EVALUATION OF THE EFFICACY OF THREE ORGANIC EXTRACT IN CONTROLLING STORAGE ROT IN SWEET POTATO

BY

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY

(MPhil, POSTHARVEST TECHNOLOGY) DEGREE.

JUNE, 2014

DECLARATION

I hereby declare that, except for specific references which have been duly acknowledged, this project is the result of my own research and it has not been submitted either in part or whole for any other degree elsewhere.

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(CO-SUPERVISOR)

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(HEAD OF DEPARTMENT)

DEDICATION

I dedicate this work to my wife,. Biama Sarpong; Children: John Mawutor, Nutifafa Derrick, Nana Yaa Yayra, and Mother, Madam Akoeley Haligah

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ABSTRACT

In the tropical regions the fresh tuber of sweet potato is generally considered to be difficult to store due to unfavourable climatic conditions. In this study the efficacy of three organic extract in controlling storage rots in three varieties of sweet potato was evaluated The work was done in laboratory and in the field to find out post harvest factors which contribute to sweet potato tuber loss in the study area Treatments used in the study included three sweet potato varieties (Ogyefo, Tek and Monami) and three plant extracts (neem seeds, onion bulb and ginger rhizome) plus a control(water). Data collected included weight loss, TSS, TTA, tuber firmness, moisture content (MC), dry matter content (DMC), sprouting index, weevil damage, decay and storability. Data collected were analyzed using Statistix 9 statistical software. Tukey HSD test at 5% was used for the mean differences. Ogyefo (control) had significantly the highest weight loss of 38.88% Neem treated Tek tubers (12.0N). were significantly the most firm. Ginger treated Tek recorded MC of 66.03% which was significantly higher than those to which treatment was applied. Neem treated Tek recorded DMC of 46.53% which was significantly the highest. Onion treated Tek recorded TTA of 6.07 which was significantly higher than those to which treatment were applied, onion treated Tek recorded TSS of 11.07 ^{o}Brix which was significantly higher than those to which treatment was applied. Neem seed extract treated Ogyefo tubers had highest sprouting (6.75%)., Ogyefo sweet potato variety treated with onion extract was least susceptible to weevil damage (1.00%). Ogyefo varieties were less susceptible to decay (1.6). Tubers treated with neem (1.8) .Across varieties, onion treated tubers (2.1) were less susceptible to decay. For storability of the varieties, Ogyefo had a storage life of 59 days, neem treated tubers had storage life of 59 days. The following fungi; *Aspergillus flavus*, and *Rhizopus stolonifer* were isolated from rotted tissues and found to be pathogenic to sweet potato tubers. The water extracts of these plants suppressed fungal growth in culture The highest percentage inhibition of 62.5% was obtained with the use of neem seed extract on *Rhizopus stolonifer* while ginger extract caused 42.7% inhibition of *Aspergillus flavus*. Rot development caused by *Aspergillus flavus* was reduced by 35.34% with the use of onion extract. Considering matrices of performance parameters it can be concluded that neem seed extract is the most efficacious of the three plant extracts. The effect of plant extract on the sensory attribute of the sweet potato tubers must be investigated.

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CHAPTER ONE

1.0 INTRODUCTION

Sweet potato (*Ipomoea batatas*L.) is ranked the 7th most important food crop in the world (FAO, 1997). Over 95% of global sweet potato crop is produced in developing countries, where it is ranked the fifth most important food crop (CIP, 2006). According to Scott *et al*. (2000) more than two billion people in Asia, Africa, and Latin America will depend on this crop for food, feed and income by 2020. Sweet potato is grown as a smallholder drought tolerant food security crop because of its ability to produce reasonable yields where most food crops would fail. Sweet potato is widely grown as a staple food in many parts of the tropic and subtropics, which includes many developing countries. It is extensively grown in the tropical zone, accounting for about 81% of total world production. It is a low cost carbohydrate source for urban consumers especially when it is available in a form, convenient for working urban people. The area harvested for sweet potato in Ghana is 74,000 ha (http://www.factfish.com , 2012) which comes after cassava and yam in order of importance among root crops Sweet potatois cultivated in Ghana mainly for the carbohydrate-rich storage roots which is utilized in many food recipes It also contributes to incomes, food security and health. It is being promoted by the Root and Tuber Improvement and Marketing Programme (RTIMP) to enrich the diet of Ghanaians where the crop is particularly important in the Central, Volta and Upper East regions

In the tropical regions, the fresh sweet potato tuber is considered to be difficult to store because it is susceptible to variety of field and storage diseases. Some of the

storage diseases include black rot which is caused by *Ceratocystis fimbriation* (Onuegbu,

2002) and charcoal rot, caused by *Macrophomina phaseoli*(Clark and Hoy, 1994).Storage diseases are generally the most serious cause of post-harvest loss in sweet potato. Disease incidence can be reduced by the appropriate handling, treatment, curing and storage. For instance, washing of tubers in water containing sodium hypochlorite that is frequently changed reduces disease incidence. Also post harvest application of fungicide will assist in disease prevention.

Rudimentary storage systems as pit, traditional, and clamp are structures used in storing sweet potato tubers. The traditional storage structure consist of a cylindrical hole dug in the dry ground and lined on the floor and walls with dry grass. The grass is used for cushioning and absorbing excess moisture. The traditional storage structure is constructed in raised ground under a tree to prevent flooding and excessive sunshine. The pit and clamp are an improvement on traditional storage structure. Cured sweet potato roots are then placed carefully in the hole, and covered with grass and soil to normal ground level. Sprouting and spoilage are usually common with these storage methods and the roots cannot be preserved well for a long time (Onwueme, 1982).

However, freshsweet potato can be stored for several months (15.6C, 85% RH) using artificial air-conditioned stores (Picha, 1987). But farmers in developing countries cannot afford this storage method

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Plant products, have generally been used in the control of insect pests. However, extracts of ginger rhizomes, garlic bulb and aloe vera were successfully used in

controlling fungal pathogens (Obagwu *et al*., 1997; Amadioha, 1999; Ahmad and Beg, 2001). The limonoids in Neem products (Azadirachtin) though extensively used in insect pest management have been reported to have some fungicidal (Stoll, 1998) and bactericidal properties (Emechebe and Alabi, 1997; Bdliya and Dahiru, 2006) and have been used in plant disease management. Plant extracts from mahogany bark and oil from seeds have also been used in the control of *Callosobruchus maculatus* in stored cowpea (Bamaiyi *et al*., 2006) and *Tribolium castaneum* in stored sorghum seeds (Bamaiyi and Bolanta, 2006). The limonoids in the mahogany products have also been found to be effective against cotton leaf worm (Abdelgaleil and Nakatani, 2003). Limonoids are reported to possess some antiviral, antifungal and bactericidal properties (Abdelgaleil *et al*., 2001; Ademola *et al*., 2004). Thus the use of such organic extracts will help improve the storage life of sweet potato for future use. Therefore there is the need to investigate the effect of use of plant extracts on the storage rot of sweet potato.

The main objectives of this study therefore were to:

i. Identify post-harvest practices/factors that contributes to deterioration of Sweet potato tuber in the Gomoa East District
ii. Assess the efficacy of three organic plant extract namely neem seeds, onion bulb and ginger rhizome in controlling storage rot in sweet potato and
iii. Assess the storability of sweet potato treated with the organic plant extracts.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 DESCRIPTION OF SWEET POTATO

Sweet potato is ranked seventh among the world's major crops with an annual production of over 100 million tonnes (Nwokocha, 1992). Sweet potato is an important staple food crop, particularly in Sub-Saharan Africa where most of it is produced. It is one of the six important root and tuber crops grown in the region. Sweet potato is the third most important root tuber crop in Sub-Sahara Africa after cassava and yam (Ewell and Matura, 1991). The crop is grown as a smallholder drought tolerant food security crop because of its ability to produce reasonable yields where most food crops would fail.

2.1.1 Botany and Economic Importance Of Sweet potato

Sweet potato (*Ipomoea batatas* L.) is a dicotyledonous plant belonging to the family Convolvulaceae. The family includes about 45 genera and 1000 species with only *Ipomoea batatas* being of economic importance as food.

Sweet potato is widely grown as a staple food in many parts of the tropics and subtropics, which includes many developing countries. It is the third most important root and tuber crop after cassava (*Manihot esculenta*) and yam (*Dioscorea* spp.) within the sub-Saharan Africa region (Ewell and Matuura, 1994). The crop is ranked 7th among the most important food crop in the world (FAO, 1997) and 5th most important food crop accounting for over 95% of global production in the developing countries (CIP, 2006). In Africa, Nigeria produces about 0.2% of the world's sweet potato (Agbo and Ene, 1994). The crop is extensively grown in tropical areas and constitutes about 81% of total world production. Scott *et al*. (2000) reported that more

than two billion people in Asia, Africa, and Latin America will depend on the crop for food, as feed for animals and income by 2020.

