include, research, extension, subsidies, organized production, processing and marketing facilities (Griffon, 1995).

1.1 Cassava

In Tanzania, cassava root herein after referred to as cassava is especially important in the Lake, Western, Southern and Eastern Zones (Msabaha *et al.* 1986). Recognising the shortage of data on cassava in Africa, the collaborative study of cassava in Africa was initiated in 1987/88 (Nweke, 1988). Phase I data, collected in a village-level survey, has given an overview of the postharvest systems for cassava (NRI, 1992). The analysis of Phase I data has also provided a stimulus for the new interest in postharvest research in Tanzania (Ndunguru *et al.* 1999). Cassava is consumed in both fresh and processed forms. The marketing of fresh cassava is limited by its very short shelf-life. Although techniques for extending shelf-life up to one week are being disseminated by NRI through the Regional Africa Technology Transfer project on Non-Grain Starch Staples (Bancroft, 1995), processing is generally used to produce a more storable commodity (Westby, 1991).

There are three principal traditional processed cassava root products in Tanzania, *makopa*, *udaga* and *kondowole*. *Makopa* is the major sun-dried product of the Coastal and Southern Zones of the country, whereas *udaga* is a fungally fermented product that is commonly processed in the Lake Zone (Mlingi, 1995). *Kodowole* is a soaked fermented cassava root product predominantly consumed in the Southern zone of Tanzania. Needs assessment surveys undertaken in Dar es Salaam, Tanga region and Lake Zone under the Regional Africa Project on Non-Grain Starch Staples (Digges *et al.* 1994; Ndunguru *et al.* 1995), have shown that the quality of both products is considered variable and unreliable by urban consumers, and that this adds to the low status that cassava holds in the market as compared to commodities such as maize and rice.

An additional potential quality problem was indicated by Crop Postharvest Programme work in Ghana which demonstrated the potential of slowly sun-dried, or poorly stored, cassava to support mycotoxin formation (Wareing, 1993).

The key quality criteria of cassava products considered by consumers have not been well defined, although some initial information has been collected by Kapinga *et al.*, (1995). Little is know about the quality and value relationships that exist for these processed products. Fungal fermentation (Westby, 1991) is the key to the processing of many of these products but little is known about the process or the possibilities for improving it. It is hypothesized that if significantly higher prices are to be gained from improved quality products, the incomes of the people living in marginal areas can be improved.

1.2 Sweet potato tubers

Sweet potato (*Ipomoea batatas* (L) Lam) is a traditional crop for subsistence farmers in Tanzania but is now increasingly being marketed. The major production areas are the Lake Zone, Southern Highlands, Eastern and Western Zone (Kapinga *et al.* 1995). The marketing systems for sweet potato tubers, however, are poorly developed with high levels of tuber damage. A survey 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 (Ndunguru *et al.* 1998; Thomson *et al.* 1997).

Although processed sweet potato products such as *matobolwa* and *michembe* exist, fresh tubers are preferred. As with cassava, precise information on the marketing system is scarce, although it is clear that the perishability of the fresh tubers is a major constraint to the marketing of the commodity. A survey of farmers undertaken by the Tanzanian National Root and Tuber Crops Programme has drawn attention to the importance of minimising losses by improving postharvest handling systems (Kapinga *et al.* 1995). The existing marketing systems for sweet potato tubers are considered poorly developed with high levels of tuber damage during transportation. However, the true extent of both biological and economic losses is not known and the relationship between cultivars, marketing systems and quality depreciation is inadequately understood. Improvements of sweet potato tuber handling are considered a high priority by the Tanzanian National Root and Tuber Crop Programme (Anon, 1993.)

Fresh sweet potato tubers are transported in sacks in Tanzania. This is in contrast to the use of partitioned fibreboard cartons filled with between 13.6 and 18.2 kg of tubers as recommended by Medlicott (1990) for export. Little is known about the handling and transport of sweet potato tubers and their effect on quality and market value in Tanzania.

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 fixed prices which differ in total weight depending on factors such as the size (small, medium, large) and quality of the tubers. The actual price of the tubers is further complicated by a "top up" of additional roots which is given as part of the sale negotiation process. With respect to quality, sweet potato tubers within each heap may be undamaged or they may have cuts or breaks, shrivelled or suffered from weevil damage.

However, the true extent of both biological and economic losses is not known and the relationship between cultivars, marketing systems and quality depreciation is inadequately understood. Scott *et al.*, (1992) reported on quality attributes of sweet potato tubers during a survey on consumer demand of the crop in Dar es Salaam. The major physical quality attributes considered during the survey-included cuts, breaks, surface weevil, bore weevils, shriveling, variety and wholesomeness. However, the relationship between product quality and market value was not established.

Monitoring the damage sustained by produce during handling is key to understanding the causes of the losses and developing means of overcoming them. Booth (1976) reported that, root crops normally succumb to injuries during harvesting and subsequent handling from the farm to the market. Objective methods for monitoring the handling of fruits and vegetables have been previously reported. Various electronic devices known as 'instrumented or electronic spheres' (Morrow and Ruscitti, 1990; Orr *et al.* 1994; Thomson and Lopresti, 1996; Baheri and Baerdemaeker, 1997), 'electronic tubers' (Peters and Leppack, 1991; Leppack, 1996), 'pressure balls' (Herold *et al.* 1996) and 'artificial fruits and vegetables' (Anderson, 1990) have been used. While these instruments have not been reported in research on sweet potato tubers, they have been used for investigating the mechanised handling of Irish potatoes (*Solanum tuberosum*).

(Peters and Leppack, 1991). They have been used to identify the critical points that affect quality, in the mechanical handling of Irish potatoes and to allow remedial action to be taken (Anderson, 1990).

1.3 Justification of the study

Fresh cassava roots cannot be stored for a long time because they begin to rot within two to four days after harvest (Booth, 1975; Nweke *et al.* 1994 and Bokanga, *et al.* 1994). It is both desirable and necessary, therefore, to process cassava into more storable commodities, which are palatable and free from their cyanogenic potential (Westby, 1991; Mlingi, 1995 and Gidamis *et al.* 1993) Globally, cassava is processed into a number of products depending on their end use (Grace, 1977). These products include chips, pellets, flour, *gari, fufu*, *chikwangue*, and cossets and starch (Grace, 1977; Nweke, *et al.* 1994; Dovlo, 1973; Cork, 1985). There are three main traditionally processed cassava products in Tanzania, "*makopa*" "*udaga*" and "*kondowole*" (Mlingi, 1995). Farmers normally process cassava into these products mainly for home consumption. Currently, farmers have started to recognize the importance of processing cassava into products that can be marketed for income generation and improve their livelihood. Processing of cassava is a means of adding value to the crop and hence better prices. However, better prices is a function of market demand of the products. Quality of the products is one of the factors that stimulates market demand for any particular product. Little is known about the quality and value relationships that exist for these processed products and hence farmers and traders cannot see the relative benefits of improving processing, storage and other handling methods as required by the markets.

As with cassava, precise information on the sweet potato tuber marketing systems is scarce, although it is clear that the perishability of the fresh tubers is a major constraint to the marketing of the commodity. The existing marketing systems for sweet potato are poorly developed with high level of root damage during transportation (Bashasha and Mwanga, 1992).

Fresh sweet potato tubers are pre-dominantly traded in Mwanza city markets. In Dar es Salaam, fresh sweet potato tubers are also traded in all major markets of the city. Needs assessment survey carried out in Dar es Salaam and lake Zone (Ndunguru *et al.* 1994; Digges *et al.* 1994) showed that the quality of sweet potatoes is variable and does not relate to market prices. The survey indicated that farmers and traders do not perceive quality to have an influence on price of sweet potato tubers and processed cassava root products. However, consumers would want to buy products that will give them maximum satisfaction in terms of both quality and quantity.

The aim of this study was to determine how producers and consumers perceive and define quality and to scientifically establish the relationship between quality and market value of the crop. The other aim of the study was also to determine how losses in quality occur and recommend means of improving quality and hence market value. Identification of critical stages in the handling and transport system that affect quality was also carried out so that low cost interventions can be developed to improve quality for the consumer and improve returns for farmers.

1.5 OBJECTIVES:

1.5.1 General objective

The overall objective of this study was to determine the relationship between quality and market value of sweet potato tubers and processed cassava root products, establish how losses in quality occur and test means of improving quality and hence market value.

Specific Objectives:

1. To identify quality attributes for fresh sweet potato tubers and processed cassava roots.
2. To develop methods for assessing the relationships between quality characteristics and market value for sweet potato tubers and processed cassava products
3. To assess marketing systems in order to identify the causes of quality loss
4. To identify means of overcoming the loss in sweet potato tuber quality during handling and transporting to the market

CHAPTER 2.0

2.0 LITERATURE REVIEW

2.1 Importance of cassava roots and sweet potato tubers

Cassava (*Manihot esculenta* Crantz) roots and sweet potato *(Ipomoea batatas* L. (Lam*)* tubers form a significant component of the staple food supply in the tropics. The world production of cassava and sweet potatoes was reported by Chandra (1998) to be 163.9 and 122.0 million metric tones, respectively. Now grown throughout the tropical world, cassava is second to sweet potato as the most important starchy root crop of the tropics (Grace, 1977). Africa produces an estimated 82.8 million tons of cassava annually which translates to an average of more than 200 calories per capita per day for 200 million people (Nweke *et al.*, 1994; Bokanga and Ekanayake, 1998). Production of sweet potatoes in Africa was reported by Woolfe (1992) to be 7.5 million metric tons. Although cassava is grown in every country of the tropics, cultivation is concentrated in Zaire, Democratic Republic of Congo, Central African Republic, Nigeria, Ghana, Cote d'Ivoire, Cameroon, Mozambique, Uganda, Tanzania and Burundi. Other important cassava producing countries are, Brazil, Colombia, Indonesia, Thailand and India (FAO, 1984). In Tanzania cassava is especially important in Lake Zone, Western, Southern and Coastal Zones (Msabaha *et al.*, 1986; Ndunguru *et. al.*, 1998). In sub - Saharan Africa the trends in cassava production, yield and area have been fluctuating over the years as shown in Table 1.

Table 1. Cassava root production, area and yield trends in Tanzania as compared to other major African growing countries, 1973 - 1995

Country	Production (000mt)			Area (000ha)			Yield (t/ha)		
	1973-75	1983-85	1993-95	1973-75	1983-85	1993-95	1973-75	1983-85	1993-'95
Tanzania	4477	6854	6670	783	673	645	4.8	10.3	10.4
Nigeria	1006	11750	30770	1007	1200	2889	10.4	9.2	10.6
Zaire	11345	15044	18405	1648	2093	2225	6.8	7.2	8.0
Ghana	1700	2956	5417	245	317	540	7.3	9.0	7.2
Uganda	2491	2607	2615	529	358	346	5.4	7.6	8.5
Mozambique	2517	3183	3661	517	540	912	5.2	5.8	3.7
Madagascar	1249	2060	2303	195	338	336	6.3	6.1	6.8
Angola	1673	1950	1482	480	500	260	3.4	3.9	3.6

Source. Henry and Gottret, 1996

Sweet potatoes are mainly produced in China, Indonesia, Uganda, Vietnam, Solomon Islands, Tonga, Rwanda, Burundi, Caribbean Islands, Papua New Guinea and New Zealand (Woolfe 1992; Chandra, 1998; MaCkay *et al.*, 1989). In Tanzania, sweet potato is important in the Lake, Eastern, Southern and Northern Highlands Zones (Kapinga *et al.* 1995). These crops are drought resistant and are also important to both rural and urban food supply. The unique advantages of these crops are capacity to produce abundant food at low cost, ability to give economic yields even in marginal lands, capacity to adapt well to wide range of climatic condition and comparative freedom from serious pests and diseases.

2.2 Utilization of cassava roots and sweet potato tubers

Cassava is the fourth most important source of calories for human consumption in the tropics (Roca and Thro, 1993). In Tanzania cassava is an important source of energy contending for second place in energy supply (Kavishe, 1993). A good proportion of cassava is consumed as human food (Araullo *et al.* 1974). The form in which cassava is consumed varies by country and region (Phillips, 1973). In Africa cassava is universally consumed as vegetable for baking or boiling or in pastes or mashes made from cassava flour. In East Africa preferences encompass consumption of pastes made from fermented or sun dried roots. Tapioca, *fufu* made from pounded and boiled roots and *gari*, which is a dried, grated, and fermented cassava, are basic dietary elements in West Africa (Jones, 1959, Graffham *et al.* 1998).

In Tanzania cassava is mainly consumed in either fresh or processed forms. In fresh form, the crop is boiled, roasted or deep-fried. In processed forms, cassava is consumed as stiff porridge made of cassava flour. Others use cassava flour to make beer (Digges, *et al.* 1994). Unlike Europe where cassava is used as animal feed, Tanzania does not prominently use cassava for feeding animals or production of starch. Sweet potatoes are used primarily as human food. In developing countries, the major portion of sweet potatoes are cooked and eaten directly after harvest (Horton *et al.* 1990). Sweet potatoes in Uganda and Rwanda are dried and ground into flour for use in gruels, porridges and soups (McDowell, 1970). In Tanzania sweet potatoes are normally consumed after boiling in water. In urban areas, particularly in Dar es Salaam, sweet potatoes are roasted or deep fried for consumption as snack foods (Ndunguru, 1992). Attempts are now being made to promote the use of sweet potatoes in bakery and confectionery products (Kapinga *et al.* 1995).

2.3 Processing of cassava roots and sweet potato tubers

Fresh cassava roots cannot be stored for a long time because they undergo physiological deterioration within two to four days after harvest (Booth, 1976; Nweke *et al.* 1994; Bokanga, 1995). The perishability of the crop and its potential toxicity makes processing important. Processing of fresh cassava is also important in order to improve its palatability and quality. Processed products have longer shelf life and are easier to transport and market (Nweke *et al.* 1992). Common processed cassava products in Africa as reported by various authors are shown in Table 2. Some of the products can be eaten without further cooking, while others require extra preparation.

Table 2. Commercial processed cassava root products in the World.

Country	Product	Reference
Republic of Congo	Manioc flour, *Chikwangue* and cossettes	Grrace (1977), Nweke (1994)
Nigeria	*Gari* and *Chips*	Nweke (1994)
Ghana	*Fufu, gari* and starch	Doku (1969) and Dovlo (1973)
European Union	Animal feed	UNCTAD (1987)
Liberia	*Dumboi*	Grace (1977)
Southern Africa	*Nsima*	Nweke (1994)
Tanzania	*Makopa, udaga* and *kondowole*	Rwiza et al., 1995; Mlingi (1995)
Uganda	Chips	Agona (1998)

Cassava processing in Africa is primarily done by women (Bokanga, 1995). Ugwu and Ay (1992) showed that the number of women involved in cassava processing increased as the opportunities for commercialization increased. It was also observed that as mechanized processing equipment, such as graters and mills were acquired, men's participation in cassava processing tended to increase. It appears, therefore, that gender role in cassava processing tends to change as processing becomes more mechanized.

The principal cassava processed products in Tanzania are " *makopa* " "*udaga*" and " *kondowole*" (Rwiza *et al.* 1995; Mlingi, 1995). "*Makopa*" is a product of peeled cassava that is cut into pieces and sun-dried to a moisture content of 8-10 percent. This is the major product of the Coastal and Southern Zones of Tanzania. "*Udaga*" which is common in the Lake Zone is a cassava product, which is peeled; semi dried and fungal fermented for 4 to 6 days and then dried. Unlike the other two products, "*kondowole*" is a product obtained by soaking peeled cassava roots in water to ferment for four to six days until tender and then sun dried. Although other definitions for these products exist, the above definitions are based on those appearing in the previous COSCA reports (Nweke *et al.* 1994).

Processing methods of sweet potatoes vary from the simple slicing and field sun drying of roots as practiced in some developing countries to the large scale, multi-stage production of frozen, canned or flaked products which is performed in developed countries such as United States of America and Japan (Woolfe, 1992). In Tanzania, dehydration of fresh or blanched sweet potatoes by sun drying has been traditionally practiced in the country. Processing of sweet potatoes is common in Mwanza, Shinyanga and Tabora regions where the crop is processed into "*michembe*" and "*matobolwa*" (Kapinga *et al.* 1995; Wright *et al.* 1997). "*Michembe*" is peeled, boiled and dried chips of sweet potatoes while "*matobolwa*" are peeled and sun dried chips of the crop.

2.4 Marketing of processed cassava roots and sweet potato tubers

Root and tuber crops play a significant role in the agro - economies of most tropical countries, contributing significantly to basic food requirements in urban and rural areas as well as having some non-food uses. Introducing root crop products into new markets offers new or improved sources of income to farmers, processors and traders (Thro, 1993; Kleih, *et al.* 1994). In broad terms, there are three major opportunities that farmers and processors can access. These are high quality cassava flour as a replacement for wheat flour, cassava starch as a raw material for food and non-food industries and cassava chips for either the domestic livestock feed sector or for export (Bokanga, 1995). In general, however, the marketing of these crops is poorly organized (Griffon, 1995) and they have not received much attention from research and development organizations. They are often grown as subsistence crops which contribute to inadequate supply to markets. As such farmers have always been discouraged to produce more due to limited outlets (Bruinsma, 1999).

Scarborough and Kydd (1992) defined a market 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. Producers can then attempt to maximize their profits by supplying the relevant quantities and qualities of goods at the least cost. Stanton *et al.*, (1994) defined marketing as the performance of business activities that direct the flow of goods and services from producers to consumers or users. Marketing consists of those efforts which effect transfers in the ownership of goods and services and which provide for their physical distribution. The marketing process consequently involves both mental and physical aspects. Mental in that sellers must know what buyers want and buyers must know what is for sale. Physical aspects must be involved in that goods must be moved to the places at which they are wanted by the time they are wanted. Based on these definitions, a lot of research is required to establish a marketing system of root and tuber crops which will conform with these definitions.

The marketing system will require to define the product characteristics, the processing required and the marketing strategy to be used. According to Bruinsma (1999), the market for processed products is expanding worldwide. Curtis (1986) argued that research responding to this trend needs to be based on recognition that root and tuber crop processing in some countries such as in Africa is dominated by women, working alone or in groups. There is little interest in this activity from commercial industrial enterprises because available large scale processing techniques cannot yet guarantee product quality that will find broad acceptance among consumers. To-date, most research has been rather descriptive apart from those carried out by *Centre de Decooperartion Internationale en Recherché Agronomique pour le Developpement* (CIRAD), *Departement des Systemes Agroalimentairies et Ruraux* (CIRAD–SAR), Natural Resources Institute (NRI), International Fund for Agricultural Development (IFAD), International Potato Centre (CIP) *Centrol Internacional de Agricultura Tropical* (CIAT) and International Institute of Tropical Agriculture (IITA) which cover trade, processing, relative importance of various cassava products, consumer preference and acceptability, functioning of small scale enterprises and enterprise organization.

Closely connected with the seasonal nature of agricultural marketing is the variation in the amount and quality of the crop from year to year. Such variations lead to fluctuations in market prices as a result of changes in the conditions of supply (Scott, 1995). The variation in quality complicates the problem of grading, makes purchases and sales more difficult especially for manufacturers who commonly demand standardized raw materials with particular characteristics. Direct relationship between growers and manufacturers are thus handcapped, and a stabilized relationship between supply and demand is difficult to attain.

The complexity of the marketing system for agricultural products arises primarily from the need to concentrate the outputs of many relatively small producers into larger lots for efficient marketing. This involves the use of more wholesale middlemen than are necessary for the marketing of manufactured products (Bruinsma; 1999). Agricultural products, however, may require one or two wholesale markets to perform the work of concentration and a like number for the process of dispersion. This will help in understanding the channels of distribution for specific agricultural products if a note is first taken on the various types of agricultural wholesale markets. While Stanton *et al.* (1994) distinguished four classes of wholesale markets for agricultural products, markets for root and tuber crops are not very well defined (Nweke, 1994). In most cases these crops are marketed in local markets sometimes called local assembly markets or growers markets, which are found, close to the areas of production (Nweke, 1994). At the local markets, these crops are sold at retail markets and roadside stalls, at ambient conditions often without packaging (Bruinsman, 1999). Operators in these markets are wholesalers, retailers and consumers. The assembling of agricultural products in local markets is the first step in concentrating them at the central wholesale market. This operation is necessary because it would be inconvenient and too expensive for most central buyers to establish direct business relationships with the many producers of the farm products that they wish to buy. The average farmer likewise finds it inconvenient and expensive to establish business connections at central markets.

In Africa, central markets or terminal markets also play a major role in marketing root and tuber crops in urban areas. These markets are those in which products are concentrated in large volumes from local markets and some cases directly from growers. Some of these products are used in factories in urban areas and some are sold to jobbers and retailers for local consumption. Price determination takes place largely in the central market. It is here that buyers and sellers are brought together and that the forces of supply and demand determine product price. The adjustment of demand and supply has been said to be the principal function of central markets. Middlemen together with numerous facilitating agents such as brokers, commission agents and auction companies carry out the functions of the central market (Horton, *et al.* 1984).

2.4.1 Processed cassava root marketing

The commercial marketing systems of cassava depend on the product forms and the stage of development of the market economy (Hendershott *et al.* 1972). The systems also depend on the consumer preference for certain cassava products and their prices. The proportion of cassava marketed was reported by Tollens (1992) to be related to remoteness from market centers. Cassava roots are bulky and perishable and therefore are expensive to transport in the fresh form. If possible, therefore, farmers are likely to sell more cassava roots in processed form rather than in fresh form. This shows that cassava root processing is an important factor in marketing.

Processed cassava root marketing operations range from fresh roots sold or bartered for direct consumption to processed products such as those shown in Table 2. According to Berry (1993), there is little evidence that markets for processed cassava roots for human consumption are near saturation. Cassava has two distinct markets, which are the domestic market, mainly for human consumption and the export market for animal feed and starch (Grace, 1977; Kay and Gooding, 1988; and Gosh *et al.* 1988).

Substantial quantities of processed cassava roots (chips and pellets) are traded worldwide for the manufacture of animal feed. Starch is also traded in the world markets for making adhesives, paper sizing, laundry, sugar syrups and alcohol. World trade in 1981 was estimated to exceed 17 million tones (Kay and Gooding, 1987). Important exporters of cassava products are Brazil, Nigeria, Indonesia, Zaire, India, Colombia (Grace, 1977), China, Malawi, Tanzania, Togo, Malaysia and Thailand (Kay and Gooding, 1987). Table 3 shows some processed cassava exports from selected countries.

Table 3. Exports of processed cassava root products selected countries ("000" MT root equivalent).