There is currently considerable interest in promoting the production of the orange-fleshed sweet potato (OFSP) varieties as a source of beta-carotene, a precursor of Vitamin A in tackling Vitamin A deficiency which is prevalent in many parts of Sub-Saharan Africa; a leading cause of early childhood death and a major risk factor for pregnant and lactating women (VITAA, 2005). In 2010, the world average annual yield for sweet potato crop was 13.2 tonnes per hectare. In Senegal, annual yield of 33.3 tonnes per hectare was reported (FAOSTAT, 2011) even though yields as high as 80 metric tonnes per hectare have been reported from farms in Israel (Duke, 1983).

2.1.2 Nutritional Value of and Uses of Sweet Potato

Sweet potato is one of the most valuable root crops of the world and contains high amount of sugar and vitamins compared with other roots and tubers (Alvavez, 1996).

The tuber is also a good source of crude fibre, carotene, protein and some vitamins (IITA, 1996), as well as calcium, phosphorus, potassium and sodium, compared with other root and tuber crops (FAO, 1990). It is undoubtedly more nutritious than other roots and tuber crops like yams, cassava and Irish potato (FAO, 1990). In addition, the tuber has also been reported to have healing properties as an antioxidant food (Meteljan, 2006).

Sweet potato is a low cost carbohydrate source for urban consumers especially when it is available in a form, convenient for working urban people. Traditionally, sweet potato may be boiled and consumed. Over 80% of the sweet potato produced in Sub-Saharan Africa is consumed fresh. A small proportion is either processed for starch or

used for animal feed. The tubers are mainly starch and soluble carbohydrates, but the leaves and vines are high in amino acids, essential minerals and vitamins. Starch and protein digestibility of raw sweet potatoes has been cited as an obstacle to increased use for animal feed (Collins, 1997).

In Africa, sweet potato is generally eaten boiled or roasted. However, when sliced, dried (usually in the sun), and ground, it gives flour that remains in good condition for a long time. The flour is used as dough conditioner in bread manufacturing and as a stabilizer in the ice-cream industry. The tubers can also be processed into chips in much the same way as Irish potato and the product is now popular in Asia. In Japan, sweet potato starch is used in the production of noodles and is also fermented for the production of distilled spirits called 'shochu'. There is increasing experimentation with multiple uses of sweet potato in Africa. Uganda for instance, has seen the development, on a small scale, of sweet potato processed products such as juice, cakes, chips and chapattis (Kenyon *et al*., 2006).

2.2 POSTHARVEST LOSSES IN SWEET POTATO

Sweet potato storage roots can be stored under controlled environments for several months. Picha (1986) reported a temperatures range of 13-15^{o}C and high relative humidity can keep the tubers up to a year in the USA. In tropical developing countries, however, Hall and Devereau (2000) and van Oirschot *et al.* (2000) demonstrated that storage for 3-4 months was possible where tubers were carefully selected and stored in traditional pits or clamps in which high humidity is naturally maintained. Kapinda *et al*. (1997) and Rees *et al*. (2001) reported that sweet potato tubers under tropical conditions have shorter shelf life of 2-3 weeks during marketing. This they attributed to the storage conditions which are poor and also to mechanical

damage during transportation. Kapinga *et al*. (1995) reported short shelf life for sweet potato in East Africa. Surveys conducted in Tanzania by Fowler and Stabrawa (1993) showed that high temperature and low humidity cause the tubers to dry out.

Wills *et al*. (1998) cautioned that mechanical damage during post-harvest handling can be detrimental to the shelf life of the fresh produce as the damage areas creates an avenue for moisture loss and pathogen entry. In Africa, sweet potatoes are transported over a long distance over rough roads and are generally packed in polypropylene sacks weighing between 100kg to 140kg. Tomlins *et al*. (2000) indicated that transportation over rough road exposes the tubers to many minor impacts due to movement of sacks on the vehicle resulting in skin injury. They further stated that at the markets, the sacks are often dropped resulting in large impacts causing the tubers to break.

2.2.1 TUBER DETERIORATION

The post harvest rots of sweet potato have been substantially reported (Data *et al*., 1987; Arinze, 1985; Onifade *et al*., 2004). These rots have been attributed to physical, physiological and microbiological factors. Mechanical damage during harvesting, storage or transportation has been implicated in tuber predisposition to storage rots or deterioration (Snowdon, 1991). The most critical factor in tuber decay is the natural openings or wounds which serve as passage way for pathogenic contamination (Degras, 1993; Udo *et al*., 2001). Rots of the fleshy parts of plants develop as tissues are disintegrated by the action of microorganisms. Extra cellular enzymes are produced in advance of the bacterial cells or fungal hyphae of the attacking pathogens. The affected tubers become hydrotic and soft, turn brown, emit offensive odour and exhibits a sharp demarcation between a healthy intact tissue and a diseased

tissue (Snowdon, 1991).

A wide variety of microorganisms, particularly moulds, have been implicated in tuber spoilage, relatively few are implicated as primary pathogens (Data *et al*., 1987; Onifade *et al*., 2004). Fungal pathogens found to be associated with tuber decay include *Ceratocysts fimbriata, Monilochaetes infuscans, Rhizopus stolonifer* (Clark and Hoy, 1994). Onuegbu (2002) reported *Penicillium* sp., *Certocystis fimbriata, Diaporthe batatalis, Aspergillus. niger*and *Aspergillus. flavus*, as fungi responsible for decay of sweet potato tubers Oyewale (2006) reported *Mortierella ramanniana, R. stolonifer, Mucor pusillus, Botrytis cinerea, Erysiphe polygoni* and *A. flavus* has been associated with post harvest fungal rots of the tuber.

Fungal and bacterial diseases affecting the storage roots are important because they affect the yield, aesthetic quality, storage life and nutritional value of the storage roots. These pathogens create local discolouration and disruption of surrounding tissues of infected tubers (Snowdon, 1991), resulting in changes in appearance, deterioration of texture and possibly flavour or taste. The activities of these pathogens results in post harvest losses, reduction in the market value and misfortune to farmers. Fungicides such as Dichloronitroanline are used to protect tubers against Rhizopus soft rot (Clark and Moyer, 1988). However, the use of synthetic fungicides apart from their potential danger to both the farmer and environment (Obagwu *et al*., 1997), are unaffordable by most farmers. Recent studies on the use of plant extracts have opened a new avenue for the control of plant diseases. These plants extracts have been reported to be safe, non-phytotoxic to man, but effective against plant pathogens. Controlling fungi and insects during storage is necessary in safeguarding food security.

2.3 MAJOR POSTHARVEST DISEASES OF SWEET POTATO

2.3.1 Fusarium Rots

Surface root is a long-known disease which affects sweet potatoes only in storage. It is caused by cortical rotting strains of *Fusarium oxysporum*, a soil-borne wound pathogen distinct from Fusarium wilt pathogen. The disease usually develops following harvesting and consist of brown, dry rot restricted to the cortex of the storage roots. Infection may also occur in the field if growth cracks develop in the storage roots. Disease severity is affected by conditions in the field leading up to harvest and dry weather which favours skinning of the tubers during harvesting, leading to an increase in the disease incidence (Loebenstein and Thottappilly, 2009).

2.3.2 Charcoal Rot

It is a postharvest disease caused by *Macrophomina phaseolina*. It is a warm weather pathogen with broad host range. It produces a firm decay of the storageroots. The tissues first turn reddish-brown and then black as sclerotia of the pathogen are produced within the tissue. Often, the sclerotia are produced only in the cortex of the tubers even though the whole tuber is affected (Bartz and Brecht, 2005).

2.3.3 Black Rot

Black rot is caused by *Ceratocytis fimbriata* and is one of the most economically significant diseases of sweet potatoes. It appears as a black, dry rot on the storage root and is often restricted top the cortex. Black sunken cankers are produced on sprouts below soil line. Perithecia of the fungus are sometimes produced on the surface of infected tissues and the tissues have a characteristic fruity odour. Losses are prevented by discarding all visibly infected tubers and rejection of tubers from soils known to be

infected (Snowdon, 2010).

2.3.4 Java Black Rot

The Java black rot is caused by *Diplodia tubericola* is one of the most devastating postharvest disease (Dalisay *et al*., 1987). Symtoms often progress from the end of the storage root and involves the entire tuber. The decay is firm, reddish-brown then turns black. The tubers desiccate and become very hard. When infection occurs through wounds, lesions are often restricted and develop a black center surrounded by a wide brown zone. The disease is fully recognized by the black stromatic domes which erupt through the periderm of the tubers. The stroma contains pycnidia with many 1 or 2-celled conidia. The fungus is soil borne and infects storage roots through wounds incurred during harvest. Stressed tubers are particularly susceptible. A greater loss occurs often following handling of stored sweet potato. The best control measures are careful handling to minimize wounding, prompt curing and storage at 12°C immediately after curing (Snowdon, 2010).