Country	Years		
	1979	1980	1981
Malawi	7	7	7
Tanzania	182	156	50
Togo	1	1	1
Brazil	49	30	20
China	250	950	1050
India	NA	12	10
Indonesia	1931	1090	1200
Malaysia	47	47	40
Thailand	12420	12071	14900
Average	17355	14612	14662

Source: Walters (1983)

The principal markets for cassava products are in the European Economic Community (EEC) (Grace, 1977; UNCTAD, 1987 and Hendershott *et al.* 1972). The main importers for starch were reported (Grace, 1977; Ghosh *et al.* 1988 and Kay and Gooding, 1987) to be United States, United Kingdom, Canada, France and Japan.

The prices for these products follow the forces of supply and demand in that they are lowest in the months of the year when shipments are at peak levels and vice versa.

As noted earlier, in addition to these prices, premiums are paid according to the quality and origin of the pellets or chips (Grace, 1977).

The majority of cassava that is marketed is consumed locally. Nweke *et al.* (1994) reported that about 45 percent of the total cassava output in various selected villages of Africa is marketed. Furthermore, about 10 percent of the villages produced cassava roots almost entirely for market. While some authors such as Scott *et al.* (1992) have written a lot about cassava root processing, limited information has been documented about the marketing systems of cassava. Even in West Africa where cassava has almost replaced cereals in some locations, marketing of the crop has still remained informal (Nweke, 1988).

In Tanzania, processed cassava root products are marketed in the local markets, both within the areas where they are produced and in urban markets. Currently, there is no standard for processed cassava root products. Cassava root products are normally brought in the market in upgraded form. As such, consignments of cassava root products vary in color, particle size and degree of contamination by sand. For these reasons, traders and farmers fail to get premium prices for the products and consumers cannot as well get products of their choice and satisfaction. This raises the need for clear understanding of the role of quality in marketing of cassava products in increasing the market value of the products in Tanzania. Limited information is currently available on how quality relates to the value of the products (Bruinsma, 1999)

2.4.2 Sweet potato tuber marketing

The marketing of any fresh product constitutes the final stage of the journey of the food from the producer to the consumer (Edmond, 1971). As with the first stage, the final stage is often hazardous and beset with difficulties. Unless proper precautions are taken and recommended practices are followed, the roots are likely to rot before they reach the consumer or at best arrive in the retail store in an attractive condition. Most sweet potatoes are consumed domestically and only a small proportion enters international trade whether in the fresh state or in a processed form and very few statistics are available (Henry *et al.*, 1998).

In many countries including United States, fresh tubers of sweet potatoes are normally retailed in the local markets. Only United States and Philippines were reported to sell sweet potato tubers in a graded form (Woolfe, 1992). Farmers from these countries normally sort their tubers after harvest and grade them into different sizes using a grade standard for sweet potatoes (Kushman, 1975). In the United States grades of sweet potatoes were established as early as in 1920 (Edmond and Ammerman, 1971). Since that time practically all growers in all commercial districts have used them.

In Tanzania, the marketing channels for sweet potato tubers do not involve stages such as grading and storage (Thomson *et al.* 1997). 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. On retail basis, fresh sweet potato tubers are normally marketed in heaps at prices ranging from TZS.100 to 300 depending on the size of the heap (Thomson *et al.* 1997) or season. A heap is a pile of sweet potatoes, which comprises of between 5 to 7 tubers of different sizes and quality attributes. One heap normally weighs between 1.2 kg to 1.5 kg.

2.5 Importance of quality in root and tuber crops

Even though quality is universally recognized as significant, there is no agreement on a definition of product quality. However, Stanton *et al.* (1994) defined quality as a set of features and characteristics of a good or service that determines its ability to satisfy needs. Despite what appears straightforward definition, consumers frequently disagree what constitute quality in a product because personal tastes are deeply involved. Besides personal tastes, individual expectations also affect judgments of quality. That is a consumer brings certain expectations to a purchase situation. Optimal quality, therefore, means that, the product provides the consumer with experience that meets, but does not exceed expectations (Scott, 1995).

Quality plays an important role in enterprise development. The criteria by which the acceptability of a food is judged by the consumer is that of quality. The term quality is used to mean conformance of a product to requirement as well as a level of performance (Stanton *et al.* 1994). For foods like sweet potato or cassava products, it will typically involve flavour, and aroma, texture and firmness, size, shape and appearance. It is a complex function of many attributes of food. Quality is measured in terms of purity, grade of material used, the technical perfection of design and standards of production (Scarborough, 1992). The measurements may be carried out in the laboratory or in the field using appropriate methods. It relates to both the process and the product, and it is one of the factors of determining competitiveness in the market. Process and product quality is influenced by the availability and reliability of equipment, information services, training and organization (Bruinsman, 1999).

Many of the these attributes are extremely difficulty to measure quantitatively and even if measurement is possible, the part each plays in the overall concept of quality will vary from consumer to consumer. It is therefore not possible to develop universal measurement of quality for any product.

Not only does the relative importance of individual attributes vary, but many of them have limiting values that render the product unacceptable whatever the values of the other attributes. Because of the difficulty of specifying quality, the concept of a "quality indicator" is often used. Ideally, a quality indicator should be a major quality attribute that must be readily measurable with sufficient precision and reproducibility. The scientific acceptability of a hypothesis requires that to be reproducible at all places and all times.

2.5.1 Processed cassava root quality

At the international markets, standards and specification do exist for cassava products. Grace (1977) and Gosh *et al.* (1988) pointed out major problems of quality in cassava products at both processing and exporting levels of the crop. Hendershott *et al.* (1972) urged that if cassava supplies of good quality are available, the crop might continue to hold its place in the American markets. For cassava, the same authors believe that, the existing cassava industry seems to be positively oriented toward improving yields and quality and a base of scientific capability has been established to which economic research could be added. Whereas quality was reported by Grace (1977) to be an important requirement in the world market of processed cassava products, there are no reported national cassava standards in the domestic markets. Grace (1977) considered qualities for cassava products be dry matter content, color, size of the chips, purity and proximate composition of the products. As cassava production is a commercial activity in Sub-Saharan Africa, the farmers, as well as processors and traders are concerned about the quality to the product. In Africa, color, texture and taste are the most important quality attributes of cassava products (Nweke *et al.* 1994). However, Hendershott (1972) urged that standards for quality of these products differed substantially among the importing countries. As such products traded in the markets are not yet consistent in quality. In the European Economic Community (EEC) market, premium prices are usually paid according to the quality of products (Grace, 1977).

Needs assessment surveys undertaken in Dar es Salaam and Tanga region and Lake Zone under the DFID Regional Africa Project on Non-Grain Starch Staples (Digges *et al.* 1994; Ndunguru *et al.* 1994) have shown that the quality of cassava products is variable. This adds to the low status that cassava holds in the market compared to commodities such as maize and rice. An additional potential quality problem was indicated by a DFID funded work in Ghana, which demonstrated the potential of slowly sun-dried, or poorly stored cassava to suggest mycotoxin formation (Wareing, 1993). Some evidence for similar inefficiencies in the processing, storage and marketing chain have been observed in Tanzania during informal surveys recently conducted in collaborative work between the Tanzania National Root and Tuber crops program and NRI in the Lake and Coast Zones (Wright *et al.* 1996). Little is known about the relationships that exist between quality and market value for these processed products. Farmers and traders cannot, therefore, see the relative benefits of improving processing, storage and other handling methods.

2.5.2 Sweet potato tuber quality

In the case of sweet potato tubers, only USA and Philippine sort and grade the crop for sale locally. Grading of sweet potato tubers is based on the length of the tuber, firmness, smooth clean tubers which are free from diseases, insect damage, cracks, freezing injuries and internal breakdown. Freedom from blemishes and diseases are other aspects of quality that need to be considered (Woolfe, 1992). Kapinga *et al.* (1995) and Scott *et al.* (1992) considered quality of sweet potatoes to be dry matter content, color of the flesh, variety, tuber size, taste, cooking quality and freedom from weevil attack. Skin injuries normally lower the quality of sweet potato tubers and, therefore, their market value. This is because sweet potato tubers have delicate skins and easily succumb to mechanical injuries. These injuries occur at all stages in the life of the produce from preharvest operations through harvesting and handling to exposure in the market and finally in the home (Booth, 1974; Stikeleather, 1990; Tomlins *et al.* 1998). The general causes of mechanical injuries were reported to be implements used in harvesting the crop, excessive handling, sun and weevils (Salunkhe and Desai, 1984).

2.5.3 Market information

Market information on agricultural products is important in order to gain an understanding about market situation on a particular product. Farmers need market information in order to know prices and the market requirement of their products in terms of quantity and quality (Stanton *et al.* 1994). They also want to have information on the existing infrastructures such as transport and storage facilities for smooth handling of the produce. Information on taxation system along the marketing chain is also important for the farmers. Similar to the farmers, traders and manufacturers also need information on the products in terms of their availability, quality and prices in order to make some decisions on the suitability of marketing the crops. However, the efficiency with which the marketing system transmits information among the different producer, wholesale and retail markets is important in assessing commodity flows and marketing techniques of a particular commodity (Bressler and King, 1970). Application of various pricing criteria is used in analyzing market efficiency.

While there is a lot of information on production, there is very limited information on the marketing of cassava and sweet potato products in Tanzania (Digges *et al.* 1994). The Marketing Development Bureau (MDB) of the Ministry of Agriculture and Co-operative announces prices of various agricultural products three times a week through radio broadcast. However, this announcement does not cover cassava and fresh sweet potatoes. Lack of market information on these crops denies both farmers and traders the chances to produce and market the crops according to the market requirement and get a better price from them. This also makes it difficult for the traders and farmers to organize themselves for a particular market due to lack of market information. This study, therefore, aimed at assessing the factors which influence the quality of processed cassava root products and fresh sweet potato tubers and hence their market value. Improving the quality of these products will increase their market demand. Consequently, their prices will go up and improve the livelihood of the farmers and processors. Consumers will also get products which will meet their preferences in terms culinary properties.

CHAPTER 3.0

MATERIALS AND METHODS:

3.1 Overview

Before the start of the work, it was necessary to develop a conceptual framework that could create an understanding of the relationship between quality and market margins of the key participants within the marketing chain. Tomek and Robinson (1981) defined market margins as the price of a collection of marketing services which is the outcome of the demand for and the supply of such services. The price of such services is determined by particular primary and derived demand and supply relations. However, marketing margins may fluctuate due to perishability of the product, the number of levels of participants in the marketing channel, the marketing services provided, and the risk and uncertainty borne by each of the market participants (Tomek and Robinson 1981). Figure 1 illustrates the scenario under which quality goods such as fresh sweet potatoes and processed cassava products can enter the market and stimulate demand among the consumer. There are three factors that are important in determining the market value of products along the marketing chain. The first factor is the ability of the suppliers to offer products that will meet the demand of the different end users in both quality and quantity. The end users might, for example consider their nutrition value, shelf life, taste, convenience of storing them and the status they confer relative to their price. The supplier is, therefore, influenced by the endowment of the factors of production. Different end users will dictate the pattern of disposal of the products. The suppliers will, therefore, use the factors of production to produce value added products at a cost that will be competitive in the market. This study investigated the factors that influenced supply of good quality sweet potato tubers and processed cassava roots to markets of Mwanza and Dar es Salaam.

The second factor is the market structure that involves various market agents as shown in Figure 1. The market is a place where sellers and buyers meet for exchange of goods and services. The role of the marketing agents is to facilitate market transaction of the products between the supplier and the consumer. It is the main activity of the market agents to arrange prices, supply market information and make negotiations between the supplier and the consumer. Since the aim of the market agent is to maximize profit, then he/she will arrange prices for the products that will satisfy his/her objectives. Studies were done in the markets to analyze the market transaction of sweet potato tubers and processed cassava roots in order to know how the market agents arrange prices and how they perceive quality of the products. Consumers were also met at the market to see if quality had any influence at all in buying the products. However, the market agents are influenced by the third factor, that is, the consumer.

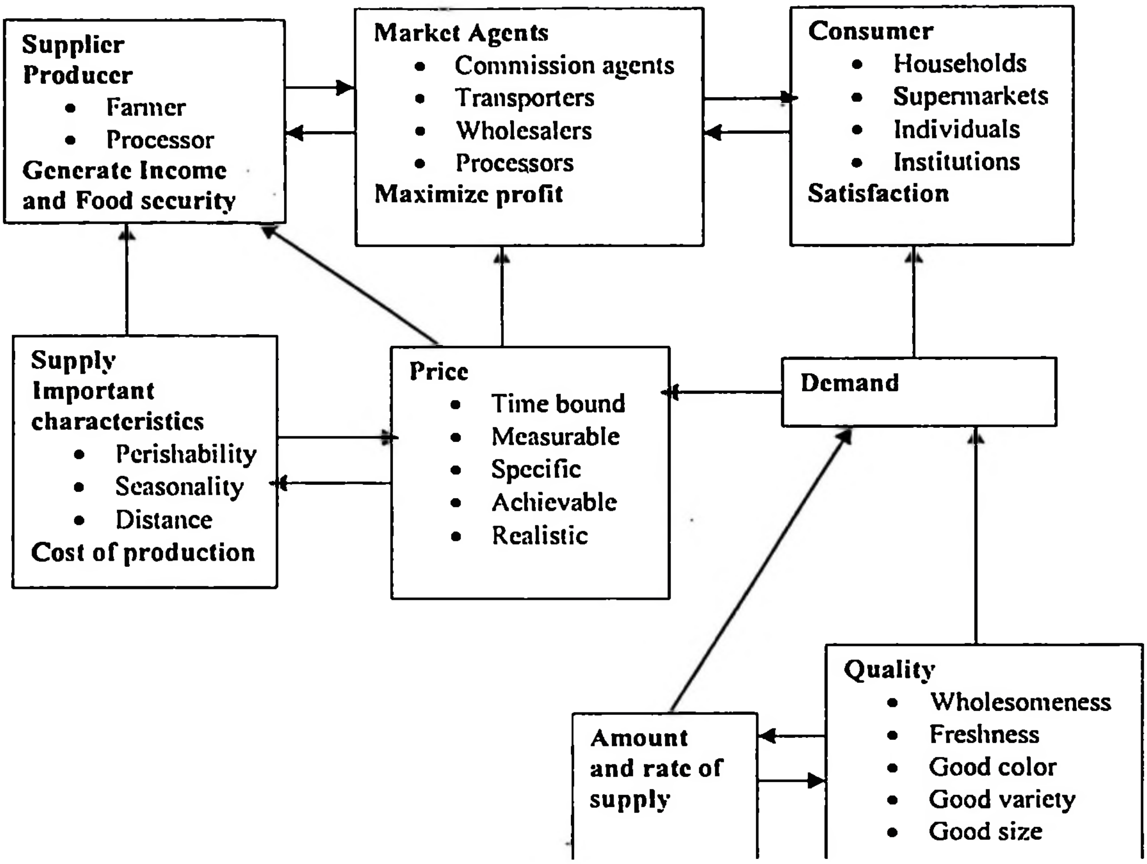

Figure 1. A model of conceptual framework for market efficiency

The third important factor is the consumer who will buy the products from the market in the form that will satisfy his/her demand in terms of quality and quantity. Prices set by the market agents will also influence consumer demand. High demand of the products by the consumers will result into higher prices of the products and, therefore, better margins of the traders and producers.

3.2 Study area

The study was conducted in Mwanza where both cassava and sweet potato tubers are produced and marketed throughout the year. Some studies on sweet potatoes were carried out in Morogoro and Dar es Salaam. Gairo and Gezaulole are areas in Morogoro and Dar es Salaam regions respectively, which produce sweet potato tubers for Dar es Salaam urban markets.

3.3 Sampling methods

This activity was done in Kirumba and Zimbabwe markets of Mwanza where both sweet potato tubers and processed cassava products are marketed. Initial observation in the various markets indicated that, cassava and sweet potato traders for any single market of Mwanza are limited in number. It was, therefore, unlikely that one could get a bigger sample size in one single market. It was also difficulty to get consumers who are willing to participate in the study from a single market. So, the choice of two markets aimed at getting more traders and consumers for the study. Clusters of traders of cassava and sweet potatoes were defined using data from the market masters of Mwanza city. Clusters comprised of men and women of different age groups and ethnicity. Using counting off sampling techniques Scott, *et al.*, (1992), five traders were sampled from the clusters for interview. Every second named trader from a list given by the market masters were interviewed. This sample was sufficient to represent a population from which many product samples could be taken. It was not possible to carry out random sampling of consumers because it was not easy to predict their number and thus not ease to prepare random numbers for the sampling procedure. The first fifteen to twenty people coming at the market to buy cassava or sweet potatoes were, therefore, interviewed.

3.4 Quality characteristics of sweet potato tubers and cassava products in markets in Mwanza City

3.4.1 Sweet potato tubers

Knowledge of the important quality characteristics of sweet potato is essential before starting to assess the relationship between quality characteristics and retail value. Previous studies on quality characteristics of sweet potatoes have been undertaken in Tanzania by Kapinga *et al.* (1995). This information was supplemented with opinions from informal open discussions with consumers and traders in Mwanza market. In this particular study, quality characteristics were divided into criteria associated with variety, damage and size. This was in accordance to the ways traders displayed the sweet potato tubers at the market.

3.4.2 Processed cassava root products

Like for sweet potatoes, the knowledge on quality characteristics of cassava products before the study was essential. Secondary information on quality characteristics of cassava products from previous work done by COSCA in 1988 and the National Co-Coordinator for Root and Tuber crops was reviewed. This information was supplemented with views from informal open discussions with consumers and traders.

3.5 Sweet potato tubers and processed cassava root marketing calendars in Mwanza City Markets

3.5.1 Sweet potato tubers

In order to gain an overview of the seasonality of the price quality relationships, a marketing calendar was prepared according to Tomlins *et al.* (1997) for each of the markets. The calendar was prepared through a participatory exercise with two market traders using a board and some grain of beans. It was found that the use of two traders facilitated discussion and led to more self correction of scoring. By trial and error, it was found that the best way to prepare the matrix on the board was to have the months on the horizontal axis and price, quantity and quality on the vertical axis. Beans were used to represent relative amounts. Traders were asked to place the appropriate number of beans for each month based on their knowledge of the market. They were encouraged to discuss their decisions and were allowed to change the scores until they were happy with the whole picture. Each bean for quantity and quality gave rough indications of changes but could not be used to measure absolute values. For prices, however each bean represented approximately TZS.1000 on the average wholesale price of a sack. The process was easily understood by the traders and it took a relatively short time. From the discussion with the traders, additional information to explain the trends and relationship in the matrix was obtained.

3.5.2 Calendar for processed cassava root products

A calendar matrix card divided into 12 months with separate categories for product quantity, price and quality was completed by two wholesale traders at Zimbabwe market with a good overall knowledge of market conditions. The method used was the same as that used for sweet potato except that the bean counters used were assigned a discrete value such as one lorry load or TZS 1000. The exercise generated very valuable insights into the seasonality of market conditions.

3.6 Studies on quality value relationship of sweet potato tubers and processed cassava root products

3.6.1 Testing of methodology for assessment of quality and market value relationship

Testing of methodology for assessment of quality value relationship was done only for fresh sweet potato tubers because of their perishability during postharvest handling. Two different complementary approaches for assessing the relationship between quality and market value of fresh sweet potato tubers were tested. The first approach used a participatory ranking and valuation exercise to gain an impression of the major quality issues and the impact of specific types of quality deterioration on market value. The second approach allowed the impact of different quality characteristics in market value to be quantified by use of appropriate statistical programme. Participatory methods rely on the active participation of market traders and consumers in the collection, analysis and interpretation of data. It is possible to generate more detailed information than can be obtained by using formal questionnaire based survey methods alone.

Kleih *et al.* (1997) gives an overview of participatory approaches to needs identification in root and tuber crops postharvest systems. The second approach involved statistical quantitative analysis of the products. Suitable methods were then used in the assessment of the quality value relationship of sweet potato tubers. For processed cassava root products, only the participatory approach was tested and adopted for use due to the nature of the product.

3.6.1.1 Participatory valuation of sweet potato tubers of different qualities

Although several participatory approaches were evaluated for collecting primary data, only the most successful are reported here. The technique used involved creating heaps of sweet potato tubers of the same variety and weight (about 1.4 kg), but with different quality attributes. Each heap comprised five sweet potato tubers. The only differences between the heaps were that one comprised of five undamaged tubers, one of five badly cut tubers, one of five badly broken tubers and one of five weevil infested tubers. The different quality attributes were, breaks, cuts, shriveling, and weevil attack each measured as zero (score 0), minor (score 1) or major (score 2). In Mwanza markets, traders normally sell sweet potatoes in heaps at prices of TZS 100, TZS 200 and TZS 300 categories. The weight of roots selected was typical of a TZS 200 heap. A sample of 5 traders and 15 customers were asked to rank the four heaps in terms of preference and then asked to value the heaps. For the second part of the exercise, TZS 200 (the usual price) was assigned to the number one ranked heap and the individuals were asked to assign any one card labeled from TZS 120 to TZS 190 in units of TZS 10 to each of the other heaps, bearing in mind their initial ranking.

In this way, a valuation estimate was obtained for each category of sweet potato damage, which was independent variety, size and market.

3.6.1.2 Statistical approach in the valuation of heaps of sweet potato tubers

A complementary part of the study involved recording the quality of sweet potatoes in a sample of heaps on sale at the major markets in Mwanza. A proforma data recording sheet is shown in appendix 1

In this appendix, location refers to the name of the market, which is Mwanza is Central, Mwaloni or Zimbabwe. Selling price per heap was easy to ascertain as traders organized heaps into TZS 100, TZS 200 and TZS 300 price categories broadly consisting of small medium and large sized sweet potato tubers, respectively. Variety refers to the variety of sweet potato tubers in a heap. Note that to facilitate subsequent analysis, every sample heap comprised of tubers of the same variety. Although mixed variety heaps are sometimes on display, these did not form part of the survey and if necessary traders were asked to form heaps of single variety. Days at the market were taken as '1' if the tubers arrived on the day of the survey, '2' if they arrived the day before the survey and so on. The top-up column is a reminder to ensure that all sales are included in the sample, including those tubers that are added to the heap on display from behind the counter when a sale is made.

Each tuber was weighed individually and assessed for four quality attributes: breaks, cuts, shriveling and weevil attack, each measured as none (score of 0), minor (score of

1) or major (score of 2). All the four attributes were assessed visually by one team member whilst the other person recorded the scores. Feeling the tuber for tenderness further assessed shriveling. For weevils, only those that burrowed through the tuber skin were included in the assessment.

All the sweet potato tubers in each heap and the top-ups were weighed together to give the total weight for the sale. Later, the total weight was checked to that of the sum of the individual weights and adjustments were made to the weights of the largest tuber if any rounding errors had arisen.

The average scores for each of the four quality attributes were calculated as a weighted average of the scores for all the individual tubers in the heap. In this way, a large damaged tuber has more impact on the score than a small damaged tuber. The total number of tubers showing evidence of any damage for the four categories was recorded.