2.3.5 Rhizopus Soft Rot

Rhizopus oryzae and *Rhizopus nigricans* are the predominant species found in the tropical and subtropical areas. Storage roots are very rapidly destroyed by soft, watery decay that consumes the entire tuber with little change in skin colour. A characteristic sweet smell (distinctive alcohol-like odour) is evolved. The fungus is fastidious about the type of wound required for infection. Infection occurs only in wounds with the surrounding tissues killed. Only harvested storage roots are affected and tubers are predisposed to the disease by prior exposure to direct sunlight. An abundance of fruit flies in the storage area usually indicates the presence of the disease. Rhizopus may be

prevented by careful handling together with prompt curing at optimum temperature and humidity. Fungicide treatment may also assist in disease control. The most effective ways to prevent disease before packing are to reduce wounding to sweet potatoes after harvest and to sufficiently cure them (Nelson, 2009).

2.3.6 Bacterial Soft-Rot

Bacteria soft rot is caused by *Erwinia chrysanthemum.* It affects both vine and storage roots and thrives at relatively higher temperatures. A soft, moist decay resembling Rhizopus soft rot turns affected storage roots tissues light brown. In storage the lesions have a dark brown to black margins and appear to be restricted. On the field, tubers are totally decayed leaving only residual fibers and periderm. Fresh wounds and high moisture levels are required for infection, making washing and packing favourable for the disease. Control may be achieved by including a mild bleach solution in the wash tank (Agrios, 2005).

2.4 CONTROL OF POSTHARVEST DISEASES OF SWEET POTATO

Sweet potato disease control has been extensively studied and several measures have been recommended. Farming practices such as crop rotation, fallowing, planting of healthy materials and the destruction of infected crop cultivars are some strategies adopted to reduce the incidence of disease on the farm. For post-harvest losses, control measures known to be effective in controlling rots includes minimizing physical damage of tubers during post-harvest operations or handling; placing tubers in an environment favourable for rapid healing of wounds where wounding cannot be entirely prevented and treating of sweet potato tubers with fungicides such as Benlate and Captan just after harvest. The boring beetle attack on shoot and tubers can be

controlled by application of granular Diazinon and Carbofuran (Amusa *et al*., 2003). Treatment of sweet potato tubers with insecticide dust (Actellic 2% dust) may reduce insect pests attack and also ameliorate physical damages acquired during harvest resulting in significantly fewer fungal lesions (Morse *et al*., 2000).

Some biological control measures have been carried out, using microbes to control sweet potato rot. Okigbo and Ikediugwu (2000) showed that *Trichoderma viride* displaced the naturally occurring mycoflora on the surface of the sweet potato tuber. This simple application of *Trichoderma viride* effectively controls the normal tuber surface mycoflora throughout storage, greatly reducing rotting. Okigbo and Nneka (2005) showed that extract of *Xylopia aethiopica* and *Zingiber officinale* controlled post-harvest sweet potato rot. It has been reported that plants with fungicidal properties are very effective in inhibiting fungal growth in-vivo and in-vitro (Kuhn and Hargreaves, 1987). *C. alata* and *D. tripetala* are among the plants with such properties (Khan *et al*., 2001).

2.5 STORAGE OF SWEET POTATO TUBERS IN TRADITIONAL STORAGE STRUCTURES

The contribution of sweet potato to incomes, food security and health in the tropics and in the developing countries is however challenged by the difficulty in storage that results from heavy weevil infestation, fungal decay and physiological breakdown under the tropical weather. These are visibly expressed as physical lesions on the tubers, dry and soft rots, weight loss and sprouting. Tortoe *et al*. (2010) reported that the traditional storage methods for the white sweet variety in Ghana recorded heavy storage losses owing to sprouting, rodent destruction, and insect and microbial damage. Traditional barns and other forms of storage structures used extensively in

tropical countries to protect the integrity of the crop have not yielded the desired results. Independent studies in Ghana by Osei-Gyamera (2000), Duku (2005) and Golokumah (2007) on various traditional storage techniques gave average shelf-life of 2 weeks. Van Oirschot *et al*. (2003) report an average shelf-life of no more than a week in East African marketing chain. The Maoris traditionally stored sweet potatoes in specially constructed underground storage houses, dug into the side of a hill.

2.6 USE OF BOTANICALS IN TUBER STORAGE

For thousands of years, natural products have been used in traditional medicine all over the world and predate the introduction of antibiotics and other modern drugs. The antimicrobial efficacy attributed to some plants in treating diseases has been beyond belief. It is estimated that local communities have used about 10% of all flowering plants on Earth to treat various infections, although only 1% have gained recognition by modern scientists (Kafaru, 1994). A typical example is the use of the essential oil, eugenol, purified from *Ocimum gratissimum* in treating human diseases has already been documented (Nakamura *et al*., 1999). Owing to the popularity of the use of plants as remedies for many infectious diseases, searches for plants containing antimicrobial substances are frequent (Betoni *et al*., 2006). Plant extracts have been used to control diseases in cowpea (Amadioha and Obi, 1998) and banana (Okigbo and Emoghene, 2004). Pesticides of plant origin are specifically more biodegradable, readily available, cheaper and environmentally friendlier than synthetic chemicals.

2.6.1 Onion Bulb

Onion (*Allium cepa*) is one of the oldest cultivated vegetables in history. It is thought that the bulbs from the onion family have been utilized as a food source for Millennia (Ody, 1997). Onion consists of its herbaceous plant part and its edible bulb part. The relative pungency of onion has both genetic and environmental components. Sulphur compounds found in onions have been shown to be anti-inflammatory both by inhibiting formation of thromboxanes and by inhibiting the action of platelet-activating factor (PAF). Thiosulfinates condition anti-thrombotic benefits, including antioxidant activity (Ying and Chang, 1998), reduced serum cholesterol and enhance in-vitro platelet activity (Goldman *et al*., 1995). This later effect is important for cardiovascular health by reducing the probability that platelets aggregate in the blood, a major cause of heart attacks and strokes (Havey, 1999). Hence, thiosulphinates found in onion have been shown to inhibit in-vitro platelet aggregation (Moritsau *et al*., 1992; Briggs and Goldman, 2002). Flavonoids are a second class of health enhancing compound produced by onions, an example is quercetin. Flavonoids are chemical compounds active against microorganisms. They have been found in-vitro to be effective antimicrobial substance against a wide array of microorganisms (Ekwenye and Elegalam, 2005).

2.6.2 Ginger Rhizomes

Ginger(*Zingiber officinale*) isfrom the family *Zingiberaceae* and consists of about 1,400 species. It is a perennial plant, with slender stem, about 24-39 inches in height and an underground stem. Ginger is extensively used commercially and domestically for its underground stem (Herbs, 2000). A lot of research has been carried out on the various herbal properties of ginger. The crop contains volatile oil, phenols, alkaloid

and mucilage. The herbal therapeutic benefits of ginger are mainly due to the presence of volatile oils and the high oleoresin content. A compound known as *gingerol* is an acrid chemical constituent of the ginger and it is responsible for the hot taste of ginger and its stimulating effect on the human body. Ginger extracts have been extensively studied for a broad range of biological activities including antibacterial, anticonvulsant, analgesic, anti-ulcer, gastric anti-secretory, anti-tumor, anti-fungal, anti-spasmodic, anti-allergenic, and other activities (Foster and Yue, 1992).

Krishnapillai (2007) in his studies on the fungicidal properties of ginger rhizome extract, a growth inhibition of 70.0% was recorded for *Fusarium* spp., 71.0% for *Colletotrichum* spp. and 64.2% for *Curvularia* spp. were recorded. Okigbo and Nmeka (2005) in their investigation on the potency of some plant extracts for the control of sweet potato tuber rot caused by *Fusarium oxysporum, Aspergillus niger and Aspergillus flavus*, found that hot water extracts of leaf and seed of uda (*Xylopia aethiopica*) and ginger (*Zingiber officinale*) were fungitoxic against the fungi. They indicated that the extracts suppressed the growth of these fungi in culture and reduced rot development in sweet potato tubers.

2.6.3 Neem Seed

Neem (*Azadirachta indica*) protects itself from the multitude of pests with a multitude of pesticidal ingredients. Its main chemical broadside is a mixture of 3 or 4 related compounds, and more than 20 minor compounds. The most dominant compounds been triterpenes specifically limonoids. Limonoids found in neem have demonstrated the ability to block insect growth, affecting a range of species that includes some of the most deadly pests of agriculture and human health. Azadirachtin, salannin,

meliantriol, and nimbin are the best known and most significant of the triterpenes (National Research Council, 1992)

Azadirachtin is the most active against insects. In addition to inhibiting their growth, it interferes with their powers of taste. Many leaf eating insects are repelled by plants to which even small amounts of azadirachtin have been applied. On the average, neem kernels contain between 2-9 mg of azadirachtin per gram of kernel. Azadirachtin does not kill insects immediately but repels and disrupts insect growth and reproduction. It is also the most potent growth regulators and feeding deterrents ever assayed. It is reported to repel or reduce the feeding of many species of pest insects including some nematodes (National Research Council, 1992). Singh (2012) indicated that azadirachtin is structurally similar to insect hormones called "ecdysones," which control the process of metamorphosis as the insects pass from larva to pupa to adult. It affects the corpus cardiacum, an organ similar to the human pituitary, which controls the secretion of hormones. This prevents the insects from molting, hence breaking the life cycle of some insects.

Another feeding inhibitor, meliantriol, is able in extremely low concentrations, to cause insects to cease eating (Singh, 2009). Salannin is a triterpenoid isolated from neem oil and powerfully inhibits feeding, but does not influence insect molts. Rizvi and Rizvi (1992) reported that the compound deter feeding at concentrations of 0.01 and 0.1% in striped cucumber beetles (*Acalymma vitttatum*) and spotted cucumber beetles (*Diabrotica undecimpunctata*). Nimbin and nimbidin also isolated from neem have been found to have antiviral activity. They affect potato virus X, vaccinia virus, and fowl pox virus. Nimbidin is the primary component of the bitter principles obtained when neem seeds are extracted with alcohol. It occurs in sizable quantities,

about 2% of the kernel. Deacetylazadirachtinol is isolated from fresh fruits and is a minor compounds which work as anti hormones and can even paralyze the "swallowing mechanism" of insects, thus, preventing insects from eating. 3-deacetylsalannin and salannol, recently isolated from neem, also act as antifeedants (National Research Council, 1992).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 FIELD SURVEY

3.1.1 Profile of Study Area

The study was carried out in the Gomoa East District. The district is located in the south-eastern part of the Central Region and situated between latitudes 05°14' North and 05°35' North and longitudes 00°22 West and 00°54' West. The district is bordered on the North-East by Agona East District, on the South-West by Gomoa West District, on the East by Awutu-Senya District, and on the South by Efutu Municipality whilst the Atlantic Ocean is found to the South-Eastern part of the District. It covers an area of 438 km square. The Population Density is estimated at 472.8 inhabitants /km² and had 54.6% of its population as females and 45.4% as male (Ghana Districts, 2012).

The district experiences two rainfall seasons. The major rainy season (March/April – June/July) and the minor season (September – November). The main dry season is from November to March and a minor one from mid-July to mid-August. The rainfall is generally low along the coast and gradually increases northward. Mean annual rainfall currently ranges between 70mm and 90mm in the Southern coastal belt and between 90mm and 110mm in the North-Western semi-deciduous forest areas (Ghana Districts, 2012).

. There are four main categories of soils namely; the forest ochrosols and oxysols intergrades, tropical black earth and forest lithosols. The forest ochrosols has a high nutrient value and is suitable for both tree and food crops, including cocoa, coffee, citrus, maize, cassava, pineapple and vegetables (Ghana Districts, 2012).

3.1.2 Sampling Area and Sampling Size

A preliminary survey was conducted to select areas with high sweet potato production. The outcome led to the selection of seven communities within the Gomoa East Distict where sweet potato production was high. These communities included Kwamekua, Eduafokwa, Esiwkwaa, Odembo junction, Amoanda, Odumase and Kristo Asafo. A total of 70 respondents consisting of 10 sweet potato farmers were randomly selected from each community. The survey was conducted in January, 2012.

3.1.3 Sampling Technique

Purposive sampling technique which is a non-probability sampling method was used. This technique enables the researcher to choose persons that are relevant to the research and are easily available to the researcher.

3.1.4 Questionnaire Design and Administration

The questionnaire construction and design covered demographic characteristics such as age, sex, educational background; farm characteristics which looked at farming experience, farm size, funding, sweet potato varieties grown, production practices carried out, harvesting of potato, handling and storage and problems associated with storage of the tubers. The survey also targeted solutions or innovations used in addressing storage problems of sweet potato. A total number of 70 questionnaires were administered to the farmers. Personal interviews and administration of semi-structured questionnaires were used in obtaining information from the farmers. Questionnaires were administered to farmers who cultivated sweet potato in the seven selected communities.

3.1.5 Data Analysis

Data collected from the survey were entered into excel and data analysis performed using Statistical Package for Social Scientists version 19 (SPSS 19). The data was presented in tables and graphs. Values were represented in percentages.

3.2 LABORATORY EXPERIMENT

3.2.1 Location of Experiment

The laboratory work was conducted at the laboratory of the Department of Horticulture and the plant pathology laboratory of the Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi. The experiment was carried out from March to April, 2012.

3.2.2 Sources of Experimental Materials

Tubers of sweet potato varieties were obtained from sweet potato farmers' farms in the Central Region. Tubers were cured in the sun for a week before transporting to the laboratory. Neem seeds were collected from Adidome in the Volta Region of Ghana. Onion bulbs and Ginger rhizomes were purchased from the Central Market in Kumasi.

3.2.3 Preparation of Sweet Potato Tubers

Mature and wholesome sweet potato of uniform tubers sizes were selected for the experiments. The selected tubers were washed under running tap water and allowed to dry under ambient conditions.

Plate 1: Tek sweet potato

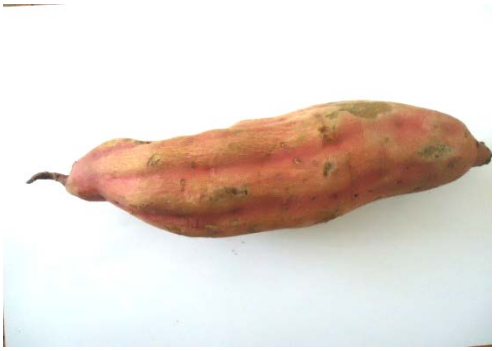

Plate 2: Ogyefoo sweet potato

Plate 3: Monami sweet potato

3.2.4 Preparation of Plant Extracts

3.2.4.1 Aqueous extract of neem seeds

The aqueous extract of neem seeds were prepared by crushing the seeds and subsequently grinding them. One kilogram of the ground seeds was placed in a cloth bag and soaked in 20 litres of water for 24 hours. The mixture was then sieved to obtain an aqueous extract for use (SMP, 2005).

3.2.4.2 Aqueous extract of onion bulb

Onion bulb aqueous extract was prepared by crushing 2kg of onions bulbs and mixed in 20 litres of water for 24 hours. The mixture was then sieved to obtain the aqueous extract for use (SMP, 2005).

3.2.4.3 Aqueous extract of ginger rhizome

Ginger rhizome aqueous extract was prepared by crushing 1kg of ginger rhizomes and mixed in 20 litres of water for 24 hours. The mixture was then sieved to obtain the aqueous extract for use (SMP, 2005).

3.2.5 Treatment of Sweet Potato Tubers with Plant Extracts

The clean and healthy tubers were dipped in the extracts. The sweet potato tubers were dipped into the solution of the neem seeds, onion bulb and ginger rhizome extracts and allowed to stand in the solution for 10 minutes. Tubers were air dried after removal from the plant extracts. In the control, tubers were dipped into water. The tubers were then placed in paper boxes and incubated at room storage conditions (28.9 ± 4.0°C and 44.6 ± 18.4 % RH)for a period of two months.

3.2.6 Experimental Design

A 3×4 factorial in Complete Randomized Design (CRD) with three replications was used for the experiment. The three plant extracts and three sweet potato varieties served as the treatments. A total of 144 sweet potato tubers were used. Each replication consisted of 48 tubers with four tubers per treatment. The treatment consisted of two factors. Factor one consisted of three sweet potato varieties namely Ogyefoo, Tek and Monami. Factor two consisted of three plant extracts namely neem

seeds, onion bulb and ginger rhizome and water as control. Twelve different treatment combinations were used.

3.2.7 Parameters Studied

3.2.7.1 Moisture and dry matter content(%) of tubers

Samples of the tubers were taken from each set of treatments. Samples were weighed before and after oven drying. Moisture content was determined as the difference in fresh weight and oven dry weight. The weight of each tuber after oven drying to constant mass was regarded as the dry matter.

$$MoistureContent(\%) = \frac{Freshweight - Dryweight}{Freshweight} \times 100$$

3.2.7.2 Weight loss of tubers (%)

Tuber weights were recorded every four days using an electronic weighing scale balance Weight loss was determined by finding the difference between the initial and final weights and expressed as percentage weight loss.

$$Weightloss\ (\%) = \frac{intialweight - finalweight}{intialweight} \times 100$$

3.2.7.3 Total soluble solids (TSS) of tubers

Total soluble solids of the tubers were determined using drops of extract on a hand held refractometer. Values were expressed in degree brix (^{o}Brix).