In order to obtain an overall sample of sufficient size and variation, five traders (or all traders if fewer than five) were sampled in each market. For each trader, the details of three heaps (or all heaps if fewer than three) were recorded for each selling price category of each variety. For example, if a trader was selling tubers in heaps of TZS 100 and TZS 200 and had four varieties, a total of 3 x 2 x 4 = 24 heaps were sampled for that trader. 184 heaps were sampled in total during the survey.

Using statistical package for social scientist (SPSS) software, the selling price per kilogram was computed for each heap and compared with seven quality related variables: breaks, cuts, shriveling, weevil scores, tuber size, age and variety. Further analysis of tuber damage by variety was made to perform multiple regression analyses.

3.6.1.3 Participatory approach for assessing the quality of processed cassava root products

This valuation was done during the low supply season usually in months of November and May when prices of the product ranged from TZS 800 to 1600 per bucket. Discussions were held with five and fifteen selected traders and customers to find out what the different processed cassava root products were and how each was differentiated according to quality. The two products in Mwanza markets are *udaga* and *makopa*. For *udaga*, both colour and particle size were said to differ. *Makopa* is a much more uniform product. Consumers and traders from each market were asked to agree or disagree on any quality attributes affecting the marketing ,of processed cassava root products. In each market, "*makopa*" and "*udaga*" chips of different quality attributes were displayed before the traders and consumers for assessment. The respondents were also required to rank the attributes in their order of importance in order to understand what affects consumer preference. Ranking was categorized as; 1= highly preferred, 2 = preferred and 3 = least preferred. The quality attributes of these products included color, particle size and degree of contamination by foreign matter. Small buckets of processed cassava root products were displayed according to specific quality criteria and 5 traders and 15 consumers were interviewed in order to find out what the different processed cassava root products are and how each was differentiated according to quality.

A sample of ten buckets of processed cassava root products was taken from Zimbabwe market, three each from sacks of white, gray and dark coloured *udaga* and one from a sack of *makopa*. Care was taken to ensure that the bags contained a uniform colour throughout and that there was no evidence of product mixing. Normally traders agree that there are three general *udaga* color types, but in reality there is a continuous range of prices from pure white to dark gray. However, for the purpose of value perceptions, the three categories of color are deemed sufficient. For each color of *udaga*, the three buckets were empted, resorted and refilled, one with fine particles, one with large particles and one with a mixture of different particle sizes. Largely because, the *makopa* on the display was fairly uniform in terms of both color and particle size, only one bucket was sampled.

The ten buckets were labeled A to J. A sample of five traders and fifteen customers was given cards which were marked with prices ranging from TZS. 800 to TZS. 1600 at TZS. 100 interval and asked to perform ranking for each type of cassava product. Each bucket contained a particular grade of product as follows;

Bucket A = Grade 1 (white *udaga* with fine, large, mixed particles).

Bucket B = Grade 2 (yellow *udaga* with fine, large, mixed particles).

Bucket C = Grade 3 (white fine *udaga*).

Bucket D = Grade 4 (gray udaga with fine, large, mixed particles).

Bucket E = Fine *udaga* of grade 1, grade 2 and grade 3.

Bucket F = White *udaga* with large particle size.

Bucket G = Yellow *udaga* with large particle size

Bucket H = Gray *udaga* with large particle size

Bucket I = Large particle size *udaga* of buckets F, G and H.

Bucket J = Grade 5 (*makopa* with large particle size).

After this exercise, attempts were made to assign a value to the different coloured products. First, three processed cassava root traders in Zimbabwe market were asked to estimate the values of each of the sample buckets, arranged into three groups of the same particle size but different in color. Buckets of *Makopa* and *Udaga* were weighed using a scale in order to have samples of approximately equal weight.

To determine customer value judgments, nine prices ranging from TZS 800 to TZS 1600 at TZS 100 interval were written on to pieces of card. This gave a manageable number of cards, one at the current general price for dried cassava products of TZS 1200 and four either side. The range also covered the approximate range of prices noted by the traders from TZS 750 to TZS 1600. A sample of 15 customers was then asked to assign values to the buckets in the same categories as traders. All the cards were carefully displayed before hand so that the customers were aware of the range. Any three of the nine cards could be used for each of the three valuation exercises. Data were recorded as shown in Appendix 1 for specific quality and price. Buckets of *makopa* and *udaga* were weighed using a weighing scale in order to have samples of approximately equal weight.

3.7 Causes of quality loss during postharvest handling of sweet potato tubers.

Booth (1974) considered losses to affect both quality and quantity of sweet potato tubers. However, there appears to be no systematic study of the extent of postharvest quality loss in relation to their market value. The major causes of loss of sweet potatoes were reported to be physical damage, pathological decay, weight loss, sprouting and greening in white varieties (Booth, 1974; Chang and Kays, 1981; Salunkhe and Desai, 1984). The general causes of mechanical injuries were reported to be implements used in harvesting the crop, excessive handling, sun (Booth, 1976; Salunkhe and Desai, 1984), finger nails of the handlers (Kushman, 1975), brushes used in packaging lines (Morris, 1981) and excessive soil moisture (Ton and Hernandez, 1978).

Processed cassava products lose quality mainly during processing when drying of the products is not efficient. Processed cassava root products during wet season encourage growth of mould in the product. Mould growth is said to reduce the quality of the processed cassava root products (Mlingi, 1995). A survey was thus conducted in Mwanza, Morogoro and Dar es Salaam in order to gain some understanding of marketing systems of sweet potato tubers and processed cassava root products. The marketing chain for each commodity was assessed in order to identify where and how the losses of the products quality occurred.

3.7.1 Quality losses of sweet potato tubers during postharvest handling

Postharvest quality, at the farmer's field and at varying stages in the marketing chain was assessed using a method tested earlier which allowed quantification of the data. The scoring systems are shown in Table 4.

Table 4. Scoring systems for various sweet potato damage

Damage description	Scoring system
Cuts	0 = none, 1 = minor, 2 = major
Shriveling	0 to 5 (0 = none, 5 = severe)
Skin weevil	0 to 5 (0 = none, 5 = severe)
Burrowing weevil	0 or 1 (0 = none, 1 = present)
Bruising	0 to 5 (0 = none, 5 = severe)
Rotting	0 to 5 (0 = none, 5 = severe)
Breaks	0 to 5 (0 = none, 5 = severe)

A total of three consignments of sweet potatoes at each of two locations (Mwanza and Dar es Salaam) were surveyed. At each location, the roots were obtained from the same farms. Three consignments of *Polista* cultivar were transported from the Sengerema District, Mwaloni and Zimbabwe markets in Mwanza and the other three consignments of SPN/O cultivar were transported from Gairo in Kilosa District to Tandale market in Dar es Salaam. At the farm, two samples of 40 randomly collected tubers were assessed for breaks, cuts, shriveling, skin weevil, bruising and rotting using the scoring system developed earlier in the study.

3.7.2 Monitoring of consignments of sweet potato tubers during transport

It was necessary to monitor the environment under which the tubers were handled from the farm to the market in order to relate the environmental factors with quality loss in sweet potatoes. The temperature, humidity and motion of the sacks were recorded by means of an 'electronic sweet potato datalogger' (RS Components, UK). (Figure 2) comprising a ventilated tubular plastic pipe (16 cm long and 6.5 cm diameter) fitted with temperature (-20 to 75°C +/- 1°C), humidity (0% to 90% +/- 5%) and shock (0 to 50 g +/1 10%) dataloggers

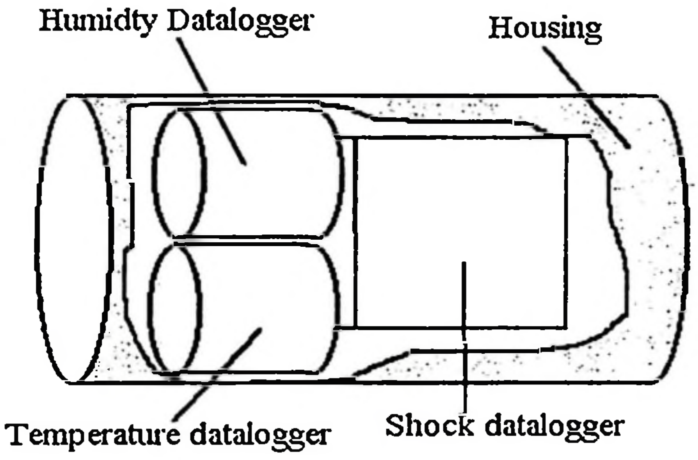

Figure 2. Electronic sweet potato logger

The temperature and humidity dataloggers were set to record every 10 minutes while the shock datalogger recorded the maximum acceleration (*g*) at either 30 s or 1 minute intervals.

To simplify the analysis and interpretation of results from the shock data loggers, shock data were classified as total shock (*g*)= sum of all shocks measured during the duration of transport and subsequent handling.

3.7.2.1 Consignments of sweet potato tubers transported from Sengerema district to Mwanza markets.

For consignments of tubers transported from Sengerema District to Mwanza, there were four sampling points in the marketing chain, namely, Farm, Lake shore at Sengerema District, Port at Mwanza and markets in Mwanza (Mwaloni and Zimbabwe) as shown in Table 5. Each of the three studies comprised 14 sacks each approximately weighing 120 kg.

Table 5. Sampling points of sweet potato tubers transported from Kaunda, Sengerema district to Mwanza markets

Approximate time for start of transportation (hrs)	Stage in transport chain	Transported sacks	Number of tubers sampled from sacks at any stage
0	Farm	Sacks (2)	Replicate of 40 freshly harvested tubers
4	Lake shore	Sacks (2)	40 tubers from each sack
18	Port at Mwanza	Sacks (2)	40 tubers from each sack
20	Market at Mwanza	Sacks (2)	40 tubers from each sack

Scores from the assessment of the tubers were recorded in a score sheet developed earlier during the methodology testing.

3.7.2.2 Consignments of sweet potato tubers transported from Gairo, Kilosa district to Tandale market, Dar es Salaam

For consignments of tubers transported from Gairo to Tandale market in Dar es Salaam, there were two sampling points, farm and market. Each of the three studies comprised 4 sacks of approximately 120 kg. The experimental design was as shown in Table 6

Table 6. Sampling stages of sweet potato tubers transported from Gairo, Kilosa district to Dar es Salaam market

Approximate time from start of transport (hrs)	Stage in transport chain	Transported sacks	Number of tubers sampled from sacks at any stage
0	Farm	0	Replicate of 40 freshly harvested tubers
24	Market	4	Replicate of 40 tubers wrapped in newspapers. Replicates of 40 tubers transported in carton

3.7.3 Evaluation of methods for overcoming quality loss in sweet potato tubers

Sweet potatoes possess delicate skin and are, therefore, prone to mechanical injury in the life of the produce from preharvest operations through harvesting and handling operations such as grading, packaging and transportation to exposure in the market (Booth, 1974). Mechanically injured sweet potatoes normally deteriorate rapidly due to respiration, water loss and entry of destructive microorganisms. During postharvest handling, sacks of sweet potatoes are dropped while loading and unloading in vehicles from various heights and impacts.

Tubers are also tightly packed in the sacks causing some skinning injuries to them. Bad roads cause some shocks to the tubers which lead to their breakages. Assessments were, therefore, done to evaluate the effects of dropping sacks of sweet potatoes, stuffing the tubers in sacks and transporting the sacks from Kaunda, Sengerema district and Gairo, Kilosa district to Mwaloni market in Mwanza and Tandale market in Dar es Salaam, respectively.

3.7.3.1 Effect of dropping sweet potato sacks on tuber quality

Sacks of sweet potatoes were bought in Kaunda and Gezaulole areas in Mwanza and Dar es Salaam regions for the study. Evaluation of the effect of dropping the sacks on tuber quality was done in the farms of the two respective areas. Experiments were conducted in duplicate unless stated otherwise. Tubers were harvested early in the morning and heaped in one place. After assessing the tubers from the heap, the rest were then tightly stuffed in sacks of 50 kg or 100 kg. Shockloggers (set to record after every five seconds) were inserted into the center of each sack. Each category of sacks were dropped 1, 3 or 6 times from a height of 0.5 m onto a firm and flat surface. Dropping of the sacks of sweet potatoes was done in replicates. Six sacks of each weight category were used in the study. Replicates of 40 tubers of sweet potatoes were sampled at random from each sack after dropping and assessed for breaks, skinning, shriveling, rotting, cuts and weevil damage. The control comprised of two samples of 40 freshly harvested undropped sweet potato tubers. This assumed a zero level damage for all parameters except those caused by weevils and hoes.

3.7.3.2 Effect of drop height on quality and shelf life

The lay out of the experiment was similar to that of the dropping experiment except that the dropping heights varied from 0.25, 0.5 or 0.75 m. The number of sacks of sweet potatoes and method for assessment of the tubers for quality was the same as that of the dropping experiment. The control comprised two samples of 40 freshly harvested and un-dropped sweet potato tubers.

The roots were then stored for two weeks in open sacks under ambient conditions where the sack weight, weight of six individual tubers and damage (shriveling and rotting) were assessed after 1, 3, 7 and 14 days.

3.7.3.3 Effect of loose or tight packaging on sweet potato quality

When sweet potato tubers are packed in sacks, they incur injuries due to bruising. This study was carried out in order to assess the effect of loose or tight packaging of sweet potato tubers on quality. Sacks of 50 kg or 100 kg were loosely or tightly packed with sweet potatoes, then dropped three times from a height of 0.5 m. Shockloggers were inserted in the center of the sacks. The control comprised of two samples of 40 freshly harvested and non packed sweet potato tubers.

3.7.3.4 Effect of stuffing sacks with sweet potato tubers on quality

Sacks of 100 kg were packed with sweet potatoes and then emptied again without dropping. Two controls of 40 freshly harvested roots were assessed. Tubers were assessed for breakage, cuts and skinning injuries.

3.7.3.5 Effect of preharvest pruning of the canopy of sweet potato vines on quality incurred during subsequent handling and shelf life

Bonte and Wright (1993) showed that pruning sweet potato vines some days before harvesting reduces loss of sweet potato quality during subsequent postharvest handling. This study was done in order to verify the effect of preharvest pruning of sweet potato vines before harvest on tuber quality. A plot of sweet potato field was selected for the study. Ten rows of sweet potatoes were selected from the plot. Half of each of the ten rows were pruned nine days before harvest (Table 7). After the nine days, the tubers were harvested and put into two heaps of pruned and un-pruned tubers. Three sacks of sweet potatoes of 100 kg were sampled from each heap and dropped three times from a height of 0.5 m. Shockloggers were placed in the center of each sack during the packaging of the sack. Replicates of 40 tubers were sampled from each sack after dropping for external quality assessment. Control samples of three lots of 40 tubers were taken in replicates from the pruned and un-pruned heaps of sweet potato tubers.

3.8 Causes of quality loss in processed cassava root products

Quality of processed cassava root products may be lost during postharvest handling. Literature was searched from various sources in order to understand how cassava products lose quality during postharvest handling. The secondary information cited was documented as part of the thesis.

3.9 Statistical methods

Analysis of variance (ANOVA), multiple linear regression (stepwise, backward mode, accept criteria F= 0.05, reject criteria F = 0.01) and principal component analysis (varimax rotation) were carried out using (SPSS).

CHAPTER 4.0

4.0 RESULTS

Research was carried out in Mwanza, Morogoro and Dar es Salaam regions in order to determine the relationship between quality and market value of sweet potato and processed cassava as out-lined in chapter 3. Factors influencing quality of each crops were identified all along the marketing chain from the farm to Mwanza and Dar es Salaam markets. Collected data were analyzed and results are presented in this chapter.

4.1 Knowledge about important quality characteristics of sweet potato tubers and processed cassava root products in Mwanza markets

Knowledge of the important quality characteristics of both cassava products and sweet potato tubers was essential before starting to assess the relationship between quality and market value of the products.

4.1.1 Sweet potato tubers

Information about quality criteria of the products was obtained from informal open discussions with consumers and traders in Mwanza markets. In this particular study, quality characteristics were divided into criteria associated with variety, damage and size of the tubers (Table 7). This type of information was very easy to collect by a small team (1-2 people) in less than one day.

Table 7. The quality characteristics of sweet potato tubers

Variety characteristics	Damage	Size and shape
Taste	Breaks	Easy of handling
Starchiness and texture	Cuts	Easy of peeling
Speed of cooking	Shriveling	
Skin colour and appearance	Surface weevil	
	Deep weevil	
	Bruising/skinning	
	Rotting	

4.1.2 Processed cassava products

Unlike sweet potato tubers, quality characteristics for processed cassava root products were divided into criteria related to colour, particle size and whether fermented or not. Table 8 shows the quality characteristics of processed cassava root products.

Table 8. Quality characteristics of processed cassava root products

Colour	Particle size	Whether fermented or not
White	Large	Unfermented
Gray	Medium	Fermented
Black	Small	

4.1.3 Sweet potato tuber marketing calendar

In order to gain an overview of the seasonality of the price quality relationship, a marketing calendar was prepared for Mwaloni market. This is a market which receives sweet potatoes from various places of production areas for supply to other markets of Mwanza City. Figure 3 shows the results of the matrix scores. Although the results are only indicative , the matrix suggests that quantities traded are highest between May and July.

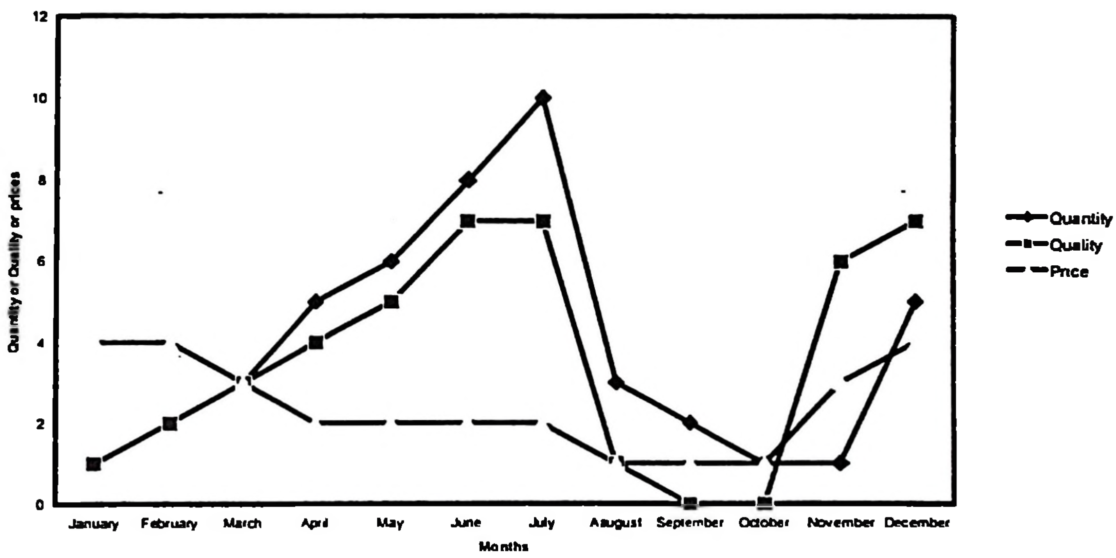

Figure 3. Ranking matrix showing seasonality for sweet potato tubers entering Mwaloni market, Mwanza

Note: Each value indicates changes in variables from month to month as perceived by two key sweet potato tuber traders.

Values for quantity and quality give rough indications of changes, but cannot be used to measure absolute values. For prices, however, each unit represents approximately TZS 1000 on the average wholesale price of a sack.

As is expected, prices were relatively low in May and July. There was a second higher peak in quantity traded in December which coincided with a crop of sweet potato tubers from paddy fields. Smaller quantities were traded in March and April (early harvest) and August and November (late harvest). Very little was traded in the remaining months since it was only available through in-ground storage and piece meal harvesting. Produce quality was highest during the main harvesting season when prices were low and quantity traded were high. Quality was lowest in September and October when tubers have gone beyond their optimum harvesting time. Prices fell to compensate for the poor quality at this time of the year. In-spite of the increase in supply of sweet potatoes during December, prices also increased due the beginning of the holy month of Ramadan and early parts of the year (January and February). Ramadan is a month when Muslims fast in Tanzania. During this period, the Muslims eat a lot of fresh cassava and sweet potatoes in breaking their fast and as such, the demand and prices for these products become increasingly very high.

4.1.4 Processed cassava root products marketing calendar

A calendar matrix card divided into 12 months with separate categories for product quantity, price and quality was completed by two wholesale traders at Zimbabwe market with a good overall knowledge of market conditions.

This exercise was carried out only at Zimbabwe market because it is the only main market trading on processed cassava root products in Mwanza city. The method used was the same as that used for sweet potato tubers. The results of the matrix scoring are displayed in Figure 4.

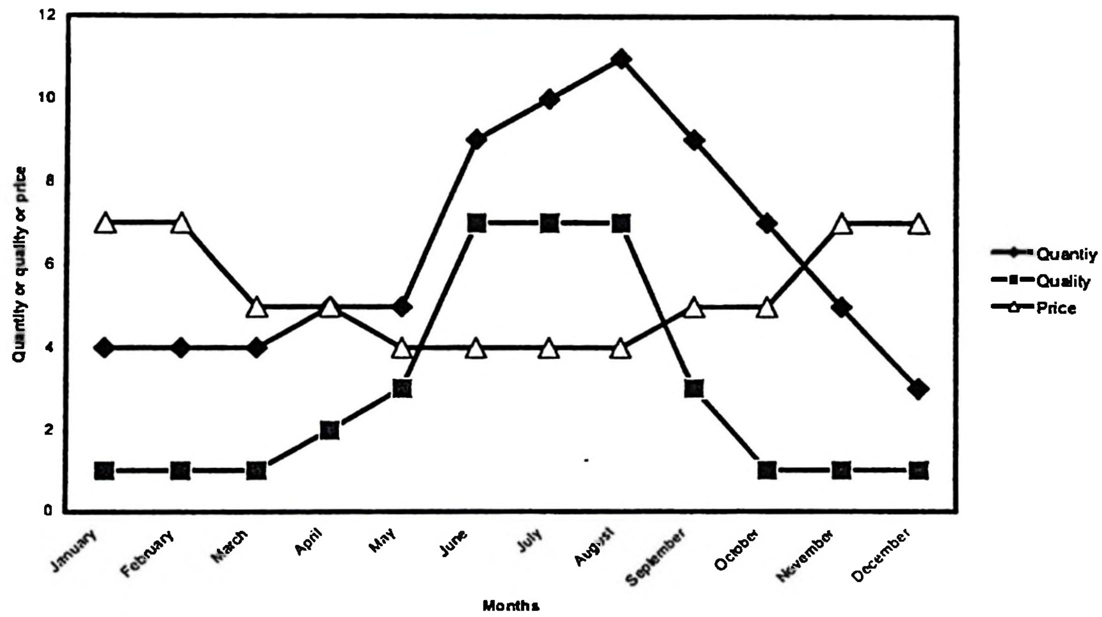

Figure 4. Ranking matrix showing seasonality for quantity, quality and price of processed cassava roots entering Zimbabwe market, Mwanza

Notes: Each value indicates changes in either supply or quality or price as perceived by key cassava traders. Values for quality give rough indications of changes, but cannot be used to measure absolute values. For prices, each unit represents approximately TZS. 1000 on the average wholesale price of a sack. For quantity, each value represents approximately one lorry.

Although the matrix only gives indicative results, it suggests that quantities traded were lowest between November and May, rise to the peak between June and September and then fell. Prices bare a very close relation to quantity with lowest prices at harvest time and highest prices between November and February. Trends in product quality followed those in quantity very closely.

4.2 Development of methods for examining the relationship between quality characteristics and value of marketed fresh sweet potato tubers and processed cassava root products

Two different complementary approaches for assessing the relationship between quality and market value of fresh tubers of sweet potatoes and processed cassava root products were developed. Both methods were used for assessing the relationship between quality and market value of the crop. The first approach used the participatory ranking and valuation exercise to gain an impression of the major quality issues and the impact of specific types of quality on market value. The second approach was the quantitative study which allowed the impact of different quality characteristics to be quantified. Participatory methods relied on the active participation of market traders and consumers in the collection, analysis and interpretation of data. It was possible to generate more detailed information than could be obtained by use of formal survey methods alone. The second approach involved quantitative analysis of the products by use of SPSS, version 8.0 which allowed tabulation, regression and other statistical interpretation of the results. For processed cassava root products, only the participatory approach was applicable due to the nature of the product.

4.2 1 Participatory valuation of sweet potato tubers

Although several approaches were used to valuate the relationship between quality and market value of sweet potato tubers, only the most successful is reported here. The technique used involved creating heaps of the sweet potato tubers of the same variety and weight (1.4 kg), but with different quality attributes such as good, with cuts, breaks and weevil damage. The weight of tubers selected was typical of a TZS 200 heap. A sample of five traders and 15 customers were asked to rank the heaps in terms of preferences and then asked to value the heaps. TZS 200 which is the normal market price was assigned to the number one ranked heap and the individuals were asked to assign any one card labeled from TZS 120 to TZS 200 in units of TZS 10 to each of the other heaps, bearing in mind their initial ranking.

Results in Table 9 indicate that, cut tubers were valued less than good tubers at 93% by traders and 85% by consumers. Similarly, broken tubers were valued at 83% and 87% by the traders and customers, respectively. Traders and customers valued sweet potato tubers infected with *Cylas spp* weevil at 64% and 63% respectively.

Table 9. Results of the market value assessment of sweet potato tubers with different quality criteria.

	Traders score n = 5		Customer score n = 15		Overall score	
Quality	Average price score TZS	Percent discount in price	Average price score	Percent discount in price	Average price score	Percent discount in price
Good	200.00	100.0	196.00	100.0	197.00	100.0
Cuts	186.00	93.0	166.70	85.0	173.10	87.9
Breaks	166.00	83.0	170.70	87.1	169.10	85.8
Weevils	128.00	64.0	123.30	62.9	124.90	63.4

Note: The most common heap value of sweet potatoes was TZS 200, typically weighing around 1.4 kg. Traders and customers were asked to first rank four heaps of sweet potatoes of different qualities, each having 5 tubers weighing a total of 1.4 kg. The current market price of a heap of TZS 200 was assigned to the number one ranked heap. The other heaps were valued using a selection of cards labeled from TZS 120 to TZS 190 at TZS 10 intervals

Results of the valuation of sweet potato tubers in Mwanza markets are presented in Figure 5.

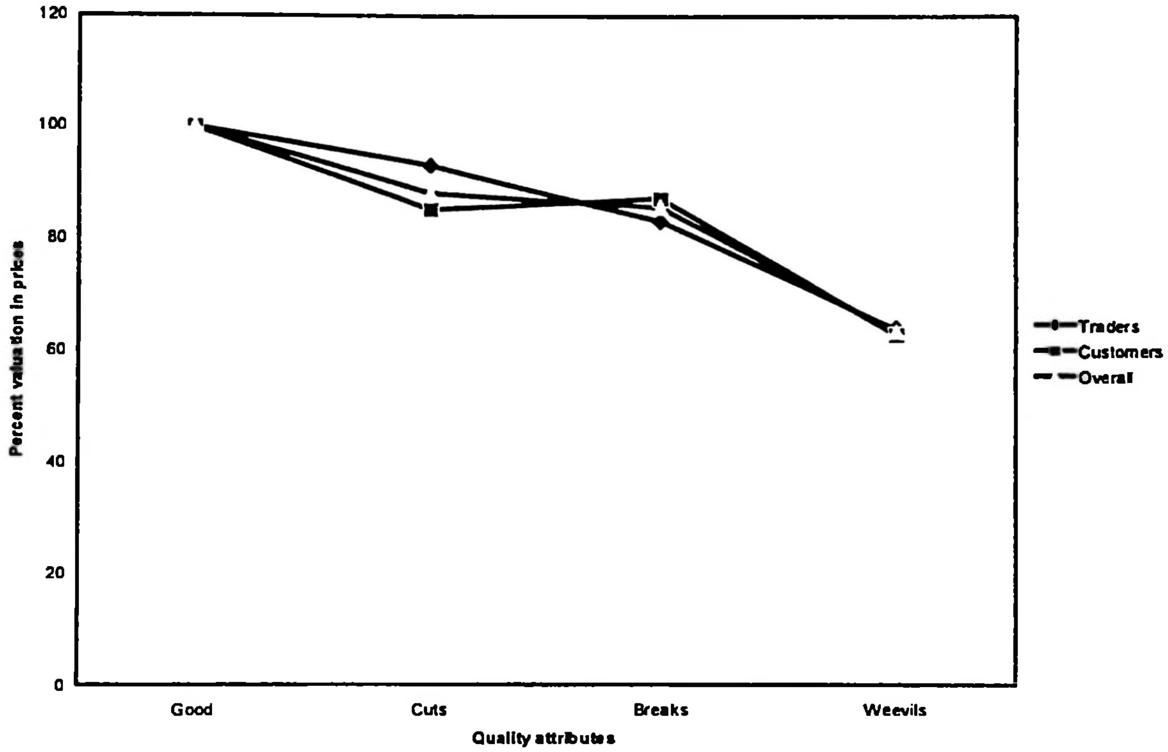

Figure 5. Percentage valuation of sweet potato tubers according to quality

Although traders and customers put low prices on sweet potatoes with cuts, breaks or weevil attack, sweet potato tubers with cuts were undervalued more by customers than the rest. For traders, sweet potato tubers with breaks were undervalued more than the rest. The value of sweet potato tubers with weevil attack was the least.

4.2.1.1 Effect of sweet potato tuber variety on price

The three most common varieties, locally known as *polista, njano* and *sinia* comprised 92% of all tubers sampled. There were marked differences in average selling prices per kilogram of each of these as shown in Table 10.

The results indicate that, *sinia* sold at an average premium of 14% above the price of *polista* and *njano* sold at a premium price of 7% compared to *polista. Mwezi moja* variety sold at 2.6% higher than *polista* while bilagara is selling at 11% lower than polista.

Table 10. Average selling price per kilogram per sweet potato tuber variety

Variety	Number of heaps	Average selling price in TZS per kilogram	Percent average price
Polista	86	134.0	96.6
Sinia	21	153.0	110.3
Njano	62	144.0	103.8
Mwezi mmoja	4	137.5	99.1
Bilagara	11	119.3	86.0
Total	184	138.7	100.0

4.2.2 Participatory valuation of processed cassava root products

Processed cassava root is a very different type of product to fresh sweet potato tubers and a different methodology was required to assess the relationship between quality characteristics and price. The data analysis recommended under the sweet potato section was not appropriate for processed cassava roots. Sweet potato tubers can be assessed individually for quality, whereas processed cassava root is powdery/small-pieced products that is best assessed in bulk.

The quality criteria themselves are also very different. For fresh sweet potato tubers, numerous quality attributes such as variety, size, breaks, cuts, shriveling and weevil attack appear to be important, whereas for processed cassava roots, there seems to be fewer significant factors such as overall colour and particle size.

Results in Table 11 indicate that traders and customers ranked fine white *udaga* in exactly the same order which is white, then gray and dark. The major determinant of *udaga* preference, therefore, appeared to be colouring of the product where whiter grades were preferred.

Table 11. Traders' and customers' valuation of processed cassava products

		Trader score n = 5		Customer score n = 15		Overall score	
label	Product quality	Average price score in TZS	Percent increase /decrease in price	Average price score in TZS	Percent increase /decrease in price	Average price score in TZS	Percent increase /decrease in price
A	Udaga. fine. white	1367	113.9	1440	120.0	1403.5	116.9[1]
D	Udaga. fine. grey	1200	100.0	1220	101.7	1210.0	100.8[5]
G	Udaga. fine. dark	1000	83.3	993	82.7	996.5	83[8]
B	Udaga. large. white	1267	105.6	1360	113.0	1313.5	109.4[3]
E	Udaga. large. grey	1167	97.2	1140	95.0	1153.5	96.1[6]
H	Udaga. large. dark	900	75.0	940	78.0	920.0	76.7[10]
J	Makopa. large	1167	97.2	1293	107.7	1230.0	102.5[4]
C	Udaga. mixed. white	1267	105.6	1387	115.6	1327.0	110.6[2]
F	Udaga. mixed. gray	1100	91.7	1147	95.6	1123.5	93.6[7]
I	Udaga. mixed. dark	917	76.4	967	80.6	942.0	78.5[9]

Notes: Data were obtained from Zimbabwe markets. Mwanza town using nine value cards rising in TZS 100 intervals from TZS 800 to TZS 1600. To ease the process. the products were assessed in three groups: A.D.G – B.E.H.J – C.F.I. Full justification for this is given in the text. A bucket is a standard measure for dried cassava. containing 11 to 14 kg depending on the size of particles. Numbers for the overall score indicate grades of cassava products according to quality in descending order. Superscripts indicate the order of preferences traders and customers ranked the products

The results suggest that customers perceive top grade. white *udaga* to be worth TZS 200 more per bucket than the medium colour, which in turn was valued at TZS 200 more than the lowest, darkest grade (Table 12).

Dark *udaga* was, therefore, valued at an average discount of 30% relative to white *udaga*. *Makopa* was consistently valued in-between the top-two grades of *udaga*, equivalent to 10% discount on the value of white *udaga*. In terms of value, fine white *udaga* was rated highest while large sized particle *udaga* received the lowest grade. The major determinant of processed cassava products' preference appeared to be colouring of the product with whiter grades being preferred. *Udaga* without mould was preferred, but there was a definite order of preference for mouldy *udaga*. The customer valuations were closely in line with the average trader perceptions of value (Figure 6)

4.2.2.1 Effect of types of mould on the value of the processed cassava root product (*Udaga)*

Moulds of different types are said to contaminate processed cassava products during processing. It was therefore important to assess the effect of mould on the quality value of processed cassava products

Colouring is thought to be given by the presence of yellow, gray and black mould that arises when moisture interferes with the drying process. The type of fermentation can also give colour the product. For example, black mould can grow vigorously on air fermented cassava than that fermented in water. Air fermented cassava products are darker than wet fermented ones. Table 12 shows the effect of colour of mould on product valuation by traders and customers. Average valuation discounts were: 10-15% for orange mould: 20-25% for green; and 35-40% for black.

Table 12. Effect of mould on the valuation of processed cassava products

		Traders' score (n = 5)		Customers' score (n = 15)	
Label	Product	Average Prices core in TZS	Percent discount in price	Average price score in (TZS)	Percent Discount In price
A	Fine *udaga* With orange mould	1215	90	1224	15
D	Fine *udaga* With green mould	1080	80	1080	25
J	Fine *udaga* With no mould	1350	100	1440	100
G	Fine *udaga* With black mould	877.5	35	864	40

Note: Data were obtained from Zimbabwe market, Mwanza. The average price of a bucket of fine white *udaga* was 1440. A bucket is a standard measure for dried cassava containing 11 to 14 kg.

A few people claimed to like the taste of *ugali* made from orange mould *udaga*, but no one interviewed liked the taste of *ugali* from green or black mould *udaga*.

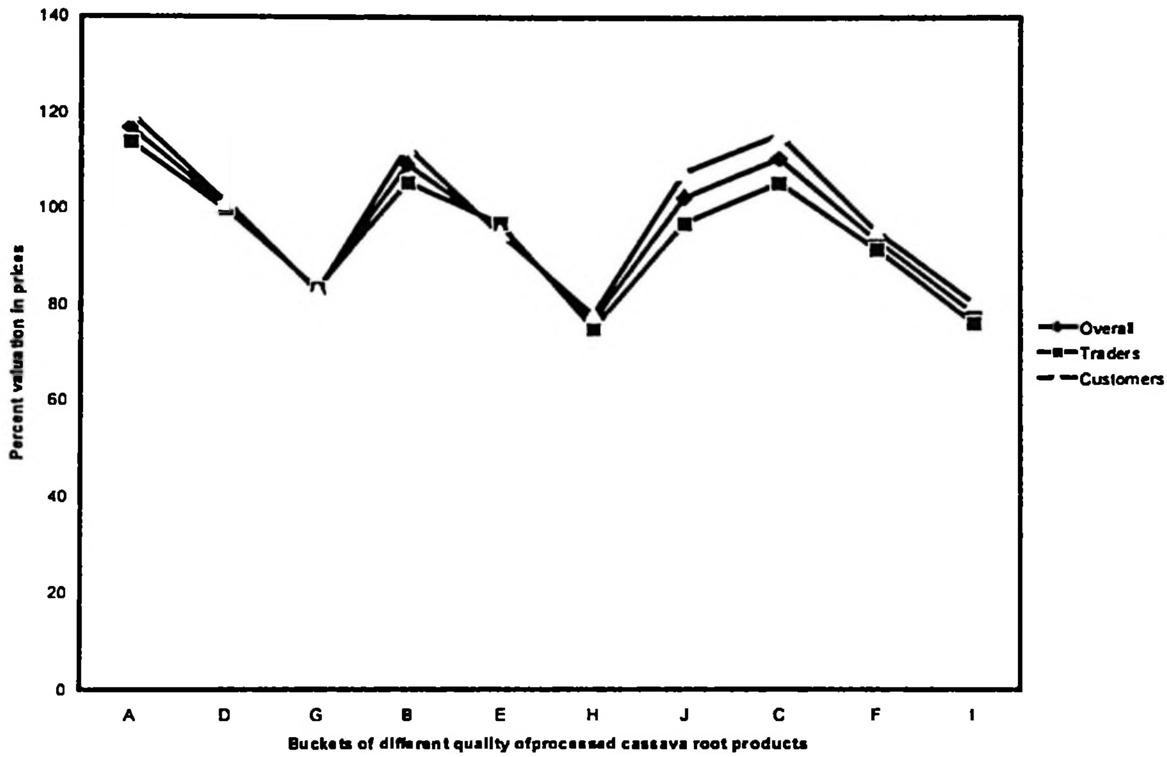

Figure 6. Percent valuation of processed cassava root prices at Mwaloni market in Mwanza city

Figure 6 also shows the trend on the valuation of cassava product at Mwaloni market. Generally, white processed cassava products were preferred more by both traders and customers to the dark coloured products. White coloured products were rated at higher values than the rest.

4.3 Statistics-based approach for assessing the quality and market value relationship of sweet potato tubers

The statistics-based approach for assessing the relationship between produce quality and value was based on measurements of representative samples of sweet potato tubers sold in the market. A sale comprised tubers in a heap on display plus additional ones that were supplied from under the counter. These additional tubers commonly comprised between 10 and 20% of the final weight of the heap and could not be considered insignificant in data analysis. As the additions tend to be of below over-average quality, this method is a way of selling poorer quality produce whilst displaying the better tubers. Heaps are sold at fixed prices. There were three major price categories for heaps; small tubers, TZS 100; medium-sized tubers, TZS 200 and large tubers, TZS 300.

4.3.1 Selling price of sweet potato tubers by quality criterion

The selling price per kilogram (the "y" variable) was calculated for each of the 327 heaps and regressed against different independent "x" variables for both low and high seasons of supply separately as shown in Table 13. The table shows the correlation coefficients and the best estimates of regression constants 'a' and 'b' where $y = a + bx$.

Table 13. Regression of value (selling price per kilogram) against various independent variables

Independent variables(x)	Regression coefficient	Intercept (a)	Slope (b)	Confidence level for (b) %
Breaks score	-0.15	122.2	-10.180	99.3
Cuts score	-0.13	131.6	-11.198	98.3
Shriveling score	-0.08	129.4	5.8665	85.9
Skin Weevil score	-0.16	115.7	-10.288	95.1
Deep weevil score	-0.18	124.8	-15.050	98.9
Weight of heap	-0.49	161.9	-0.0227	100.0
Average tuber size	-0.43	150.0	-15.050	100.0
Days at market	+0.07	136.3	+1.88	64.7

4.3.2 Effect of tuber weight on the value of sweet potato tubers

Tuber weight had an effect on value (Table 14). Sweet potato tubers in the medium sized category, selling at TZS 200 per heap and weighing an average of 223.3 g each, was sold at a 12% premium per kilogram when compared to the smallest size category selling at TZS 100 per heap and weighing an average of 109.1g. Very large tubers selling at TZS 300 per heap and weighing an average of 391.7g, sold at a price of 133.1 per kilogram, very similar to the smallest size category. Table 14 shows the effect of tuber size on value. These results suggest that customers prefer medium sized tubers to very small or very large ones.

Table 14. Effect of tuber weight on market value

Price category (TZS per heap)	Number of heaps	Average weight per tuber (g)	Average selling price (TZS per
100	57	109.1	130.4
200	107	223.3	145.4
300	20	391.7	133.1

4.3.3 Effect of variety on selling price of sweet potato tubers

The most common varieties in Mwanza markets are *polista*, *njano* and *sinia* with smaller quantities of *bilagara* also being sold. Regression analyses were carried out to determine the relationship between varieties of sweet potato tubers and their market values. Results shown in Table 15 show that of the three main varieties of sweet potatoes in Mwanza markets, *njano* is the most preferred overall, selling at an average premium of 10% above the price of *polista* and *sinia*.

Table 15. Average selling price by sweet potato variety in Mwaloni market, Mwanza city

Variety	Number of heaps	Average price of a heap (Tas)
Polista	165	126.5
Sinia	48	126.1
Njano	85	137.7
Bilagara	25	102.8
Total	327	127.7

4.3.4. Development of a model for assessing quality and value relationship of sweet potato tubers

In order to include continuous variables such as the various damage scores and discrete one such as potato variety, the SPSS statistical package was used to analyze the data. Using this package, a series of regression analysis were performed in order to add or remove variables to arrive at the best model for the data being analyzed. The results of the best fit multiple regression for the data are shown in Table 16.

Table 16. Multiple regression analysis for continuous and discrete variables

Estimates of regression coefficient

Variable/ constant	Estimates	standard error	t statistics
Constant	144.6	4.88	29.56
Sinia variety	12.43	4.88	2.55
Njano variety	8.61	3.06	2.81
Mwaloni market	0.22	4.31	0.05
Kirumba market	12.15	5.17	2.35
Zimbabwe market	-4.46	3.95	-1.13
Breaks score	-8.17	3.78	-2.16
Cuts score	-9.99	4.93	-2.03

Notes: Based on *polista* as the common variety and Central as the standard market the analysis excludes 11 heaps of *bilagala* varieties as these constitute insufficient data for meaningful analysis.

In order to show the impact of each variety, market, breaks and cuts scores on selling price, accumulated analysis of variance was calculated as shown in Table 17.

The F statistics shown in the table indicates that we can be over 95% confident that each of the variables has an impact on selling price.

The regression coefficient estimates can be used to make best estimates of selling price ('y') for polista variety sweet potato tubers in central market based on the following standard formula: $y = 144.16 - 8.17b - 9.99c$. Where;

y = selling price per kilogram in Tanzania shilling:

b = weighted average heap score for breaks damage; and c = weighted average heap score for cuts damage.

Table 17. Accumulative analysis of variance for different variables affecting the quality of sweet potato tubers

Variable	Mean sum of squares	Variance ratio	F-statistics	Confidence level %
Variety	3414.5	10.71	<0.001	<99.9
Market	1265.4	3.97	0.009	00.1
Breaks score	1304.2	4.09	0.045	95.5

This standard formula needs to be adjusted for other varieties and other markets with figures of estimates from Table 19.

For estimates of *Sinia* and *Njano* varieties in the same market (Central) it is necessary to add 12.43 and 8.61, respectively to estimates obtained from the above formula. Similarly, for estimates in other markets we need to add or subtract the relevant coefficients from Table 18. As an illustration, the estimated selling prices for unbroken (and uncut) and badly broken but uncut sweet potato tubers for all combinations of market and variety potato in each market in Mwanza is sold at premium prices.

Table 18. Estimated selling prices (TZS per kilogram) for broken and unbroken varieties of sweet potato tubers in each market in Mwanza city

	Polista		Sinia		Njano	
Market	Bad Breaks	No breaks	Bad breaks	No breaks	Bad Breaks	No breaks
Central	127.82	144.16	140.25	156.59	136.43	152.77
Mwaloni	128.04	144.38	140.47	156.81	136.65	152.99
Kirumba	139.97	156.31	152.40	168.74	148.58	164.92
Zimbabwe	123.36	139.70	135.79	152.13	131.97	148.31

The results indicated in Table 18 show that broken tubers of sweet potatoes were expected to sell at a significant discount to unbroken ones.

The same was true for cut as opposed to uncut ones, although a full illustration is not given here. In broad terms the discounts for damaged sweet potato tubers ranged between 10 and 15% of the value of the undamaged product.

Table 18 also illustrates the variation in the price discount of sweet potato tubers based on both variety and market location.

4.4 Identification of causes of quality loss in sweet potato tubers

Identification of causes of quality loss in sweet potato tubers was important in order to recommend means of improving quality to the farmers and traders.

4.4.1 Effect of harvesting of sweet potato tubers on tuber quality

Sweet potato tubers possess a delicate skin and are prone to mechanical injury during harvesting (Booth,1974). The general causes of mechanical injuries were reported to be implements used in harvesting the crop (Salunkhe and Desai , 1984). In Tanzania, hoes are used in harvesting sweet potato tubers.

At the farm, a total of 40 sweet potatoes were randomly selected and assessed for breaks, skinning, cuts, rots, shriveling and weevil damage (skin and burrowing). The experiment was replicated three times. The proportion of sweet potatoes with cuts varied between 20% and 35%, skin weevil 13% to 59% and burrowing weevil 1% to 4% (Table 19).