3.2.7.4 Total titratable acidity (TTA) of tubers

Total titratable acidity was determined by blending 30g of sweet potato tubers with 90ml distilled water using a blender fitted with a filter. Twenty-five milliliters (25ml) of the filtrate was pipetted into a 200ml conical flask with 25ml of distilled water added. Four drops of phenolphthalein indicator was added and titrated against 0.1N Sodium hydroxide (NaOH) (AOAC, 1990).

3.2.7.5 Tuber firmness

Fruit firmness was determined using a penetrometer. This was done at the twentieth day of the experiment (N).

3.2.7.6 Sprouting index of tubers

Sweet potato tubers were assessed for signs of sprouting and the sprouting index calculated by the formula proved by Amoah *et al*. (2011);

$$SproutingIndex = \frac{numberofsproutedtuber}{totalnumberoftuber} \times 100$$

3.2.7.7 Extent of weevil damage of tubers

Sweet potato tubers that show the presence of *Cylas* species or tunnels created by the weevils were recorded as damaged. This was calculated as a percentage of the initial number of tubers (Nicole, 1997).

3.2.7.8 Percentage tuber decay

Percentage tuber decay was determined through visual observation of rot. Rot severity assessment was done based on a scale of 1–5 as described by Rees *et al*. (2003), where:

1- No rot / no decay

2 – 25% of tubers rotten / damaged

3 – 50% of tubers rotten / damaged

4 – 75% of tubers rotten / damaged

5 – 100% of tubers rotten / damaged

3.2.7.9 Shelf life studies of tubers

The shelf life of the sweet potato tubers was determined at the end of the experiment. The number of days taken for half of the sweet potato tubers to lose their marketability was taken as the shelf life of the tuber

3.2.8 Identification of causal fungal organism

Characteristics of fungal isolates from rotten sweet potato tubers such as pigment production, colony texture, spore or conidia-producing structures and spore shapes were documented. The characteristics were observed from fungal tissues grown on PDA for one week or more, depending on the fungal species. Additionally. Spore and mycelium characteristics were studied using the compound microscope. These characteristics were used in identifying the fungal organisms to the species level, as described by Mathur and Kongsdal (2003) and Barnett and Hunter (1972).

Plate 4: Decayed tuber

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3.2.9 Data Analysis

The data collected were subjected to Analysis of Variance (ANOVA) using Statistix 9 statistical software. Difference between treatments means were separated using Tukey HSD test at 5% (P=0.05). Square root transformation [√(x+1)] was performed on three parameters; sprouting index, weevil damage and tuber decay before subjecting data to ANOVA.

3.3 PATHOGENICITY STUDIES

3.3.1 Collection of Diseased Sweet Potato Tubers

Rotten tubers of sweet potato were collected from first experiment.

3.3.2 Isolation of Fungal Species from Sweet Potato Tubers

Pieces of diseased tissues cut from the periphery of rotten sweet potato tubers with a sterilized knife were surface-sterilized in 5% sodium hypochlorite solution for 5 minutes. The surface sterilized diseased tissues were washed three times in sterile distilled water. The tissues were allowed to dry in a sterile Lamina flow chamber. The dried disease tissues were plated on an artificial potato dextrose agar (PDA) medium (Manufacturer: Mearck). Four to five days after incubation, mycelia that grew from

the plated sweet potato tissues were sub-cultured onto fresh PDA. Further sub-culturing was carried out until pure cultures of single species isolates were obtained. From these pure cultures, inocula of the different fungal species isolates were obtained for the pathogenicity tests.

Fresh, healthy sweet potato tubers were washed with tap water, rinsed with distilled water and surface sterilized with 70% ethanol. Cylindrical discs were removed from the tuber with a sterile 4 mm cork borer. A disc of a five days old culture of the isolated fungi was transferred into holes created in the tubers. Vaseline was used to completely seal each side and pieces of cotton were placed on the vaseline. The inoculated tubers were placed in separate airtight containers and incubated for 14 days atroom temperature (28 ± 2oC). The same procedure was used for the control except that discs of uninoculated PDA were placed in the holes created in the tubers (Amienyo and Ataga, 2006). After the incubation period, the tubers were examined for infection anddisease development.

3.4 CONTROL OF SWEET POTATO ROT ORGANISMS WITH BOTANICAL EXTRACTS:

3.4.1 Preparation of extracts of botanicals:

Cold water extraction method was used for the preparation of the botanical extracts. Neem seed ginger rhizome and onion bulbs were washed thoroughly with water. Each botanical was further blended into a fine paste .(Binatone, BLG-401, Hong Kong) at a speed of 4000 r.p.m. for five to ten minutes. Extract concentration of 5% (w/v) was obtained by adding 95mls of sterile distilled water to 5g each of ginger rhizome and neem seed in a beaker. A concentration of 10%(w/v) of onion bulb extract was obtained by adding 90mls of sterile distilled water to 10g botanical paste of onion

bulb. The efficacies of the botanical extracts were tested for their fungicidal activity in controlling sweet potato tuber rot fungi.

3.4.2 Anti-fungal Activity of plant extracts *in vitro* on sweet potato rot organisms

Two test fungi*Rhizopus stolonifer* and *Aspergillus flavus* obtained from rotten sweet potato tissues were used in this experiment. Surface coating of Potato Dextrose Agar (PDA) medium with botanical extracts was the method used to investigate the efficacy of the extracts. PDA medium was prepared by suspending 39g of product in one litre distilled water and autoclaving at 121 ^{O}C for 15 minutes. The medium was poured into sterilized petri dishes and allowed to solidify. Five millilitres (5mls) of each botanical extract preparation was spread thinly on the surface of the PDA in petri dishes. The extract was allowed to dry and the coated medium inoculated centrally with discs (5mm diameter) obtained from one-week-old cultures of the test fungi, *Rhizopus stolonifer.and Aspergillus flavus*. Three replications were set for each treatment. Controls were set up in which PDA with no botanical extract were inoculated with test fungi.

The method of Amadioha and Obi (1999) was used to determine the effect of the extract on fungal growth. This involved creating a four equal section on each Petri-dish by drawing two perpendicular lines at the bottom of the plate, the point of intersection indicating the centre of the plate. This was done before dispensing PDA into each of the plates. Plant materials were separately introduced into the Petri-dish containing the media (PDA). A disc (5mm diameter) of the pure culture of each isolate was placed on the extract just at the point of intersection of the two lines drawn at the bottom of the Petri dish. Control experiments were set up without addition of

any plant material. Fungi toxicity wasrecorded in terms of percentage colony inhibition and calculated according the formula: by Amadioha and Obi (1999)

Growth inhibition (%) = DC – DT X 100

DC 1

Where: DC -Average Diameter of control and

DT -Average diameter of fungal colony with treatment

CHAPTER FOUR

4.0 RESULTS

4.1 FIELD SURVEY OF POTATO FARMERS

4.1.1 Farmer Characteristics

4.1.1.1 Gender distribution of farmers

In all the communities, except Kristo Asafo, both gender were involved in sweet potato cultivation with the males dominating. At Kristo Asafo, the gender was all male (Table 4.1).

Table 4.1: Sex of respondents in sevencommunities

Community	Sex of respondents	
	% male	% female
Amoanda	80	20
Eduafokwa	80	20
Esiwkwaa	60	40
Kristo Asafo	100	0
Kwamekwaa	70	30
Odembo junction	90	10
Odumase	80	20
Total	80%	20%

4.1.1.2 Age distribution of farmers

The age distribution of farmers varied within the various communities. Whereas at Amoanda most of the farmers (80 %) were elderly, at Odumase majority of the farmers (80 %) were youthful (Table 4.2). Across the communities, most of the farmers (45.7 %) were in their prime age group of 41-50 years. Interestingly, an

appreciable percentage of farmers were also quite elderly in the 51-60 years group (Table 4.2).

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Table 4.2: Age of respondents in seven communities

Community	Percent Age groups of respondents				
	20-30	31-40	41-50	51-60	> 60
Amoanda	-	20	-	60	20
Eduafokwa	-	20	60	20	-
Esiwkwaa	-	-	80	20	-
Kristo Asafo	-	-	80	20	-
kwamekwaa	20	30	20	20	10
Odembo junction	-	-	40	60	-
Odumase	20	20	40	20	-
Total	5.7%	12.9%	45.7%	31.4%	4.3%

4.1.1.3 Educational background of farmers

The educational background of farmers varied with the various communities. Whereas at Esiwkwa almost all the farmers (60 %) had MLSC, at Eduafokwa all the farmers (100 %) had no formal education (Table 4.3). Interestingly, at Kristo Asafo the percentage of farmers who have no educational background were equal to those who have MLSC. Across the communities, majority of the farmers (65.7%) had no formal education and 4.3% had education up to JHS level.