After harvesting, the proportion of minor breaks varied between 13% to 24% while the major breaks varied between 3% and 5%. Scores for skinning injuries varied between 19% to 53% and 0% to 6% for minor and major injuries, respectively.

Table 19. Quality losses of sweet potato tubers during harvesting

Replicates of defects assessment of sweet potato tubers during harvesting

	Percent loss			
Type of Damage	1	2	3	average
Breaks				
minor	13.0	24.0	20.0	19.0
major	3.0	4.0	5.0	4.0
Skinning				
minor	36.0	19.0	53.0	36.0
major	4.0	0.0	6.0	3.0
Cuts	35.0	26.0	20.0	27.0
Skin weevil	59.0	13.0	26.0	33.0
Burrowing weevil	2.0	1.0	4.0	2.0
Rots	20.0	2.0	0.0	7.0

4.4.2 Effect of stuffing sacks of sweet potato tubers on quality

Sweet potato tubers are traditionally packed and transported in polypropylene sacks weighing between 100 kg and 200 kg. This experiment was carried out in order to assess the effect of stuffing sweet potato tubers into sacks on quality.

To assess the effect of filling the sacks on quality, a total of four sacks were tightly stuffed with 100 kg of sweet potatoes and then immediately emptied and the tubers assessed for damage. The total scores for major breaks and skinning did not show any major effect. Compared to freshly harvested tubers, however, the proportion of tubers with minor (score of 2 or less) breaks and skinning injury increased significantly (P=0.001) from 20 to 34% and 31 to 49% respectively (Table 20).

Table 20. **Influence of stuffing sacks of sweet potato tubers on quality**

	% scores of damage on sweet potato tubers	
Quality variable	**Control**	**Stuffed in sacks**
Breaks		
Minor	20.0	34.0
Major	4.0	8.0
Skinning		
minor	31.3	49.0
Major	15.0	20.0

4.4.3 Effect of transportation of sweet potatoes from the farm to the markets of Mwanza and Dar es Salaam

4.4.3.1 Studies in the Lake Zone

At the farm sweet potatoes were usually harvested on the day and packed into sacks and transported to the lakeshore (1 to 11 km) singly by bicycle or in bulk by trolley (up to 9 sacks). The sacks were gently loaded onto bicycles but could be handled roughly when loaded onto the trolley. The bicycles and trolleys were pushed by hand along dirt tracks to the lakeshore.

When the sacks were unloaded at the lakeshore, they could be dropped from a height as great as 1.5 m onto the sand or possibly onto other sacks of sweet potato. During the wait (4 hours) for the ship to arrive, the sacks were sat on and stood on by a number of people. The ferry was capable of carrying several vehicles and took up to 10 hours to travel from Kahunda to Mwanza port. The sacks were roughly handled when being loaded onto the ferry. They were rolled up a steep metal ramp into the hold of the ship. On arrival at Mwanza port, porters would carry the sacks on their shoulders and drop them onto a concrete surface or other sacks of sweet potato at the customs station. Fig. 7 and 8 indicate the amount of shock sweet potato tubers received during transportation from Kaunda in Sengerema district to Mwaloni markets in Mwanza city.

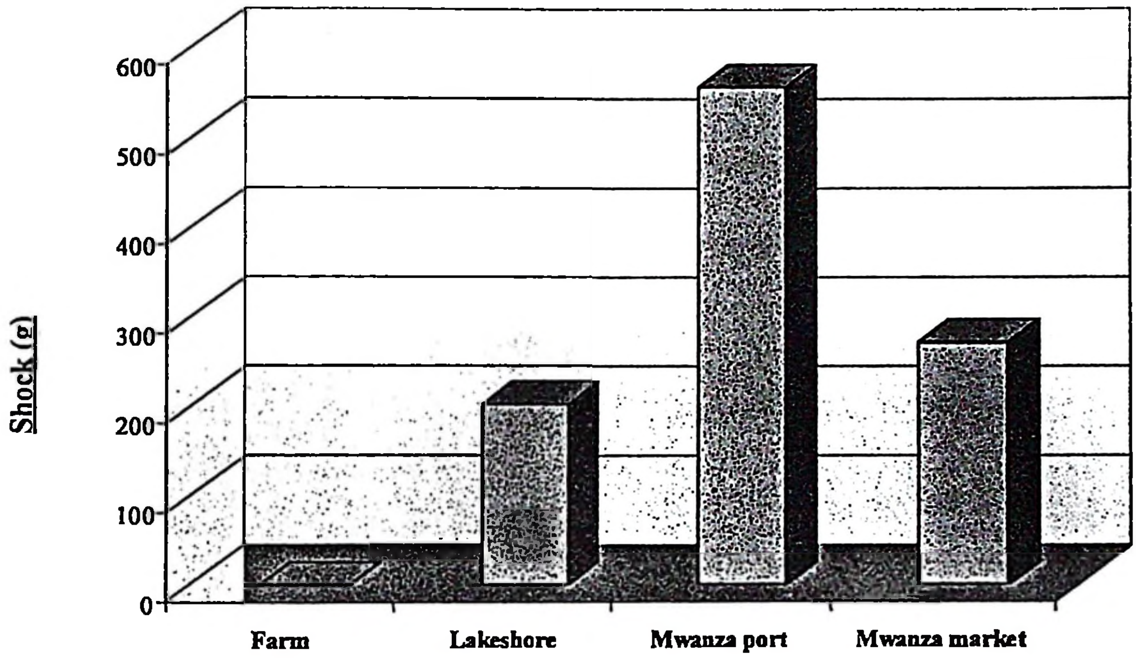

Figure 7. Contribution of each stage in the transport chain to shock (g) indicated by datalogger

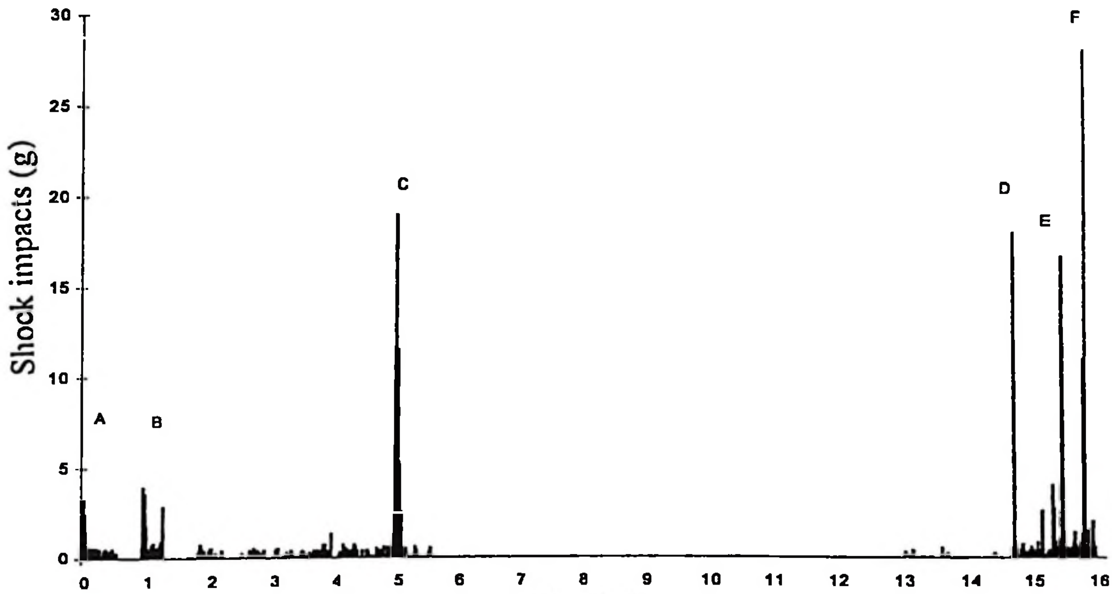

Figure 8 Shock profile for each sack of sweet potato tubers along the transport chain from Kaunda to Mwanza market.

Note: A = loading onto bicycle, B = unloading onto sandy beach on shore of Lake Victoria, C = loading onto the ferry, D = unloading from ferry at Mwanza port, E = handling at port customs and loading onto a light commercial vehicle, F = transport to market and unloading

The stages at which the sacks were observed to be subjected to large shocks correspond to the locations on the figures marked A (loading onto a bicycle or trolley at the farm), B unloading at the beach), C (loading on the ferry), D (unloading from the ferry), E (handling at the customs station) and F (handling at the market). The largest shocks occurred at Mwanza port (unloading from the ship and handling at customs) and at the market by the traders. Loading the sacks onto the ferry from the lake shore was also an area where sacks could receive large shocks (up to 20-g) although this was more variable. Here the sacks were either carried then dropped or rolled along the ground. A further area of rough handling occurred when the sacks were loading onto the trolley at the farm. Transport from the farm to the lake shore (between points A and B) resulted in a large number of minor shocks.

Table 21 shows the mean quality of the sweet potato tubers at key selected stages in the transport chain during the low and main harvest seasons. The largest loss in quality occurred between the lake shore and the port at Mwanza when sacks were loaded and unloaded from the ship and handled at the port. These results correspond also with the shock impacts which the tubers received during transportation in the main season as shown in Figure 16.

At retail market tubers with severe breaks accounted for about 20 per cent of the roots in a sack (Table 21). Using estimates suggested previously in this study (section 4.2) for relating quality to market value, this corresponded to a loss of between 3 and 13 per cent (mean of 9 per cent) in market value per sack.

Table 21. Tuber damage for sweet potato tubers (*Polista* variety) when transported during the low and main seasons from Kaunda to Mwanza market

		Stage in marketing chain			
Root damage	**Season**	**Farm (after packaging)**	**Lake shore**	**Port**	**Market**
Broken roots	Main	4 (0)	7 (1)	43 (19)	40 (17)
	Low	16 (4)	20 (9)	33 (16)	44 (21)
Skinning injury	Main	22 (1)	30 (2)	85 (28)	89 (37)
	Low	21 (3)	70 (18)	118 (72)	133 (86)
Cuts	Main	6 (2)	9 (3)	17 (6)	13 (4)
	Low	9 (0)	8 (1)	15 (3)	16 (4)

The total score is the sum of individual scores of 40 randomly selected roots as outlined in section 2.0 on methodology development. In brackets, the percentage of all 40 roots with severe damage (a score of three or greater), is indicated.

Low season values are the means of 3 sacks and main season values are the means of 6 sacks. Each season was sampled only once.

From the Table 21, skinning injury increased significantly (P = 0.01) during loading and unloading from the ship. Those tubers with severe skinning injury represented 37 per cent and 86 per cent of tubers in a sack in the main and low seasons respectively. Skinning injury, however, had only small effect on market value in Tanzania as shown in section 4.5.3.6. Figure 8 also shows the influence of transport of sweet potato tubers from Kaunda, Sengerema to Mwanza on breaks.

Results from the participatory surveys in Mwanza indicated a higher incidence of shriveling in sweet potatoes sold at markets in Mwanza during the low season. In this study, few incidences of shriveling were noted during either the low or main season. Shriveling was probably not a direct result of transport and handling, occurring if roots remained at the farm for too long prior to transport.

4.4.3.2 Studies done in the Eastern zone

Sweet potatoes (cultivar, SPN/0) were transported from Gairo to Dar es Salaam by road using either a truck or pickup. The number of handling steps was generally less since the farms were often close to the main road and the trucks would travel directly to Tandale markets in Dar es Salaam. The sacks were gently loaded onto a pickup that was then driven to main road about 1.0 km away from the farm.

When the sacks were unloaded at the main road, they could be dropped from a height as great as 1.5 m onto the ground. The sacks of sweet potatoes were then loaded into a truck for transport to Dar es salaam. The truck took up to 22 hours to travel from Gairo to Dar es Salaam. The sacks were roughly handled when being loaded onto the truck. They were rolled up a steep metal ramp into the truck. On arrival at Tandale market in Dar es Salaam, porters would carry the sacks on their shoulders and drop them onto a ground surface or other sacks of sweet potato tubers.

Assessment was made to identify the losses in quality that occurred during transport from Gairo in Kilosa district to Tandale market in Dar es Salaam. Assessment of shock impacts received by the sweet potato tubers was done in order to predict the loss in quality of sweet potato tubers due to shock impacts received by the tubers during transportation. Shockloggers were placed in each sack in order to monitor the shock impacts on the sweet potato tubers. Figure 9 shows the shock impact profile of the sweet potato tubers transported from Gairo to Dar es Salaam. Higher shock impact on sweet potato tubers occurred during loading and unloading of the sacks.

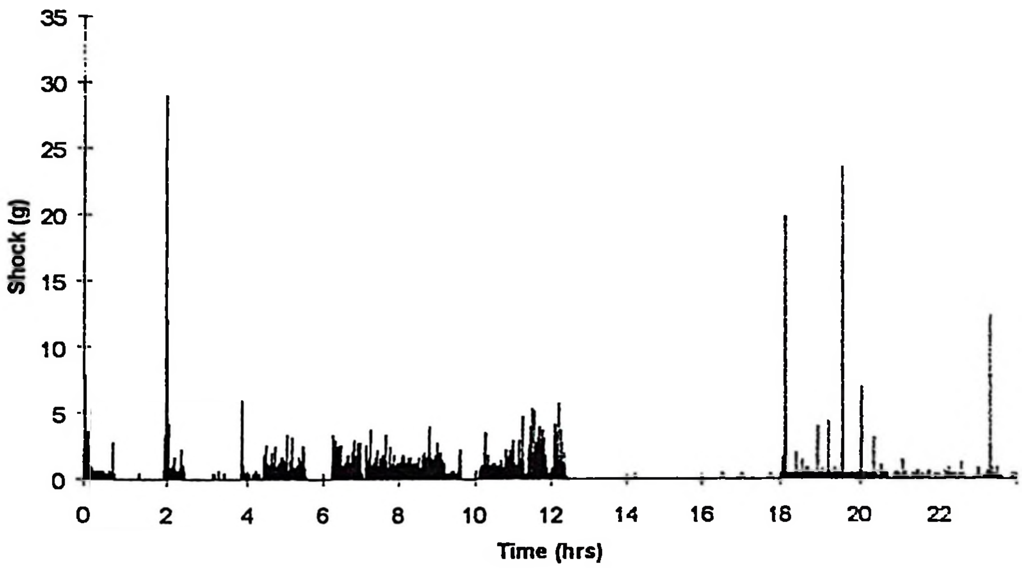

Figure 9. Shock profile for each sack of sweet potato tubers along the transport chain from Gairo to Dar es Salaam

Table 22 shows the results of the losses in quality which occurred during transportation. The mean total score for broken tubers increased from 16 at the farm to 42 at the market and this was estimated to represent a loss between 6 and 13 per cent (mean 9 per cent) in market value when calculated using the method developed earlier in this study (section 3.0). If tubers with severe (score of 3 or greater) breaks and skinning injury were considered, breaks increased from 2 per cent at harvest to 15 per cent in sacks arriving at the market and severe skinning injury increased from 0 to 34 per cent. Handling and transportation did not increase the injury to the tubers from cuts.

Table 22. Change in quality of sweet potato tubers when transported from farm to markets in Dar es Salaam

	stage in the marketing chain	
Type of quality loss	Farm (after packaging) (scores)	Market (scores)
Breakage	16 (2)	42 (15)
Skinning	8 (0)	75 (34)
Cuts	4 (3)	6 (3)

Note: The total score is the sum of individual scores of 40 randomly selected tubers. In brackets is the per cent of all 40 tubers with severe damage (a score of three or greater) is indicated. Values are the means of 2 lots of 40 tubers of 4 sacks.

4.4.3.2.1 Relative humidity and temperature in sweet potato tuber sacks during transport

Data loggers were used to monitor both temperature and relative humidity in the environment in which the tubers were transported. The humidity recorded is given in Figure 10. Relative humidity differed with location in the sack, the lowest being at the top, which was exposed to the wind. The relative humidity in the sack was higher than the ambient and rose to 95% or greater after 4 to 12 hours.

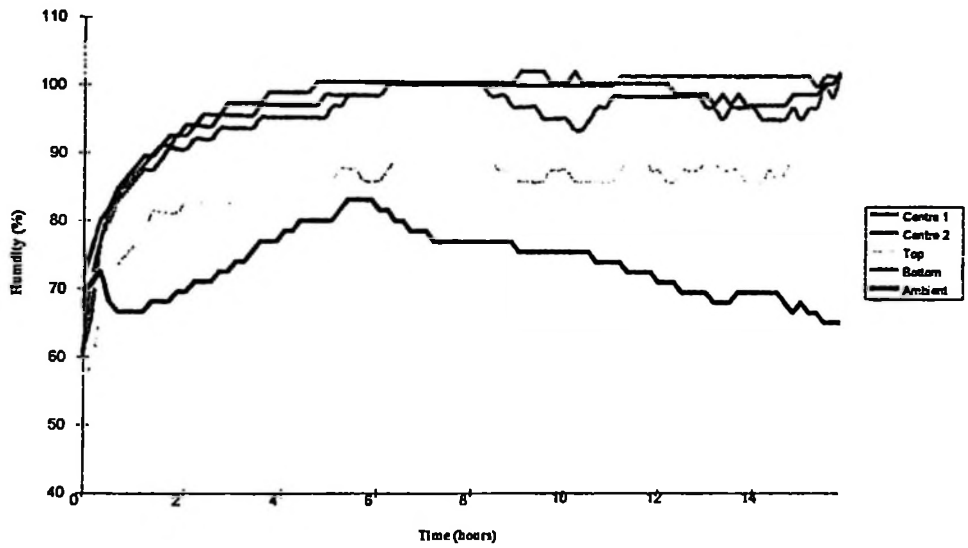

Figure 10. Relative humidity in a sack of sweet potato tubers being transported from Kaunda to the Mwanza market

A total of four temperature dataloggers were buried in a sack; two in the centre, one at the top and one at the bottom. The temperature dataloggers were set to record at ten minute intervals. The temperatures within the sacks are given in Figure 11. The temperature within the sack varied by up to 10°C and differed between the locations. The temperatures were similar in the centre and bottom where it steadily increased by between 3°C and 6°C for the first 6 to 7 hours after which it started to decline. The temperature at the top followed a different pattern with little change for the first 6 hours followed by a decline of 5°C.

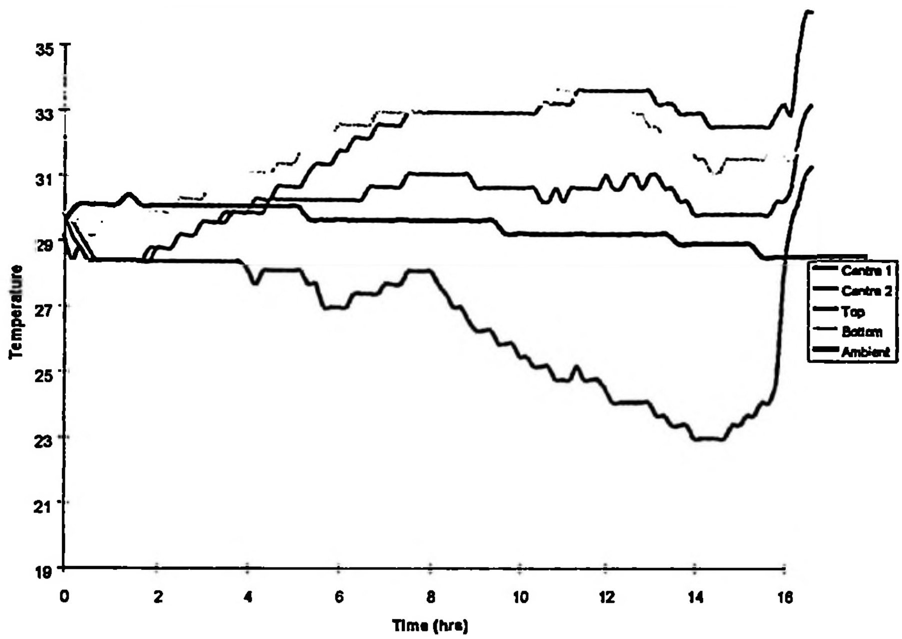

Figure 11 Temperature in a sack of sweet potatoes being transported from Kaunda to Mwanza market

4.5 Causes of quality loss in sweet potato tubers during postharvest handling

Sweet potato tubers are usually subjected to shock impacts that facilitate quality loss in sweet potato tubers during postharvest handling from the farm to the market. The aim of these experiments was to verify the relationship between shock impact and sweet potato tuber damage.

4.5.1 Assessment of the relationship between acceleration (*g*) and the height that a sack was dropped

When sweet potato tubers are transported from the farm to the markets, they could be dropped during loading and unloading at various points along the marketing chain. As such, the tubers receive shock impacts that catalyze the loss of sweet potato quality.

Understanding this relationship could help to identify critical heights from which sacks of sweet potato tubers could be dropped with minimum loss of quality.

The relationship was determined between readings taken from two impact data loggers inserted in a sack weighing 120 kg when dropped on a firm floor. The curve in Figure 12 indicates that the impact recorded increased with the increase in height of the drop (R^2=0.875 and 0.792). The results were similar for the two data loggers although the readings are scattered.

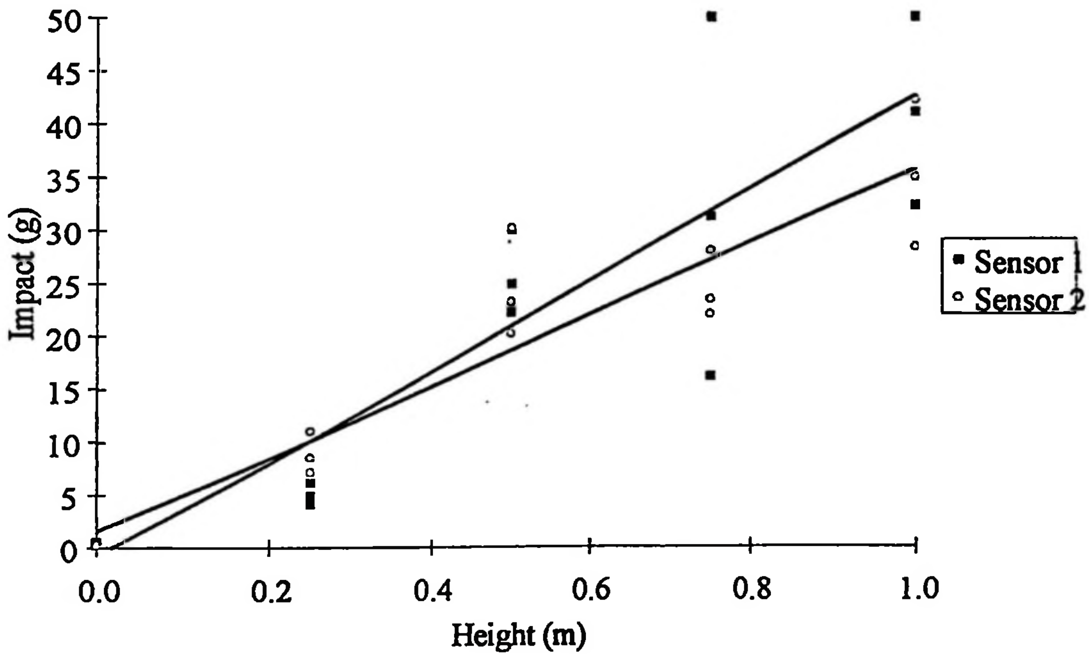

Figure 12. Correlation between impact (g) and height (m) from which a polypropylene sack filled with 120 kg sweet potato tubers was dropped.