Table 4.3: Education background in seven communities

Community	Percent Education background of respondents			Total
	JHS	MSLC	No formal edu.	
Amoanda	20	40	40	100
Eduafokwa	-	-	100	100
Esiwkwaa	-	60	40	100
Kristo Asafo	-	50	50	100
kwamekwaa	10	10	80	100
Odembo junction	-	30	70	100
Odumase	-	20	80	100
Total	4.3%	30.0%	65.7%%	100.0

4.1.2 Farm Characteristics

4.1.2.1 Farm size, cultivation experience and production level

The sweet potatoes were usually cultivated in pure stands. Other crops grown in addition to sweet potato included maize, cassava, pineapples, water melons, pepper, okro and pepper. .

In all the communities, except Odembo Junction and Odumase which had average farm size of 6.25acres and 7.0 acres respectively the other communities have average farm sizes below 4.0 acres

The farming experience of farmers varied with the various communities. Whereas at Amoanda the farmers have an average farming experience of 4.2 years, at Odembo Junction and Kristo Asafo the farmers have an average farming experience of 21 years and 17.75 years, respectively.(Table 4.4).

The average weight of produce harvested varied with the various communities. Although at Amoanda average produce harvested was 3.9 tonnes, it was as high as 6.3 tonnes at both Esiwkwaa and Kristo Asafo.

Table 4.4: Farm characteristics in seven communities

Community	Farm size (acres)		Experience (years)		Total harvest (tonnes)	
	Avg.	Range	Avg.	Range	Avg.	Range
Amoanda	1.80	1-3	4.20	4-5	3.9	3.2-4.3
Eduafokwa	1.83	1-3	9.33	5-20	4.1	3.2 -5.2
Esiwkwaa	3.60	2-5	16.60	15-20	6.3	5.4-7.2
Kristo Asafo	3.50	3-4	17.75	15-20	6.3	5.4 -7.2
Kwamekwaa	1.31	1-3	10.25	3-21	4.2	3.4 -7.2
Odembo Junction	6.25	2-8	21.00	18-25	6.1	4.5 -7.2
Odumase	7.00	3-12	16.40	9-23	5.8	2.7 -8.1

4.1.2.2 Farming funding sources

The source of farming fund for farmers varied with the various communities. In four communities which were Amoanda Eduafokwa Esiwkwaa Kristo Asafo farmers finance their farming activities from their own resources (100%). Interestingly, at Odumase the respondents used their own resources, loans, and both loans and their own resources to fund their farming activities.

Across communities majority of the farmers (84.2%) fund farming activities from their own source (Table 4.5)

Table 4.5: Source of funding for the farming activities in seven communities

Community	Sources of funding			Total
	Own source	Loan	Both	
Amoanda	100	-	-	100
Eduafokwa	100	-	-	100
Esiwkwaa	100	-	-	1oo
Kristo Asafo	100	-	-	100
kwamekwaa	60	-	40	100
Odembo junction	70	-	30	100
odumase	60	20	20	100
Total	84.2%	2.9%	12.9%	100.0%

4.1.2.3 Germplasm of sweet potatoes cultivated

At Amoanda and Odembo Junction 20% of farmers in each of these communities cultivated improved varieties All farmers at Kristo Asafo, Eduafokwaa, Kwamekwaa, cultivated only the local variety of sweet potato. Interestingly, at Esiwkwaa 60% of farmers cultivated both local and improved varieties.

Across communities majority the of farmers (80%) cultivated only the local varieties of sweet potato(Table 4.6)

Table4.6: Variety of sweet potato cultivated in seven communities.

Community	Varietyof sweet potato cultivated(%)			Total
	Local	Improved	both	
Amoanda	80	20	-	100
Eduafokwa	100	-	-	100
Esiwkwaa	40	-	60	100
Kristo Asafo	100	-	-	100
kwamekwaa	100	-	-	100
Odembo junction	80	20	-	100
odumase	60	-	40	10
Total	80.0%	5.7%	14.3%	100.0%

4.1.2.4 Harvesting Procedure and Duration

Farmers determine maturity of the sweet potato crop by yellowing of its leaves and then harvested them manually

In all the communities, except Odumase where 20% of the farmers harvested all the crops at maturity once, majority of the farmers do not harvest crops at once (97.1%).Table (4.7).

Table 4.7: Harvesting of sweet potato at once in seven communities.

Community	do you harvest all the crops at once		Total
	Yes	No	
Amoanda	-	100	100
Eduafokwa	-	100	100
Esiwkwaa	-	100	100
Kristo Asafo	-	100	100
kwamekwaa	-	100	100
Odembo junction	-	100	100
odumase	20	80	100
Total	2.9%	97.1%	100.0%

Farmers who did not harvest the entire crop at once indicated that it tookeither 1 week (4.4 %), 2 weeks (84.5%) or3 weeks (11.1%) to harvest the entire crop. But majority harvested over a 2 –week period.

4.1.3: Storage and losses of sweet potato

Most of the farmers (97.8 %) stored the tubers for periods ranging from 1-2 weeks (48.9 %) and 3-6 weeks (48.9 %). Only 2.2% of the farmers stored sweet potato tubers for more than 6 weeks. In storage, most of the farmers (95.9 %) encountered tuber spoilage which they attributed to insect infestation, rodent damage and fungal rot of tubers. The rot disease was reported by the farmers to be the most important of the three causal agents of spoilage.

4.1.4 Measures aimed at reducing postharvest losses in tubers

Majority of the farmers (95.6 %) indicated that they received assistance from the Extension staff of MOFA in various forms (Table 4.8). These included techniques for avoiding bruising of tubers harvested (46.7 %), selection and storage of good and matured tubers (36.7 %), information on timely/early harvesting of matured tubers (6.7 %), proper disposal of damaged and insect infested tubers (5 %), curing tubers before storing (3.3 %) and education on the use of recommended fertilizers and their correct dosage (1.7%).

Table 4.8: Extension services received in reducing losses in sweet potato

Assistance received from MoFA	Frequency	Percent
Use of recommended fertilizers and correct dosage	1	1.7
Damaged and insect infested tubers should be properly disposed off	4	5.0
Timely / early harvesting of matured tubers	5	6.7
Avoid bruising of tubers harvested	33	46.7
Good and matured tubers should be stored	26	36.7
Tubers should be cured before storing	2	3.3
Total	70	100.0

4.2 LABORATORY STUDIES

4.2.1 Initial physical and organoleptic properties of sweet potato varieties

Table 4.9 shows some organoleptic and physical properties of the tubers which were taken before application of extracts and then in storage. All the varieties had an approximate TTA value of 5, although Tek had slightly higher value whiles Ogyefo had the lowest value among the three varieties. A different trend was however observed for TSS. Tek had the highest value whiles Monami recorded the least value. Tek and Ogyefo contained more moisture than Monami. Ogyefo tubers were much firmer that Tek and Monami tubers.

Table 4.9: Initial Organoleptic and Physical Properties of three varieties of sweet potato

Varieties	TTA(%)	TSS(^{0}Brix)	MC(%)	FIRMNESS(N)
Tek	5.13	13.53	63.5	4.66
Ogyefo	4.93	13.13	62	6.10
Monami	5.01	12.87	58.5	4.60

4.2.2 Effect of extracts application on weight Loss of tubersof three varieties

Table 4.10shows the interactive effects of variety and plant extracts on weight loss of sweet potato tubers of the three varieties. Ogyefo without treatment recorded the highest weight loss (38.88%), significantly greater than most of the treatment combinations, except Monami without treatment and Monami with ginger treatment. Tek treated with onion (13.85%), ginger (15.18 %) and neem (15.69 %) recorded significantly the lowest weight losses. Across the extracts, Tek recorded the least

weight loss, about 73 % lower in weight than the mean of the other two varieties. All the extracts resulted in significant weight losses as compared to the control (water).

Table 4.10: Effect of variety and organic plant extracts on per cent weight loss of tubers of three sweet potato varieties

Varieties	Percentage weight loss(%)				
	Plant Extracts				
	Neem	Ginger	Onion	Control	Mean
Tek	15.69	15.18	13.85	16.77	15.37
Ogyefo	20.22	23.31	18.72	38.85	25.28
Monami	19.08	32.57	23.68	36.46	27.95
Mean	18.33	23.69	18.75	30.70	

HSD 5%Variety = 4.91; Extract = 6.22 ; Variety x Extract = 13.69

4.2.3 Total Soluble Solids of Sweet Potato Tubers

Table 4.11shows the interactive effect of three variety and different organic plant extracts on TSS of sweet potato tubers. From the results, Tek sweet potato variety with onion treatment had TSS of 11.07 ^{o}Brix which is significantly greater than the others. Monami treated with ginger extract had a TSSof 9.10 ^{o}Brix was not different from Tek treated with neem. The treatment combinations with the least TSS were Monami treated with neem and Tek variety treated with ginger (6.53^{o}Brix).

Across extracts, Tek had a significantly higher TSS (9.10 ^{o}Brix) than Ogyefo and Monami. All tubers treated with extracts had significant higher TSS compared to the control (water)tubers.

Table 4.11: Effect of variety and organic plant extracts on total soluble solids of tubers of three sweet potato varieties(^{0}Brix)

	Total soluble solids (TSS)				
Varieties	Neem	Ginger	Onion	control	Mean
Tek	9.10	9.10	11.07	7.13	9.10
Ogyefo	7.17	7.07	7.33	7.07	7.15
Monami	6.53	6.53	6.77	6.93	7.33
Mean	7.60	7.57	8.39	7.04	

HSD 5% Variety = 0.06 ;Extract = 0.08 ; Variety x Extract = 0.19

4.2.3 Total Titratable Acidity of Sweet Potato Tubers

Table 4.12 shows the interactive effects of variety and plant extracts on TTA of sweet potato tubers of the three varieties. Onion treated Tek variety had the highest TTA(6.07), significantly greater than all of the treatment combinations. The lowest TTA of 3.53 and 3.77 were recorded for Tek treated with ginger and Ogyefo treated with ginger, respectively.

Across the extracts, Tek recorded the highest TTA,(4.88)significantly higher than the other two varieties.Except ginger which had significantly lower TTA (3.87) than control, the other extracts resulted in significantlyhigher TTA as compared to the control (water).(Table 4.12)

Table 4.12: Effect of variety and different organic plant extracts on total titratable acidity[

Varieties	Titratable acidity				
	Plant Extracts				
	Neem	Ginger	Onion	Control	Mean
Tek	5.10	3.53	6.07	4.83	4.88
Ogyefo	4.17	3.77	3.93	4.27	4.03
Monami	4.93	4.30	4.07	4.63	4.48
Mean	4.73	3.87	4.69	4.58	
HSD 5%	Variety = 0.06 ; Extract = 0.08 ; Variety x Extract = 0.19				

4.2.4 Tuber Firmness of Sweet Potato

Table 4.13 shows the interactive effects of variety and plant extracts on firmness of sweet potato tubers of the three varieties. Neem extract treated Tek variety recorded the highest firmness (12.0N), significantly greater than all of the treatment combinations. The least results from treatment combinations on firmness of 5.47Nwas recorded for Onion extract treated Monami Across the extracts, Tek tubers had the highest firmness,(8.83N) significantly higher than the other two vanities In exclusion of ginger which had significantly lower firmness (6.33N) than control, the other extracts resulted in significantly higher firmness as compared to the control (water).

Table 4.13: Effect of variety and different organic plant extracts on firmness(N)

Varieties	Firmness of sweet potato				
	Plant Extracts				
	Neem	Ginger	Onion	Control	Mean
Tek	12.00	6.43	9.87	7.03	8.83
Ogyefo	7.07	6.07	8.63	6.67	7.11
Monami	6.43	6.50	5.47	6.13	6.13
Mean	8.50	6.33	7.99	6.61	

HSD 5% Variety = 0.06 ; Extract = 0.08 ; Variety x Extract = 0.19

4.2.5 Moisture Content of Sweet Potato Tubers

Table 4.14 shows the interactive effects of variety and plant extracts on moisture content of sweet potato tubers of the three varieties. Ginger extract treated Tek variety had the highest moisture content (66.03%), which is significantly greater than all of the treatment combinations. The least results from treatment combinations on moisture content of 53.73% was recorded for Neem extract treated Monami. Across the extracts, Tek recorded the highest moisture content,(63.58%) significantly higher than the other two vanities.

Exceptneem treated tubers which had significantly lower moisture content (50.53%) than the control, the other extracts on tubers resulted in significantly higher moisture content as compared to the control (water).

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Table 4.14: Effect of variety and different organic plant extracts on moisture content (%)

	Percentage (%) moisture content				
	Plant Extracts				
Varieties	Neem	Ginger	Onion	Control	Mean
Tek	61.60	66.03	63.37	63.33	63.58
Ogyefo	60.27	59.97	63.23	54.37	59.46
Monami	53.73	54.90	59.97	54.70	55.83
Mean	50.53	60.30	62.19	57.48	
HSD 5%	Variety = 0.06 ; Extract = 0.08 ; Variety x Extract = 0.19				

4.2.6 Dry Matter content of Sweet Potato Tubers

Table 4.15 shows the interactive effects of variety and plant extracts on Dry Matter Content (DMC) of sweet potato tubers of the three varieties. Neem extract treated Monami had the highest DMC of46.53% which was significantly greater than all the treatment combinations. The treatment combination with least DMC of 34.23% was recorded for ginger extract treated Tek. Across the extracts, Monami had the highest Dry Matter content DMC, (44.38%) which is significantly higher than the other two varieties.

All the treated tubers had significant lower Dry Matter content compared to the control (water) which recorded 42.74%

Table 4.15: Effect of variety and different organic plant extracts on dry matter content (%)

Varieties	Percentage Dry matter content(%)				
	Plant Extracts				
	Neem	Ginger	Onion	Control	Mean
Tek	38.60	34.23	36.77	36.93	36.63
Ogyefo	40.07	40.37	37.03	45.77	40.81
Monami	46.53	45.30	40.17	45.53	44.38
Mean	41.73	39.97	37.99	42.74	
HSD 5%	Variety = 0.06 ; Extract = 0.08 ; Variety x Extract = 0.19				

4.2.7 Sprouting Index of Sweet Potato Tubers

There were no significant interactions between variety and plant extracts on Sprouting Index of sweet potato tubers. Sprouting Index ranged from 2.37% for both Tek-control and Ginger extract treated Tek to 6.75% recorded by Neem treated Ogyefo.

Across extracts, there were no significant differences among varieties neither were there significant differences among the extracts and the control.

4.2.8 Extent of Weevil Damage of Sweet Potato Tubers

There were no significant interactions between variety and plant extracts on Weevil Damage of sweet potato tubers of the three varieties. Weevil Damage ranged from 1.0% for onion extract treated Ogyefo to 5.62% recorded by Monami-control.

Across extracts, there were no significant differences among varieties neither were there significant differences among the extracts and the control.

4.2.9 Percentage Tuber Decay of Sweet Potato

There were no significant interactions between variety and plant extracts for tuber decay .Ogyefo recorded the least score of 1.6, indicative that 25% of the tubers were rotten and it was significantly lower than the other two varieties Tek and Monami. However, there was no significant difference between Tek and Monami(Tables 4.16) Among the extracts neem resulted in significantly lower tuber decay with a score of 1.8 than onion and ginger Ginger and onion recorded significantly higher tuber decay score than control(Tables 4.17)

Table 4.16: Percentage tuber decay of sweet potato varieties

Sweet potato varieties	Decay score	Interpretation
Tek	2.8	50% of tubers rotten
Ogyefo	1.6	25% of tubers rotten
Monami	2.8	50% of tubers rotten
HSD 5%	0.81	

Table 4.17: Effect of different organic plant extract on percentage decay of sweet potato tuber

Plant extract	Scale	Interpretation
Neem	1.8	25% of tubers rotten
Ginger	2.6	50% of tubers rotten
Onion	3.1	50% of tubers rotten
Control	2.1	25% of tubers rotten
HSD 5%	1.03	

Decay Scale: **1**- no rot / decay; **2** - 25% of tubers rotten / damaged; **3** - 50% of tubers

rotten / damaged; **4** - 75% of tubers rotten / damaged; **5** - 100% of tubers rotten / damaged

4.2.10 Shelf Life Studies of Sweet Potato Tubers

There were no significant interactions between variety and plant extracts for tuber shelf life.Tek had significantly shorter shelf life of 48 days, than Ogyefo and Monami. However, there were no significant difference between the shelf lives of Ogyefo(59days) and Monami(55days)(Table 4.18).

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Table 4.18: Shelf life studies of sweet potato varieties

Sweet potato varieties	Shelf life (days)
Tek	48
Ogyefo	59
Monami	55
HSD5%	6.61

4.2.11 Isolation of Fungal Species from Rot affected Sweet Potato Tubers

A number of fungi were isolated from rotted sweet potato tubers of which the most frequently occurring were *Aspergillus flavus, Aspergillus niger,* and *Rhizopus stolonifer* Two of these fungi *Aspergillus flavus*,and *Rhizopus stolonifer* occurred in the sweet potato tubers of three varieties while a third fungus, *Aspergillus niger* was isolated only in Tek (Table 4.20). These fungi were found to be pathogenic and caused sweet potato rot.