4.5.2 Effect of the number of shock impacts on the breakage of sweet potato tubers

During transport from the farm to the markets, sacks were observed to be dropped from shoulders which is about one metre high from the ground on several occasions. The sacks weighing up to 200 kg in some instances were too heavy to be lowered slowly. Since it was proven in the previous experiment (4.4.3.1) that drop height was related to the impact on the sacks, a trial was conducted in order to determine the effect of the number of drops from fixed height on the breaks of tubers in a sack of sweet potatoes. In dropping the sacks, it was assumed that the dropping impact could result in breakages and skinning of the tubers.

A total of twelve tightly packed sacks of 50 kg and 100 kg were dropped once, three times and six times from a height of 0.5 m. The control comprised samples of 40 freshly harvested tubers. One metre was the maximum height at which the shock loggers could record the acceleration. Samples of treated tubers were stored for fourteen days to observe the effect on storability.

Multiple linear regression analysis ($P \leq 0.001$, R^2 adjusted = 0.570) indicated that each impact increased the occurrence of broken tubers (Figure 13) while the weight of the sack (50 or 100 kg) had no influence (Appendix 6)

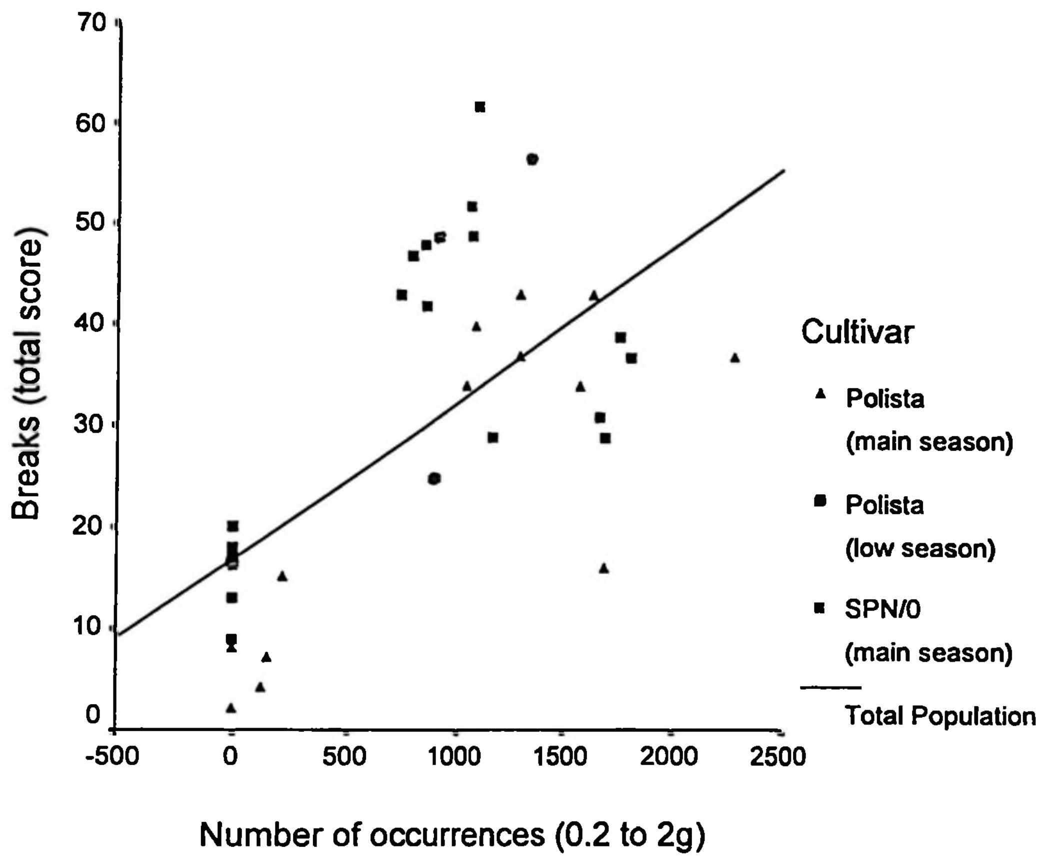

Figure 13. Relationship of shock impact occurrence on sweet potato tuber breakage

In the shelf life study, multiple regression analysis (R^2 adjusted= 0.898) revealed that weight loss during storage increased significantly (P= 0.01) with shock impacts (Figure 14). This weight loss was most marked after 14 days storage where 6 drops could account for a mean loss in weight of 14%.

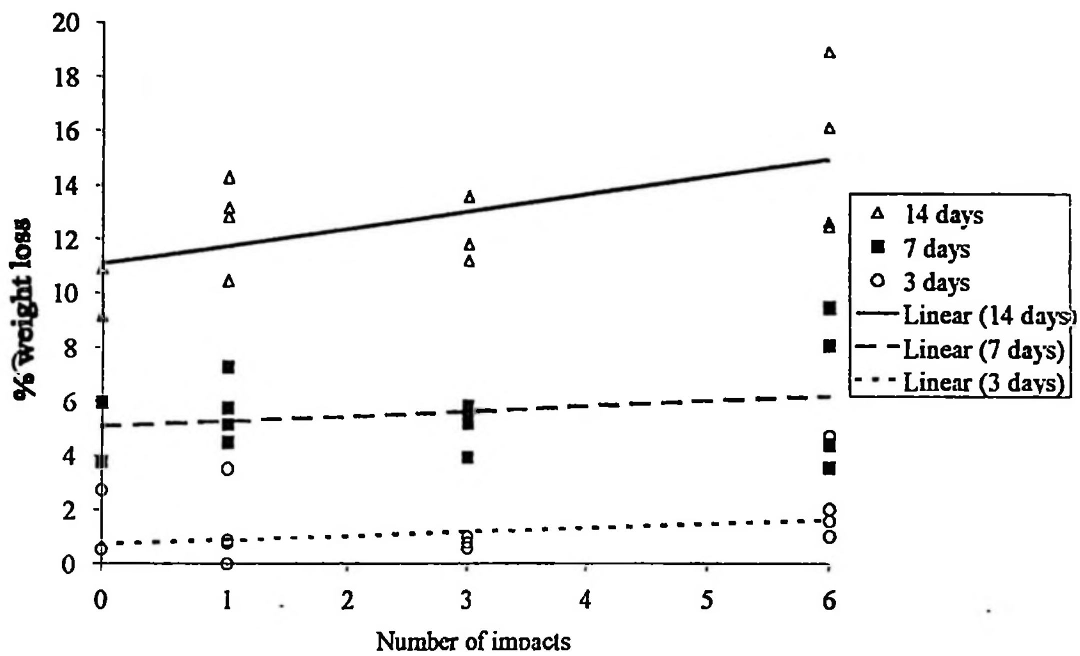

Figure 14. Effect of impacts on the weight loss during storage of sweet potato tubers

4.5.3 Effect of height from which a sack of sweet potatoes is dropped on tuber breakage

Since dropping sacks of sweet potato had an effect on the occurrence of broken tubers, an investigation was carried out to determine the effect of drop height on the tuber quality. Twelve sacks were dropped from 0.25 m, 0.5 m and 1m to simulate the handling of sacks during transport. Each of the six sacks weighed 50 kg while the rest weighed 100 kg each.

Two sacks from either 50 kg or 100 kg were subjected to one particular drop height and assessed for tuber breakage.

Multiple linear regression analysis indicated that the height from which a sack was dropped was nearly significant (P = 0.05) with respect to damage from broken tubers while the sack weight had no effect. The scatter plot in Figure 15 indicate that while the score for mean breakages increased with the height of the drop, dropping the sack from any height between 0.25 m and 1 m can result in a significant occurrence of breaks.

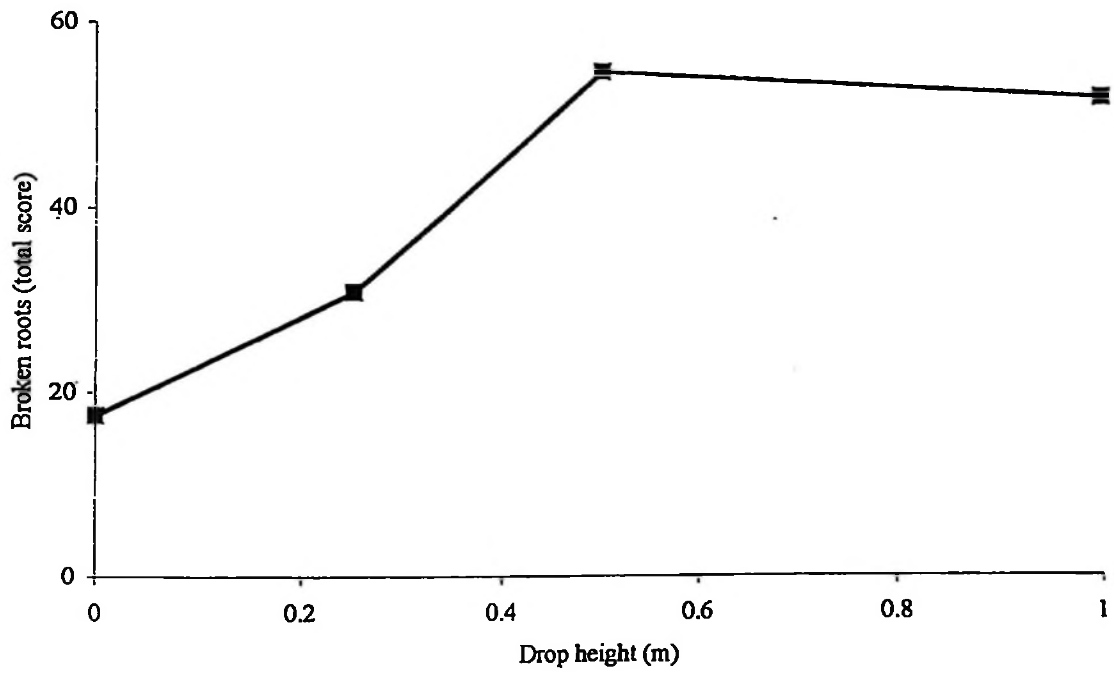

Figure 15. Relationship between drop height and sweet potato tuber breakage

4.5.4 Effect of number of drops of sweet potato sacks on tuber breakage

It was observed that when transporting sacks sweet potato tubers weighing up to 150 kg from the farm to the markets, the farmers and porters carried them at shoulder height. Since the sacks were too heavy to lower slowly, they were usually dropped. To simulate the effect of dropping, in this study, sacks were dropped 1, 3 or 6 times from a height of 0.5 m.

Multiple linear regression analysis ($P \leq 0.01$, R^2 adjusted = 0.570) indicated that dropping the sack increased the occurrence of breaks while the weight of the sack (50 kg and 100 kg) had no significant effect (Fig. 16). With respect of losses in market value, each drop from a height of 0.5 m, could result in a loss of 1.3%.

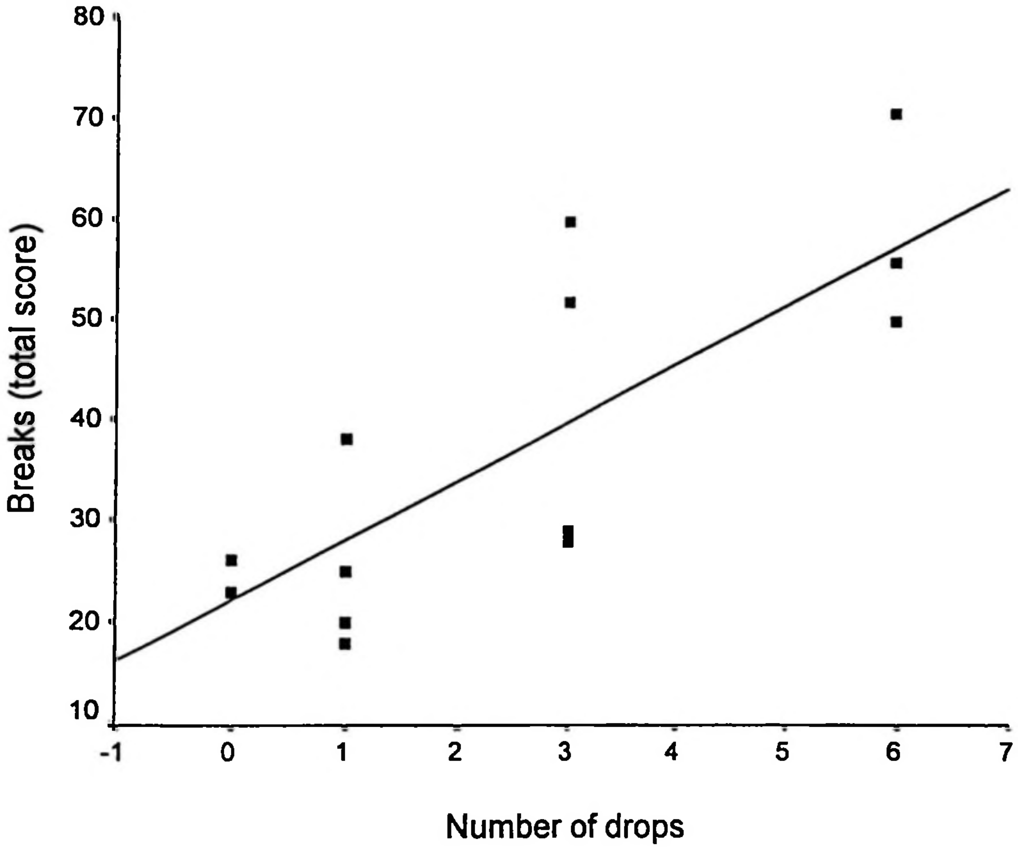

Figure 16. **Relationship between number of drops of sweet potato sacks and tuber breakage**

4.5.5 Influence of drop height on storage of sweet potato tubers

Multiple linear regression analysis (R^2 adjusted= 0.908) indicated that the height from which a sack was dropped increased significantly the weight loss during storage (P= 0.001) (Figure 17). The height from which a sack was dropped had influence on the occurrence of weight loss. Dropping a sack from a height of 1 m would account for a weight loss of 15% after 14 days storage.

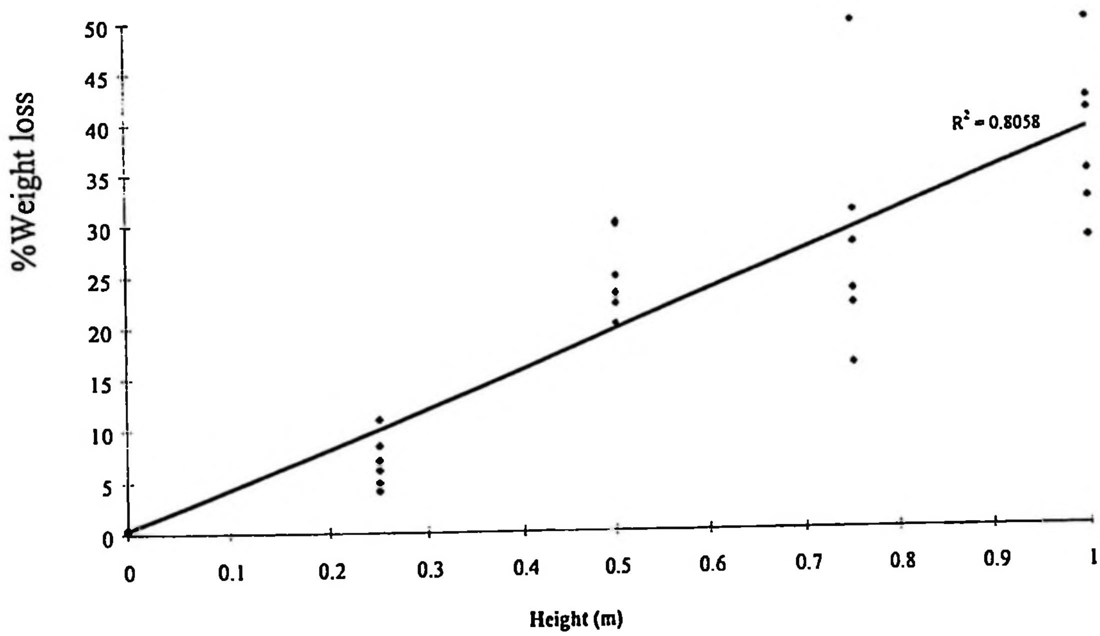

Figure 17. Influence of drop height and storage time on weight loss (%) of sweet potato tubers

4.5.6 Effect of dropping sacks on skinning injuries of the sweet potato tubers

Skinning injuries normally lower the quality of sweet potato tubers and, therefore, their market value. This is because sweet potato tubers have delicate skins and easily succumb to mechanical injuries which take many forms at all stages in the life of the produce from preharvest operations through harvesting and handling operation to exposure in the market and finally in the home (Booth, 1974). In the dropping experiment, investigations were also carried out in order to determine the effect of dropping the sacks on skinning injuries of sweet potato tubers.

Multiple linear regression analysis ($P \leq 0.01$, R^2 adjusted=0.509) indicated that increasing the height of the drop intensified the skinning injury (Fig.18). The weight of the sack had no significant influence on skinning injury.

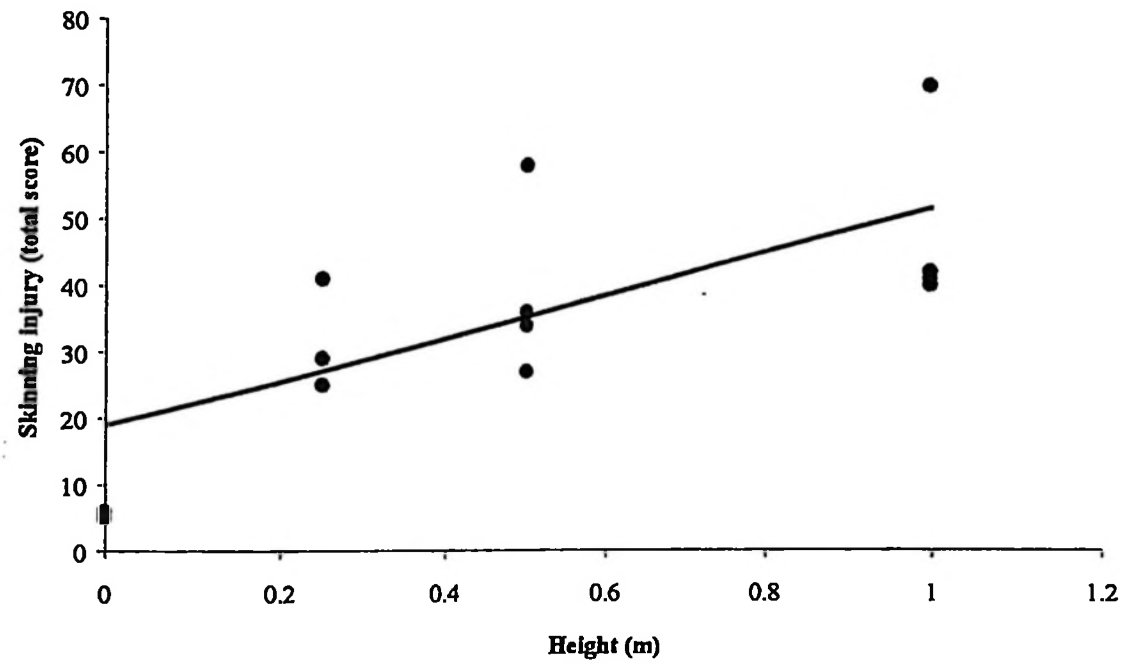

Figure 18. Influence of drop height of sacks of sweet potato tubers on skinning injury

Where: skinning injury (total score) = (height of drop in metres x 32.571) + 19.071

4.5.7 Effect of tuber skinning injury on the storage life of sweet potatoes

The contribution of skinning injury during shelf life storage of sweet potato tubers was investigated.

Multiple linear regression analysis indicated that skinning injury, sustained during the experiment was significantly correlated with weight loss (P= 0.001) when tubers were stored (R^2 adjusted =0.855). The scatter plot indicating the effect of skinning injury (total score) on weight loss with storage time (days) is given in Fig. 19. The longer the roots were stored, the greater the effect of skinning injury on weight loss. At 3 days storage, skinning injury had no effect on weight loss. After 7 days storage, however, skinning injury accounted for losses between 5% and 9% and this increased to between 10% and 18% after 14 days storage depending on the severity of the skinning injury.

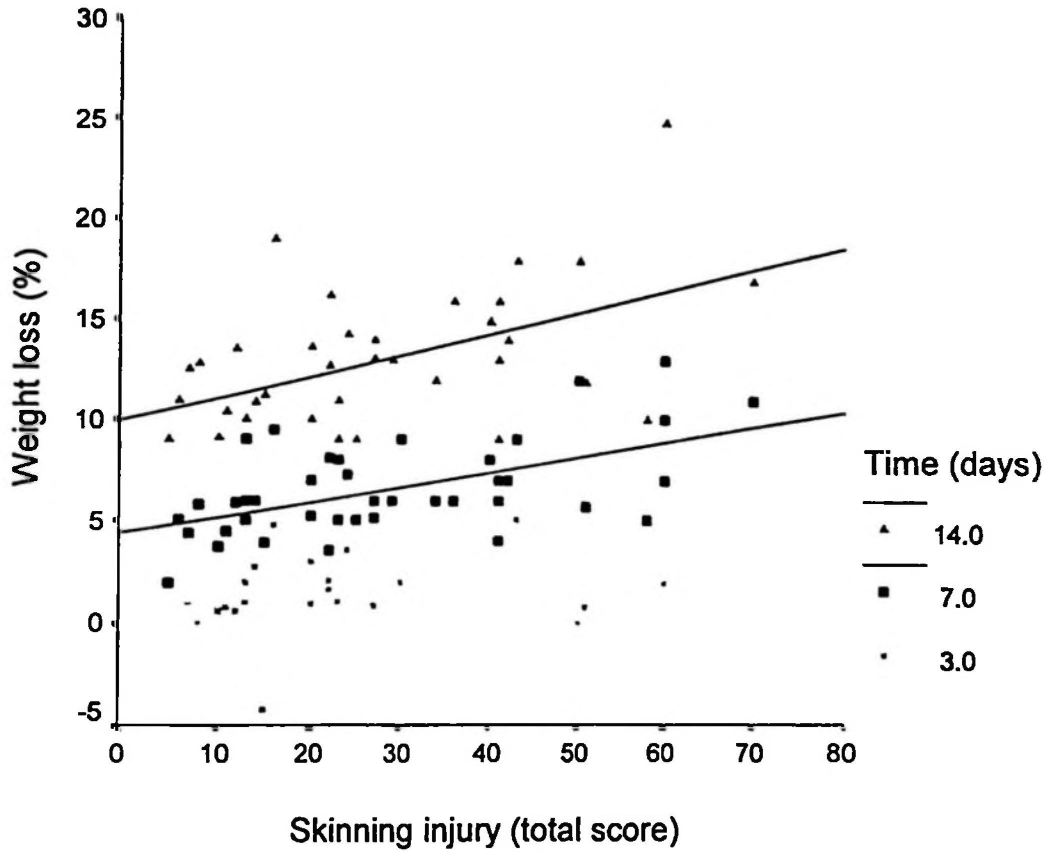

Figure 19. Effect of skinning injury incurred during handling on weight loss (%) during storage at ambient temperature and humidity

4.5.8 Relationships between impact and skinning injury to sweet potatoes

The impacts (*g*) were classified into categories being 0.2 to 2 g, 2 to 5 g, 5 to 10 g, 10 to 20 g, 20 to 30 g and greater than 30 g. Multiple linear regression analysis (backward mode, accept F = 0.05, reject F = 0.01) indicated that the number of impacts in the category between 0.2 and 2 g significantly correlated with skinning injury (P=0.001) and (P= 0.001), (R^2 adjusted = 0.651) and broken tubers (R^2 adjusted = 0.407), respectively. The scatter plots for skinning injury and broken tubers (Figures 18 and 19) suggest that susceptibility to injury was influenced by the number of impacts.

4.6 Effect of different packaging methods on the quality of tubers after handling and transportation

The traditional method of packaging, comprises a woven polypropylene sack filled with 100 kg sweet potatoes. Previous results (section 4.0) have demonstrated that losses in market value of 13%, resulting from broken and cut tubers, may occur using the woven polypropylene sacks. The use of a particular packaging method such as cardboard boxes and wooden crates and by reducing the weight of the package could have an effect on the quality of sweet potato tubers during handling and transportation. Trials were made to investigate the effect of packaging methods of sweet potatoes on loss of quality. Table 23 shows the effects of different packaging methods on sweet potato tubers during handling from the farm to the market.

Table 23. Effect of packaging materials on tuber injury after handling and transport.

	Root quality (total score)				
	Fresh roots (at harvest)	**Cardboard box (20 kg)**	**Wooden box (30 kg)**	**Polypropylene sack (20 kg)**	**Polypropylene sack (100 kg)**
Skinning injury	6	12	19	38	43
Broken roots	3	2	2	4	5
Cut roots	7	7	5	6	7

ANOVA (P = 0.001) indicated that the type of packaging had a significant effect on the severity of skinning injury (Table 23), and that transportation distance had no effect.

The least significant difference test (LSD) indicated that tubers transported in cardboard boxes and wooden crates were of a similar quality to the control while those transported in the polypropylene sacks (20 kg and 100 kg) had more damage. Packaging had no significant effect on either broken or cut tubers.

The mean number of impacts recorded for each packaging method after handling and transportation and their distribution against time is given in Table 24. The packages were transported to the market for the first 9 hours, followed by overnight storage and at 18 to 21 hours handled at the market by market staff. The number and intensity of impacts recorded appeared to be influenced by the weight of the package and the method of packing.

The lowest number of impacts (Table 24) were recorded in the tightly packed polypropylene sacks containing 20 or 100 kg sweet potatoes. The greatest numbers of impacts were recorded in the loosely filled cardboard box and wooden crate containing 20 kg and 30 kg sweet potato tubers, respectively. While the number of impacts was greatest in the loosely filled packaging (cardboard box and wooden crate), the occurrence of skinning injury was the least. Tight packaging in polypropylene sacks is, therefore, the most detrimental of the techniques evaluated.

Table 24. Mean number of impacts during handling and transportation

	Mean number of impacts			
Impact intensity	**Cardboard box (20 kg)**	**Wooden crate (30 kg)**	**Polypropylene sack (20 kg)**	**Polypropylene sack (100 kg)**
2 to 5 g	62	53	6	5
5 to 10 g	17	12	2	0
10 to 20 g	4	0	0	1
Total	83	35	8	6

4.7 Effect of preharvest curing on sweet potato tuber quality during handling

Preharvest curing by removal of the plant canopy prior to harvest has been reported to reduce damage by 62% during subsequent postharvest handling (Bonte and Wright, 1993).

The results of this experiment indicated that damage from skinning injury at harvest and subsequent postharvest handling was highly significant (P=0.001). Skinning injury was reduced if the canopy was pruned for either 14 or 19 days before harvest (Table 26). Preharvest pruning had no significant effect on the occurrence of broken, shriveled or cut roots and weevil infestation.

Table 25. Effect of preharvest curing on the occurrence of skinning injury when harvesting sweet potato tubers

	Skinning injury (total score)		
	9 days	14 days	19 days
Pruned	9	5	7
Not pruned	7	28	21

Table 26. Effect of preharvest curing on the occurrence of skinning injury when polypropylene sacks, containing 50 kg sweet potato tubers, were dropped three times from a height of 0.5 m.

	Skinning injury (total score)		
	9 days	14 days	19 days
Pruned	69	30	40
Not pruned	48	78	79

CHAPTER 5.0

5.0 DISCUSSION

Sweet potatoes and cassava are important staple food crops in several areas of Tanzania. Increasing amounts of fresh sweet potato tubers and processed cassava root products in particular are being marketed providing important sources of income for rural producers and offering important sources of food to the rapidly expanding urban population. However, despite the increasing utilization of sweet potatoes in urban areas, little is known about the relationships that exist between quality and value of sweet potato tubers and cassava root products in these areas. Without this knowledge it is not clear whether any advantage is to be gained by improving the quality of the marketed product. The overall objective of this study was to determine the influence of quality on the market value of processed cassava products and sweet potato tubers and suggest measures which can lead to improvements in their handling during marketing. The study was divided into three sections which were;

- identification of quality attributes for fresh sweet potato tubers and processed cassava;
- development of methods for assessing quality and market value relationship of cassava products and sweet potatoes tubers;
- identification of the causes of loss in quality at market level;

Initial studies started with the broad limit of fresh sweet potato and dried cassava, but it was decided to focus on fresh sweet potato in later studies.

5.1 Identification of quality attributes of sweet potato tubers and processed cassava root products in Mwanza markets

Stanton *et al.* (1994) defined quality as a set of features and characteristics of goods and services which determines their ability to satisfy needs. According to this definition, the quality features in both sweet potato and cassava root products are those consumers and traders in Mwanza City think will satisfy their needs.

Knowledge of the important quality characteristics of sweet potato tubers and cassava root products is essential before starting to assess the relationship between quality characteristics and market value. Studies performed in Tanzania by Kapinga *et al.* (1995), focusing on sweet potato varieties indicated that taste, texture, and appearance are the major quality determinants of sweet potatoes sold in Mwanza markets. This information was confirmed in this study with opinions gained from informal open discussions with consumers and traders in Mwanza markets. According to these results, three main varieties were identified to conform with the above criterion. Sweet potato damage is a complicated factor to assess, comprising of numerous factors as shown in Table 8 and was a major focus of this study. Sweet potato size is another quality attribute that affects ease of handling and peeling. The assessment made by consumers and traders on sweet potato quality conforms with those reported by Scott *et al.* (1992). The authors considered quality of sweet potato tubers to be based on dry matter content, colour of flesh, variety, tuber size, taste, cooking quality and freedom from weevil attack. Booth (1974) also considered mechanical injuries such as cuts, bruises and breaks to be basic quality factors of sweet potato tubers.

Two major processed cassava root products are marketed in Mwanza town. These are *udaga* which is a heap fermented product and *makopa* which is a non-fermented product. Both consumers and traders value these products in terms colour, particle size and the method of fermentation. The main colours of dried cassava products are white, gray or black. Consumer's preference for a particular colour of product is dictated by its end use (eg stiff porridge or local brew)

Consumers and traders indicated particle size as another important quality characteristic. The particle size of the products normally determines the amount of product in the bucket and the degree of contamination by sand when the product is very fine. Dry cassava is normally sold in buckets in Mwanza town. The quality criteria identified in this study as similar to those generally identified for cassava products in Africa (colour, texture and taste) when surveyed in the collaborative study of cassava in Africa (Nweke, 1994).

5.1.1 Sweet potato tubers and processed cassava root marketing calendars

Preparing a calendar is one way of gaining an overview of the marketing of sweet potato and cassava products' market in Mwanza. With sweet potato tubers, quality is highest during the main season when prices are relatively low and quantities high. Quality is lowest in September and October when sweet potatoes have overstayed their optimum harvesting time and become rather watery. Prices fall to compensate for the poor quality at this time of the year. Therefore the relationship between product value and quality does not appear to be constant throughout the year. Production of sweet potato tubers in Mwanza is guided by weather. The main planting season is normally the same for all farmers around the region. Harvesting of the main crop is usually done during April to September. Sweet potato tubers harvested during this time are good in quality and better for the market. During this period the Mwanza markets are oversupplied with sweet potato tubers that make prices to fall significantly despite of their good quality. This is not a normal market situation for of normal goods.

Taking an annual perspective for processed cassava root products, there appears to be a negative correlation between product price and product quality. Trends in product quality followed those in quantity very closely. This is because most cassava is harvested in dry season when dried products are less spoiled by rain. Little is harvested when it is raining and the quality of the dried product declines. There appears, therefore, to be a negative correlation between product price and product quality. Prices are highest when quality is worst and lowest when quality is best. Since price data are measured in thousand's shillings of wholesale price, the calendar suggests that prices almost double when supplies are low. Since quantity also represent the number of lorries arriving at the market, then assuming that delivery size is constant per lorry throughout the year, the matrix also suggests that quantities traded are three to four times greater in the peak as opposed to the low season. Oversupply of good quality processed cassava root products in the market results in low prices and vice versa. At any given time, however, a better quality product can be expected to be valued more higher than a lower quality one.

The participatory development of a seasonal calendars not only gives an overview of the price and (or) quality relationship changes over the year, but also provides additional information through the explanation given on the traders understanding why these occur. Such additional information would have been very difficult to obtain through formal questionnaire-based surveys. In both cases, the results demonstrate that quality and prices change throughout the season. Therefore, this type of information is essential for a full understanding of the quality and (or) value relationship in urban markets.

5.2 Methods for examining the relationship between quality characteristics and market value of sweet potato tubers and processed cassava root products

Two different, but complementary methodological approaches for assessing the relationship between the quality and economic value of sweet potato tubers and processed cassava root products were developed during the study. One is based on participatory data collection involving both traders and consumers and the other uses a statistical analysis of marketed heaps of sweet potato tubers. By analysing the impact of the different types of quality damage on value of the produce, it should be possible to identify quality improvements that are most valued in the market.

5.2.1 Participatory valuation of sweet potato tubers

Results in Table 11 gives an example of the data obtained by using the participatory method in valuating sweet potato tubers sold in Mwanza markets. This approach to data collection gives a relatively rapid means of assessing the importance placed by traders and consumers on different types of damage and allows a value to be assigned to the different preferences.

The approach is flexible in such way that it can also be used to assess sweet potato tubers according to variety. The results obtained could also be used in grading the tubers according to their perceived values relative to their quality characteristics. The method seems to be reliable since it proved that traders and consumers agreed as shown in the regression analysis (Figure 5). This technique was also rapid, taking less than one day per market and required only one researcher.

5.2.2 Participatory valuation of processed cassava root products

The results in Table 12 show that, the major determinant of dried cassava products preference, therefore, appears to be colouring of the products with whiter grades being preferred. There was also major agreement on the ranking of large particle products. Larger white *udaga* and *makopa* were ranked ahead of large medium coloured *udaga,* followed by large dark *udaga*. From the results, it can be noted that dried cassava products can be graded into at least ten grades as shown in Table 12 by the traders. At the international market, cassava products are valued according to their dry matter content, colour, size of the chips, purity and proximate composition of the products (Grace, 1977). In Tanzania, there are no formal standards for processed cassava root products. The traders and consumers perception of grades of cassava products in Mwanza could help in the formulation of standards for the products. Of course the method could also be standardised for use in the rapid assessment of the quality of the products.

The results in Table 13 show the effect of mould on the valuation of processed cassava root products. Generally no mould is liked, but there is a definite order of dislike of mouldy cassava products of different colours. Average valuation discounts are 10-15% for orange mould, 20-25% for green and 35-40% for black. It has been shown that most of the customers in Mwanza town do not like any of the visible moulds that appear on dried cassava. Mould is not recommended in the international market as contaminated products may contain mycotoxins; specially aflatoxin (Westby, 1991).

5.2.3 Statistical method for valuating sweet potato tubers in Mwanza markets

The statistical analysis of the composition of heaps of sweet potato tubers provides quantitative data on the implication of various quality parameters on price. Results of this method produced similar levels of price reduction for tubers with cuts, broken tubers and weevil infected tubers as compared with the participatory method. There was a variation in results of valuation on sweet potato tuber variety between the two methods of assessment. The statistic-based approach could have generated errors due to sampling procedure. This method could be used to evaluate varieties, size of sweet potato tubers and the markets in which the crop was being marketed (Tables 14, 15, and 17). Considerable resources are required for the statistically based approach. In the examples detailed above, three researchers spend one week in the market collecting data and then a further one week analysing the data. Another limitation of the approach is that it is dependent upon a reasonable level of all types of damaged tubers being available in the market.

The above data analysis demonstrate how different methodologies, both participatory and statistics-based, can be used to investigate the same relationship, in this case that between the quality and economic value of sweet potato tubers or processed cassava root products. There are advantages and disadvantages to the two types of approach evaluated. Statistics-based analyses of heaps, for example, allow data gathering in a consistent and concise way, but it can be monotonous and time consuming for researchers and respondents. This can result in an element of carelessness when recording or giving data. Significant resources are required for field studies and access to a computer. It is also difficult to investigate opinions that are very sensitive or subjective in nature through such approach. Data analyses is retrospective in nature and opportunities for the confirmation of observations or obtaining additional information are limited.

Participatory methods encourage a greater flexibility in data collection and can allow more avenues of experimentation not previously thought of, but can be difficult to apply consistently or produce data that are difficult to summarize. As is observed from the examples in this study, participatory methods were significantly faster than the corresponding statistically-based analytical approach. This has implication for human and financial resource allocation. It is sometimes necessary for policy decisions to have estimates of numerical relationships between variables and this is sometimes difficult to achieve through the use of participatory methods alone.

Compton *et al.* (1995) discussed the use of rapid survey methods for assessing storage losses of durable commodities and concluded that a range of tools should be used to meet the specific objectives of the study. Participatory exercises are the most appropriate for obtaining in-depth explanation of customer and trader opinions on an issue such as product quality. By involving participants in 'games' such as the construction of marketing calendars and valuation using monetary cards, interest is generated and participants are more likely to give in-depth explanations of their preferences. More formal statistical methods are best where a large volume of numeric or simple verbal data that can be analysed in the office is required. The approach does, however, lack flexibility. It is possible to adopt both approaches to benefit from the advantage of each method and to compare the results of each as a cross check on accuracy. This was done during the development of the methodology in this study where the relationship between sweet potato value and various damage criteria were investigated. The approach could be used to study similar relationships for other commodities marketed in a similar manner.

5.3 Identification of causes of losses in quality at market level

5.3.1 Causes of quality loss in processed cassava root products during marketing.

The major criterion used by both traders and customers to assess quality of processed cassava root products is colour. Results from the calendar matrix developed by the traders and customers on the quantity, quality and price of processed cassava root products in Mwanza town (Figure 4) indicate that seasonality affected the colour of these products.

During the dry season most of the *udaga* and *makopa* sold in the markets were white as opposed to those sold during the rainy season. Mould growth during processing and handling was implicated to impart colours to the products. During the rain season cassava products failed to dry properly resulting in the growth of mould on the surface of the products. Moisture encourages the growth of mould during processing and possibly during transport. A sack of dried cassava arriving at the market can contain products bearing all types of mould as there is generally little grading of dried cassava and traders can mix products purchased from different farmers and produced under different conditions.

5.3.2 Causes of quality loss in sweet potato tubers in the field

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. Results from Tables 21 and 22 indicate that sweet potatoes suffer minor and major injuries from skinning, cuts and breaks. These injuries affect the quality of sweet potato tubers and hence their market values. Skinning injury (Kushman 1975, Stikeleather and Harrell, 1990) has been reported to be a major factor contributing to weight loss during storage and this research confirms these findings. Kapinga *et al.* (1997) reported that in the Lake Zone, Tanzania, retailers kept tubers for up to 7 days before sale and consumers for a further 14 days before consumption. Therefore, skinning injury may contribute to reduction of shelf life for traders and wholesalers.

The influence of skinning injury on consumer acceptability, however, appears to differ with culture and this influences the feasibility for extending the shelf life. In the United States, skinning injury detracted from the appearance of the root reducing consumer acceptability (Stikeleather and Harrell, 1990). The same authors also reported skinning injury to make sweet potato tubers more susceptible to rots. The results from this study tend to support this. Multiple linear regression analysis indicated that skinning injury and storage time significantly increased rots (P = 0.001). The wide scatter of the data (Fig. 12), however, suggests that the magnitude of rots is influenced by other factors. The occurrence of broken roots and cuts did increase the incidence of rots. Broken roots have been mentioned as one of the factors contributing to shelf life loses in sweet potato tubers (Woolfe, 1992). Freedom from mechanical damage, surface wounds and bruising also reduce shelf life (Onwueme, 1978; Medlicott,1990). Damage from cuts to tubers has been reported to reduce the shelf life in Tanzania (Kapinga *et al.* 1997).

5.3.3 Causes of quality loss in sweet potato tubers during handling and transport from the farm to markets of Mwanza and/or Dar es Salaam.

Commercial consignments of sacks of sweet potatoes were monitored from harvest to markets in Mwanza or Dar es Salaam. Sweet potato tubers transported from the farm to the markets experienced some impacts which depended on the height from which the sacks were dropped and the number of drops during handling (Figure 15). Results from Table 23 suggest that for sweet potatoes, considerable injury from broken tubers can occur if a sack is dropped from a height of 0.25 m or greater. Damage from broken tubers increased the more times a sack was dropped.

This study also show that vibrations during transport on ships and by truck also increased skinning injury. The weight of the sack (50 or 100 kg) had no effect in reducing the occurrence of either broken roots or skinning injury. A reduction in the weight of the sack, however, may also lessen risks of skin injuries (Buescher, 1977) but could lead to increased costs from the use of more polypropylene sacks and more journeys.

Overall, the handling and transport system could result in up to 20 per cent of tubers in a sack with severe breaks and between 35 per cent and 86 per cent with severe skinning injury. Impact loggers located at the centre of sacks provided an objective method for continuously monitoring the handling of the produce. The most severe handling occurred during unloading and loading. Sacks transported in the Lake Zone received an average of two impacts of 20 g or greater, which is equivalent to a drop from 0.5 m. Sacks transported to Dar es Salaam received an average of one impact of 20 g or greater. Multiple regression analysis indicated that skinning injury and broken tubers correlated with minor impacts between 0.2 g and 2 g.

These studies using impact loggers also provide a useful means of comparing varieties. Regression analysis indicated that for tubers handled and transported in 100 kg sacks, both varieties tested (Polista and SPN/0) were equally susceptible to skinning injury and broken tubers and that this was not affected by season. This technique could be used for evaluating other varieties or alternative packaging systems.

Even though the impact sensor appeared to be better for predicting susceptibility to skinning injury caused by surface abrasion, it was less effective at predicting broken roots. It is thought that an instrument capable of measuring compression forces might be more suited to predicting this type of injury.

Sweet potato tubers generate more heat from respiration than the Irish potato (150W/ton and 50W/ton at 20°C respectively (Anon, 1989). Since large quantities of sweet potato tubers were transported in a confined space, the temperature and humidity in the centre of sacks was monitored to determine if detrimental changes occurred. The mean temperature (Figure 19) tended to be more influenced by the ambient temperature than by sweet potato tuber varieties; it was cooler in the main harvest season. The mean temperatures at the centre of the sack in the main and low harvest seasons were 23°C and 26°C, respectively. The relative humidities in the sacks were similar at 90% or greater (Figure 18). These temperatures and humidities did not appear to be injurious to the quality of the roots during handling and transportation.

5.3.4 Effect of pre-harvest pruning on quality loss of sweet potatoes

Furthermore, pre-harvest curing of tubers (Bonte and Wright, 1993) by pruning the plant canopy up to 14 days before harvest has been reported to reduce the injury to roots during handling and transport. Postharvest curing facilitates wound healing and reduces root injury during subsequent handling and transport. It is not widely practised in Tanzania and may offer a simple and low-cost technique for reducing susceptibility to injury.

5.3.5 Causes of quality losses in sweet potato tubers due to different methods of packaging

Investigations utilising alternative methods of packaging (cardboard and wooden boxes) may lead to reduced postharvest losses in Tanzania. The traditional method of packaging comprises a woven polypropylene sack filled with 100 kg sweet potatoes. Previous results of this study has demonstrated that losses in market value of 13%, resulting from broken and cut roots, may occur using this packaging method. This traditional method was compared with low cost alternatives to determine if damage during handling and transport could be reduced.

Previous results of this study indicated that discounts in the price of sweet potatoes, as judged by consumers and traders, was influenced by the proportion of broken and cut roots. Since the method of packaging did not significantly affect the occurrence of breaks and cuts, then method of packaging had little influence on the market value of sweet potatoes unless the tubers overstayed in the market. While not improving the market value, however, a reduction in the skinning injury by transporting in cardboard boxes would increase the shelf life for wholesales, market traders and consumers. The use of small packages could probably minimize skinning injuries as indicated below.

Partitioned cardboard boxes have been recommended for the handling and transport of sweet potatoes in the USA and for export from the Caribbean (Estes *et al.* 1989; Medlicot, 1990). An investigation of the use of boxes (Estes *et al.* 1989) for transporting sweet potatoes indicated that skinning, cuts and breakage damage were reduced by use of a box containing 18 kg instead of one that contained 23 kg. Medlicott (1990) recommended packing boxes with between 14 and 18 kg of tubers.

5.3.6 Influence of preharvest curing on sweet potato tuber quality during handling

Underground storage organs such as sweet potato tubers tend to have poorly developed cuticles. Curing is recommended so that a surface layer of protective suberised wound periderm tissue is formed over the produce, especially at wound sites (Wills *et al.* 1998). Many authors recommend curing of sweet potatoes before they can be stored successfully (Booth,1974; Buescher, 1977; Cooley,1957; Keleny, 1965; Morris, 1981; Salunkhe and Desai, 1984). Curing is a wound healing process during which the skin of the sweet potato become strengthened by the formation of the cork cell. Even though many researchers have reported some ideal conditions for curing (Keleny, 1965) the conditions for curing consists of temperatures between 25-33°C with a relative humidity of 80-95% for 4-7 days. However, pre-harvest curing of the roots (Bonte and Wright, 1993) has been reported to reduce the injury to roots during handling and transport. A linear relationship between reduction in skinning damage and length of time the canopy was removed prior to harvest was reported. Damage was reduced by 62% if the canopy was removed ten days before harvest.

The availability of fresh sweet potato tubers and cassava in Mwanza and Dar es Salaam markets is seasonal. Quantities supplied, quality and prices fluctuate with time of the year. Consumers and traders in Mwanza prefer white processed cassava products and give them high values of prices than average price. For sweet potato tubers, consumers and traders prefer tubers which are free from cuts, bruises, breakages and weevil infestation. Quality attributes such as weevils infestation, breakages, cuts and bruises lower the market prices of sweet potatoes.

During handling of sweet potato tubers from the farm to the markets of Mwanza and Dar es Salaam, the crop is subjected to shock impacts which result into skinning injury, cuts and breakages.

Pruning the canopy of sweet potatoes two weeks before harvesting improves the quality of the crop during handling. Similarly, proper packaging of sweet potato tubers minimizes quality loss of the crop during transportation

CHAPTER 6.0

6.0 Conclusion and Recommendation

In Mwanza city there appears to be trader's and consumer's preference for processed cassava roots that is as white as possible. Darker products give *ugali* that is less appealing to the eye and that some say has an inferior taste. Darker products are generally only bought by brewers and poor individuals who negotiate discounts or by other customers if better quality products are not available.

The analysis indicates that if *udaga* was well graded when it entered the market, rather than selling at a standard price, significant price differentiation could be made. The average product price would probably remain the same, but product quality would be more predictable and consumers would be given more choice. Consumers may then use the product in a variety of ways depending on the quality of the product. Grading *udaga* will encourage processors to produce white cassava products which are demanded by the market. As such the processors can sell more *udaga* at better price and earn more incomes for their livelihood. Similarly, traders can sell more *udaga* to the consumers and get more income. Those who wanted a better quality product could pay more and those who were satisfied with poorer quality could pay less. Good market price for cassava products would stimulate production of cassava among farmers and make them earn more income by selling more cassava to the processors. It has been shown that most customers in Mwanza town do not like any of the visible moulds that appear on dried cassava. If mould were scraped off the roots after fermentation, the potential market value of the product would be increased. Processors should be encouraged to process cassava during the dry season (June to October) so that whiter products could be obtained. The processed *udaga* could then be sold during the rain season (November to April) in order to get the advantage of higher prices for the product. The availability of fresh cassava for processing at this period of the year is also highest. Processors could be trained on the technology of processing high quality flour developed by the International Institute of Tropical Agriculture (IITA), Ibadan Nigeria. This technology has been proven to produce cassava flour that is white and fine. The flour can be used for making stiff porridge, bakery and confectionery products.

Processors would also be encouraged to process more *makopa* that can be sold in the market at intermediate prices between the white *udaga* and the dark *udaga*.

Researchers of root and tuber crops would be encouraged to identify critical stages in the handling and transport system that affect quality of processed cassava root products and develop low cost interventions to improve their quality.

In the case of sweet potatoes both traders and customers consistently place lower valuations on damaged tubers than on undamaged ones. A high proportion of sweet potatoes entering the market place are damaged in some way or another. Evidence of weevil attack leads to the greatest reduction in value, with average discounts of around 30-40% for surface attack and over 50% for deeper attack. Small but still significant discount of between 10-30% occur if sweet potato is shriveled, cut, broken or small in size. These results suggest that efforts to improve the quality of sweet potatoes should

focus firstly on reducing the number of weevil damaged tubers entering the market, especially deep burrowing weevil. The second priority should be to reduce breaks, cuts and shriveling. However, any postharvest intervention that reduces sweet potato damage will have a significant positive impact on quality perceptions in the market place.
Farmers should be encouraged to harvest sweet potato tubers immediately they are mature using proper implements in order reduce weevil infestation, breakages and cuts of the tubers. Stuffing of sweet potatoes into polyproplene sacks resulted into skinning and breakage of the tubers. Researchers are recommended to develop an alternative packaging method which will not cause damage to the tubers.

There is also evidence to suggest that there is significant variation in the value of sweet potatoes by variety. Results show that yellow skinned varieties are preferred and sell at an average premium of 10% above the price of reddish and purple ones. This suggest that farmers should attempt to supply more of the '*Njano*' variety of sweet potatoes to the Mwanza markets. However, these varieties may contain other characteristics not suitable to agronomic practices such as low resistance to diseases.

The Tanzania Bureau of Standards (TBS) should draft some specifications for fresh sweet potato tubers and processed cassava root products that will facilitate grading of the products and marketing.

In Mwanza markets, Prices of both sweet potato tubers and processed cassava roots are lowest when quality of the two crops is good. This is because of oversupply of the products in the market during the main season of production. Farmers are, therefore, encouraged to store the products until such time when the market prices are better. However, researchers could help the farmers to assess the economic comparative advantages of storing the products.

Results from examples on the use of both participatory and statistical approach in assessing the relationship between quality and market value of cassava and sweet potato, developed in this study suggest that the methods are useful and can be promoted for wide dissemination.

In this study the major causes of loss in quality of sweet potato during handling and transport have been identified. Overcoming problems associated with severe handling requires a combination of education of the handlers and in some cases, redesigning of the unloading areas. The effect of minor impacts may be reduced by improved road conditions, reduction in weight of roots in a sack or changes in packaging material (for example, from polypropylene sacks to cardboard boxes). Changes in practice that are within the financial means of those involved need to be evaluated technically and economically. The data obtained in this study should assist this process.

In addition to improved handling and transport, the shelf life may be extended by removal of damaged roots before storage and by the control of temperature and relative humidity (Woolfe, 1992). Little, however, is known about the exact conditions (temperature, relative humidity, packaging, and ventilation) under which retailers in Tanzania store their sweet potatoes.

The use of data loggers for monitoring the impacts, temperature and relative humidity during handling and transport of sweet potatoes helped to identify critical areas where losses occurred mostly. Researcher should be encouraged to these type of devices in doing similar studies.

Education of traders and wholesalers in the importance of handling and transport of sweet potatoes could increase market value. Reduced skinning injury, however, while significantly extending the shelf life, does not increase market value (Ndunguru *et al*, 1998).

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8.0 APPENDICES

Appendix 1. Pro-forma data recording sheet

Location: Code:		Date: Code:			
Selling price per heap:		Variety: Code:			
		Days at market:			
Heap:	Ref:	For all scores: 0 = none. 1= minor. 2 = major			
Top-up (x)	Weight (grams)	Breaks score	cuts score	shriveling score	Weevil score
Total weight		Average score	Average score	Average score	Average score
Total number of sweet potato:		Number:	Number:	Number:	Number

Appendix 2 Anova tables – mwanza (main season)

Breaks – transport system to Mwanza

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
CONSIGNM	330.389	2	165.194	2.358	.113
LOCATION	2069.556	2	1034.778	14.770	.000
TRANSPOR	5377.778	1	5377.778	76.762	.000
LOCATION * TRANSPOR	2653.556	2	1326.778	18.938	.000
Error	1961.611	28	70.058		
Corrected Total	12392.889	35			

Skinning injury – transport system to Mwanza

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
CONSIGNM	347.167	2	173.583	1.998	.155
LOCATION	6966.500	2	3483.250	40.089	.000
TRANSPOR	28561.000	1	28561.000	328.715	.000
LOCATION * TRANSPOR	6004.500	2	3002.250	34.554	.000
Error	2432.833	28	86.887		
Corrected Total	44312.000	35			

Cuts – transport system to Mwanza

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
CONSIGNM	150.056	2	75.028	5.397	.010
LOCATION	45.389	2	22.694	1.632	.214
TRANSPOR	277.778	1	277.778	19.980	.000
TRANSPOR	277.778	1	277.778	19.980	.000
LOCATION * TRANSPOR	159.389	2	79.694	5.732	.008
LOCATION * TRANSPOR	159.389	2	79.694	5.732	.008
Error	389.278	28	13.903		
Error	389.278	28	13.903		
Corrected Total	1021.889	35			
Corrected Total	1021.889	35			

Shock (g) – transport system to Mwanza

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
CONSIGNM	12339.735	1	12339.735	.367	.564
CONSIGNM	12339.735	1	12339.735	.367	.564
LOCATION	1208149.788	2	604074.894	17.975	.002

Error	235247.280	7	33606.754		
Corrected Total	1445238.342	10			

Appendix 3 Anova tables – analysis of consignments transported to Dar es salaam

Variation in shock (g) between consignments (1, 2, 3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	472411.870	2	236205.935	.892	.430
Intercept	7078579.380	1	7078579.380	26.740	.000
CONSIGNM	472411.870	2	236205.935	.892	.430
Error	3970752.870	15	264716.858		
Total	11521744.120	18			
Corrected Total	4443164.740	17			

Breaks with transport in sacks

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4839.125	8	604.891	11.581	.000
Intercept	12848.067	1	12848.067	245.974	.000
CONSIGNM	211.733	2	105.867	2.027	.166
TRANSPOR	4353.792	2	2176.896	41.676	.000
CONSIGNM * TRANSPOR	136.333	4	34.083	.653	.634
Error	783.500	15	52.233		
Total	25633.000	24			
Corrected Total	5622.625	23			

Skinning with transport in sacks

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	40182.958	8	5022.870	212.833	.000
Intercept	19010.400	1	19010.400	805.525	.000
CONSIGNM	2562.300	2	1281.150	54.286	.000
TRANSPOR	27955.125	2	13977.562	592.270	.000
CONSIGNM * TRANSPOR	5982.500	4	1495.625	63.374	.000
Error	354.000	15	23.600		
Error	354.000	15	23.600		
Total	80963.000	24			
Total	80963.000	24			
Corrected Total	40536.958	23			
Corrected Total	40536.958	23			

Appendix 4 **Anova tables – comparison of low and main seasons in Mwanza**

Comparison of shock (g) between low and main seasons at Mwanza

		Sum of		Mean		Sig
	Source of Variation	Squares	DF	Square	F	of F
	Main Effects	1346545.817	3	448848.606	20.729	.000
SEASON1		109683.316	1	109683.316	5.065	.041
LOCATION		1187184.793	2	593592.397	27.413	.000
	2-Way Interactions	194263.740	2	97131.870	4.486	.031
SEASON1	LOCATION	194263.740	2	97131.870	4.486	.031
Explained		1540809.557	5	308161.911	14.231	.000
Residual		303150.148	14	21653.582		
Total		1843959.705	19	97050.511		

Comparison of breaks between low and main seasons at Mwanza

		Sum of		Mean		Sig
	Source of Variation	Squares	DF	Square	F	of F
	Main Effects	8616.060	4	2154.015	20.732	.000
SEASON1		160.992	1	160.992	1.550	.224
LOCATION		8323.441	3	2774.480	26.704	.000
	2-Way Interactions	648.940	3	216.313	2.082	.126
SEASON1	LOCATION	648.940	3	216.313	2.082	.126
Explained		9265.001	7	1323.572	12.739	.000
Residual		2805.235	27	103.898		
Total		12070.236	34	355.007		

Comparison of skinning injury between low and main seasons at Mwanza

		Sum of		Mean		Sig
	Source of Variation	Squares	DF	Square	F	of F
	Main Effects	48307.732	4	12076.933	83.857	.000
SEASON1		7188.473	1	7188.473	49.914	.000
LOCATION		39154.392	3	13051.464	90.624	.000
	2-Way Interactions	1965.113	3	655.038	4.548	.011
SEASON1	LOCATION	1965.113	3	655.038	4.548	.011

Explained		50272.845	7	7181.835	49.86 8	.000
Residual		3888.473	27	144.018		
Total		54161.318	34	1592.980		

Appendix 5 Comparison of sweet potato cultivars with respect to shock, breaks and skinning injury

Skinning injury
Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.813	.660	.651	25.760

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	45142.440	1	45142.440	68.028	.000
Residual	23225.653	35	663.590		
Total	68368.092	36			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	20.241	6.569		3.081	.004
N0.2TO2	5.122E-02	.006	.813	8.248	.000

Breaks
Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.651	.423	.407	12.755

Anova

	Sum of Squares	df	Mean Square	F	Sig.
Regression	4182.822	1	4182.822	25.711	.000
Residual	5694.048	35	162.687		
Total	9876.870	36			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
B	Std. Error	Beta			
(Constant)	16.862	3.253		5.184	.000
N0.2TO2	1.559E-02	.003	.651	5.071	.000

Appendix 6 Multiple regression tables for study varying the number of drops

Regression on breaks

Multiple R	.79763					
R Square	.63622					
Adjusted R Square	.57007					
Standard Error	11.22503					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		2423.98588		1211.99294
Residual		11		1386.01412		126.00128
F =	9.61889	Signif F =	.0038			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DPS		5.699153	1.461374	.770919	3.900	.0025
WT		.029605	.093192	.062797	.318	.7567
(Constant)		20.813559	6.535465		3.185	.0087

Regression on shock (g)

Multiple R	.93222					
R Square	.86903					
Adjusted R Square	.83993					
Standard Error	28.00401					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		46834.18441		23417.09220
Residual		9		7058.02226		784.22470
F =	29.86018	Signif F =	.0001			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DPS		30.020395	3.934224	.920480	7.631	.0000
WT		.395333	.323362	.147479	1.223	.2525
(Constant)		-37.851316	28.731510		- 1.317	.2203

Appendix 7 Regression tables for study varying the height of drops

Breaks

Multiple R	.63140					
R Square	.39866					
Adjusted R Square	.28933					
Standard Error	15.75266					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		1809.60440		904.80220
Residual		11		2729.60989		248.14635
F =	3.64624	Signif F =	.0610			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
HT		28.637363	13.210621	.562292	2.168	.0530
WT		.068462	.133475	.133045	.513	.6182
(Constant)		22.923077	9.268053		2.473	.0309

Skinning injury

	Sum of Squares	df	Mean Square	F	Sig.
Regression	1856.571	1	1856.571	11.026	.006
Residual	2020.643	12	168.387		
Total	3877.214	13			
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	19.071	6.007		3.175	.008
HT	32.571	9.809	.692	3.320	.006

Shock (g)

Multiple R	.82760					
R Square	.68492					
Adjusted R Square	.62764					
Standard Error	30.29956					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		21952.80586		10976.40293
Residual		11		10098.69414		918.06310
F =	11.95604	Signif F =	.0017			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
HT		69.318681	25.410052	.512207	2.728	.0196
WT		.635897	.256734	.465055	2.477	.0307
(Constant)		30.961538	17.826696		1.737	.1103

Appendix 8 Anova table for influence of stuffing sacks on quality

Minor Breaks

Source		D.F.	Squares	Squares		Ratio	Prob.
Between Groups		1	275.520 8	275.520 8		16.4031	.0155
Within Groups		4	67.1875	16.7969			
Total		5	342.708 3				
			Standard	Standard			
Group	Count	Mean	Deviatio n	Error			95 Pct Conf Int for Mean
Loose	2	20.0000	3.5355	2.5000	-11.7655	TO	51.7655
Tight	4	34.3750	4.2696	2.1348	27.5813	TO	41.1687
Total	6	29.5833	8.2790	3.3799	20.8952	TO	38.2715

Skinning injury

Source		D.F.	Squares	Squares		Ratio	Prob.
Between Groups		1	438.020 8	438.020 8		12.0573	.0255
Within Groups		4	145.312 5	36.3281			
Total		5	583.333 3				
			Standard	Standard			
Group	Count	Mean	Deviatio n	Error			95 Pct Conf Int for Mean
Loose	2	31.2500	5.3033	3.7500	-16.3983	TO	78.8983
Tight	4	49.3750	6.2500	3.1250	39.4300	TO	59.3200
Total	6	43.3333	10.8012	4.4096	31.9983	TO	54.6684

Appendix 9 Influence of wrapping of roots in newspaper

Skinning

	Source		D.F.	Squares	Squares		Ratio	Prob.
	Between Groups		1	1302.0833	1302.0833		156.6416	.0002
	Within Groups		4	33.2500	8.3125			
Total			5	1335.3333				
				Standard	Standard			
Group		Count	Mean	Deviation	Error			95 Pct Conf Int for Mean
Normal		4	39.7500	1.7078	.8539	37.0325	TO	42.4675
Wrapped		2	8.5000	4.9497	3.5000	-35.9717	TO	52.9717
Total		6	29.3333	16.3422	6.6717	12.1835	TO	46.4831

Appendix 10 Multiple regression tables: storage of roots – influence of number of drops

Weight loss

Multiple R		.94939				
R Square		.90133				
	Adjusted R Square	.89761				
Standard Error		1.73930				
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		1464.65725		732.32863
Residual		53		160.33443		3.02518
F =	242.07787	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DROPS		.251127	.104156	.104030	2.411	.0194
DAY		1.023087	.046778	.943668	21.871	.0000
(Constant)		-2.183736	.477553		-4.573	.0000

Shrivelling

Multiple R	.98579					
R Square	.97179					
Adjusted R Square	.97126					
Standard Error	5.69048					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		1		59121.88456		59121.88456
Residual		53		1716.22453		32.38159
F =	1825.78668	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DAY		6.565040	.153643	.985794	42.729	.0000
(Constant)		-10.746706	1.236280		-8.693	.0000

Appendix 11 Multiple regression: economic evaluation on the influence of the number of drops on losses during storage

Multiple R	.94614					
R Square	.89518					
Adjusted R Square	.89324					
Standard Error	3.29093					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		1		4994.54846		4994.54846
Residual		54		584.83280		10.83024
F =	461.16705	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DAY		1.900709	.088509	.946139	21.475	.0000
(Constant)		-1.812976	.706686		-2.565	.0131

Appendix 12 Multiple regression tables: storage of roots - influence of height of drops

Weight loss

Multiple R	.95544					
R Square	.91287					
Adjusted R Square	.90840					
Standard Error	1.67900					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		1151.82795		575.91397
Residual		39		109.94197		2.81902
F =	204.29546	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
HEIGHT		2.633327	.732774	.169861	3.594	.0009
DAY		.970062	.048767	.940220	19.892	.0000
(Constant)		-2.264452	.573808		-3.946	.0003

Shrivelling

Multiple R	.94385					
R Square	.89085					
Adjusted R Square	.88525					
Standard Error	17.19056					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		94064.88734		47032.44367
Residual		39		11525.09385		295.51523
F =	159.15404	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
DAY		8.737317	.499309	.925736	17.499	.0000
WEIGHT		.263681	.075803	.184022	3.478	.0013
(Constant)		-20.784076	6.647568		-3.127	.0033

Appendix 13 Multiple regression tables: economic evaluation - influence of the height of drops on losses during storage

Multiple R	.93677					
R Square	.87755					
Adjusted R Square	.87127					
Standard Error	7.53297					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		2		15859.65819		7929.82909
Residual		39		2213.08113		56.74567
F =	139.74333	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
HEIGHT		10.866661	3.287659	.185210	3.305	.0020
DAY		3.585652	.218799	.918283	16.388	.0000
(Constant)		-9.515450	2.574447		-3.696	.0007

Appendix 14 Multple regression tables - pruning and storage of roots

Weight loss

Multiple R	.85074					
R Square	.72375					
Adjusted R Square	.70492					
Standard Error	4.89523					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		3		2762.45390		920.81797
Residual		44		1054.38518		23.96330
F =	38.42618	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
PRUNE		-1.506948	1.414365	-.084496	-1.065	.2925
DAY		1.453069	.142343	.809643	10.208	.0000
SACK2		5.166871	1.416970	.289460	3.646	.0007
(Constant)		-3.958003	1.532151		-2.583	.0132

Rotting

Multiple R	.66418					
R Square	.44114					
Adjusted R Square	.40304					
Standard Error	11.22366					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		3		4375.19480		1458.39827
Residual		44		5542.70520		125.97057
F =	11.57729	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
PRUNE		-5.613578	3.242818	-.195263	-1.731	.0904
DAY		1.013680	.326361	.350389	3.106	.0033
SACK2		15.925866	3.248793	.553486	4.902	.0000
(Constant)		-2.273433	3.512876		-.647	.5209

Shrivelling

Multiple R	.89556					
R Square	.80202					
Adjusted R Square	.78853					
Standard Error	18.20959					
Analysis of Variance						
		DF		Sum of Squares		Mean Square
Regression		3		59105.74274		19701.91425
Residual		44		14589.92393		331.58918
F =	59.41664	Signif F =	.0000			
------------------ Variables in the Equation ------------------						
Variable		B	SE B	Beta	T	Sig T
PRUNE		-4.850169	5.261242	-.061891	-.922	.3616
DAY		7.047360	.529497	.893644	13.310	.0000
SACK2		.404067	5.270935	.005152	.077	.9392
(Constant)		10.751968	5.699391		1.887	.0658

Appendix 15 Multiple regression tables - factors affecting quality on sweet potatoes during storage

Weight loss

R	R Square	Adjusted R Square	Std. Error of the Estimate
.926	.857	.855	2.138

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	3822.499	2	1911.249	417.978	.000
Residual	640.165	140	4.573		
Total	4462.664	142			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2.536	.414		-6.123	.000
DAY	1.014	.036	.913	28.535	.000
SKINSUM	5.306E-02	.010	.162	5.070	.000

Rots

R	R Square	Adjusted R Square	Std. Error of the Estimate
.436	.190	.178	8.984

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2648.903	2	1324.451	16.408	.000
Residual	11300.750	140	80.720		
Total	13949.653	142			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-4.780	1.740		-2.746	.007
DAY	.410	.149	.209	2.746	.007
SKINSUM	.223	.044	.385	5.067	.000

Shrivelling

R	R Square	Adjusted R Square	Std. Error of the Estimate
.913	.833	.831	17.363

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	209543.958	2	104771.979	347.543	.000
Regression	209543.958	2	104771.979	347.543	.000
Residual	41903.641	139	301.465		
Residual	41903.641	139	301.465		
Total	251447.599	141			
Total	251447.599	141			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
	B	Std. Error	Beta		
(Constant)	-15.806	3.393		-4.659	.000
(Constant)	-15.806	3.393		-4.659	.000
DAY	7.494	.289	.897	25.915	.000
DAY	7.494	.289	.897	25.915	.000
SKINSUM	.457	.085	.185	5.354	.000