Table 4.20 Fungal isolates from infected sweet potato varieties

Sweet potato variety	Fungal isolates

Tek	*Rhizopus stolonifer*,*Aspergillus flavus* and *Aspergillus niger*
Ogyefo	*Rhizopus stolonifer*. *Aspergillus flavus*
Monami	*Rhizopus stolonifer*, *Aspergillus flavus*

Plate 5: Decayed Tek tuber

Plate 6: Decayed Ogyeefo

Plate 7: Decayed Monami tuber

4.2.12 Effect of plant extracts on fungal mycelia growth

Table 4.21 shows the effect of the three plant extracts in the control of fungal mycelia growth in vitro of the isolated fungi. There were significant differences in the effectiveness of the plant extracts against both .*Rhizopus stolonifer*and *Aspergillus flavus.*Among the extracts, neem had a significantly greater percentage inhibition of62.5% whereas onionhas the least inhibition (37.7%) against the mycelia growth of*Rhizopus stolonifer*.Similarly against the mycelia growth of *Aspergillus flavus,* neem extract inhibitionwas56.3%, significantly greater than ginger(42.7%) and onion (35.3%).

Table 4.21 Percentage inhibition of some plant extracts against sp. Rhizopus stolonifer and Aspergillus flavus

	% inhibition	
	Fungi	
Extracts	*Rhizopus stolonifer*.	*Aspergillus flavus*
Ginger	49	42.7
Neem	62.5	56.3
Onion	37.7	35.3
HSD5%	7.7	6.3

CHAPTER FIVE

DISCUSSION

5.1 FIELD SURVEY

5.1.1 Relationship between farmer community characteristics and causes of Spoilage in storage

The survey conducted revealed that sweet potato production in the Gomoa East District was dominated more by males than females even though the 2010 population and housing Census revealed that there were more females than males in the district (Ghana Statistical Service, 2012). The large proportion of males involved in sweet potato production is indicative that the cultivation of the crop is labour intensive. Most of the farmers were aged between 40 to 49 years which reflected the active working class of the population in the district. It was also observed that about 65.7% of the farmers had no formal education with a few having Middle School Leaving Certificate(MSLC) qualification. The educational level of the farmers can influence the rate of sweet potato production technology adoption in the area.

The farmers had rich experience in sweet potato production. Whereas at Amoanda the farmers have an average of 4.2 years farming experience.at Odembo Junction and Kristo Asafo the farmers have an average farming experience of 21 years and 17.75 years, respectively.(Table 4.4).

The average yield ranged from 6.3 tonnes/ha in Esiwkwaa to 3.9 tonnes/ha in Amoanda.Yield as high as 33.3 ton/ha had been reported in Senegal (FAOSTAT, 2011) and 80 mt/ha in Israel (Duke, 1983). Sweet potatoes were usually grown in addition to staples, fruits and vegetables. Farming activities were normally funded by the farmers themselves. Even though the improved varieties were better in terms of

nutritional composition, the local sweet potato variety was the most cultivated. This was attributed partly to the ready availability of planting material and also to the fact that the local variety is native and well suited to the environment. Consequently the local varieties were more preferred than the improved varieties.

An appreciable number of the farmers (97.8%)across communities stored sweet potato tubers over a period of two weeks and 2.2% stored the tubers over six weeks

Majority of the farmers(95.9%) indicated that, they had spoilage in storage and the nature of spoilage included insect infestation resulting in holes in tubers, tuber rots from fungi and rodent attack. The farmers indicated that they received assistance in the form of extension services provided by MoFA and it was aimed at reduction of postharvest loss in sweet potato tubers. However the extension services did not indicate pre-storage treatment of sweet potato tubers with synthetic chemicals like washing of tubers in water containing sodium hypochlorite that is frequently changed to reduce disease incidence during storage nor the use of organic extracts.

5.2 Effect of Deterioration in storage on tuber physical and organoleptic properties

The weight losses of the tubers were significantly different among the varieties and the plant extracts used. Sweet potato variety, Monami lost more weight (27.95%) than Ogyefo (25.28%) and Tek (15.37%) varieties. The significant differences in weight loss could be due to varietal differences. Also, in the organic plant extracts, the control treatment lost more weight (30.7%) followed by ginger extract (23.7%). However, Ogyefo and Monami sweet potato varieties without any organic plant extracts recorded significantly the highest weight loss of 38.88% and 36.46%

respectively. Ginger treated tubers of Monami sweet potato variety recorded the third highest weight loss (32.57%). The significant high weight loss resulting from moisture loss from the control can be attributed to the fact that sweet potato tubers have thin skins and therefore offered less resistance to moisture loss than tubers treated with plant extract which formed a barrier around the tubers thereby restricting the amount of moisture loss..

Total titratable acidity of the tubers were significantly different among the varieties and the organic plant extract used and among the interaction of factors. Sweet potato total titratable acidity (TTA) was the highest (5.13) in Tek cultivar, followed by Monami and Ogyefoo with 5.01 and 4.93 initially before application of extract andthen storage. The difference in titratable acidity in these three cultivars was significant. The titratable acidity decreased at the end of storage duration but was the highest (4.83) in Tek variety followed by Monami and Ogyefoo with 4.63 and 4.27 respectively. The changes in titratable acidity might be affected by the rate of metabolism (Clarke *et al*., 2001) especially respiration, which consumed organic acid and thus declined the TTA (Rivera, 2005; Ghafir *et al*., 2009).

Sweet potato total soluble solids were the highest (13.53 ^{o}Brix) in Tek cultivar, followed by Monami and Ogyefoo with 12.87 ^{o}Brix and 13.13 ^{o}Brix respectively initially before application of extract and then storage. The difference in total soluble solids in these three cultivars was significant. The total soluble solids at the end of the storage period was the highest inTek (7.1 ^{o}Brix 3) variety followed by Monami and Ogyefoo with 6.93 ^{o}Brix and 7.07 ^{o}Brix, respectively. The changes in total soluble solids might be affected by the rate of metabolism (Clarke *et al*., 2001) especially

respiration, which consumed sugars and thus decline TSS(Rivera, 2005; Ghafir *et al*., 2009).

Firmness of the tubers were significantly different among the varieties and the organic plant extract used. Tuber firmness was highest in Ogyefo (6.10N) cultivar, followed by Monami and Tek with 4.60N and 3.80Nrespectively initially before application of extracts and then storage. The difference in firmness in these three cultivars was significant. The tuber firmness interestingly increased at the end of storage period so that it was the highest (7.03N) in Tek variety followed by Ogyefo and Monami with 6.67Nand 6.13N respectively. The firmness of the treated tubers showed Tek (8.83 N) sweet potato to be significantly higher than Ogyefo and Monami. The effect of neem extract (8.50 N)on firmness is significantly higher than ginger and onion extracts for firmness of the tubers.

Additionally, tuber firmness was affected by the, treatment combinations and the storage period .In general, storage for the period of 2 months increased firmness regardless of treatment. Tuber periderm thickening may be responsible for increase in firmness and could have continued in storage due to the rate of evapo-transpiration, respiration rates, resulting in loss of solutes and water (Gavlheiro *et al*., 2003; Erturk, 2003; Ghafir *et al*., 2009).

5.3 Effect of Deterioration in Storage on Moisture and Dry Matter Content of Tubers

Water loss from tubers is a key factor in their keeping quality during marketing. Initially Significantly Tek (63.5 %) had highest moisture content among the varieties before storage. Yet in the dry matter content, Monami(41,5%) sweet potato variety

had significantly the highest dry matter among the varieties. The moisture content of tubers decreased at the end of storage period; it was highest in Tek(63.37%) followed by Monami and Ogyefo with (54.73%) and (54.37%) respectively within the storage duration.

Similar observation was also made in the tubers treated with plant extracts. Onion treated tubers conserved significantly more moisture than neem treated and ginger treated tubers. However, a similar reverse trend was observed in the dry matter content where the untreated and neem treated tubers recording significantly higher dry matter content than ginger and onion treated tubers.

Moisture loss observed in this study can be attributed to a number of factors such as injuries to tubers, the respiration activity and the environmental condition around the tubers. According to van Oirschot *et al*. (2000), sweet potato loses about 90% of its initial weight through water loss under normal marketing conditions. Olaitan (2012) reported that sweet potato tubers have very low respiratory rates and that water loss through undamaged periderm is usually low compared to damaged areas. Kader (1992) reported that loss of moisture content in produce could be attributed to the difference in water vapour pressure within the commodity and the surrounding air a situation which may have contributed to the moisture loss in the study. Moreover, the significant moisture loss might had been enhanced by the respiratory activities of both the sweet potato and rot development as the tissues were degraded by pathogens. Conversely, Amoah *et al*. (2011) attributed dry matter and moisture loss to respiration and transpiration. Hu *et al.* (2004) in their work reported that the thin skin of sweet potato tubers could easily be damaged during harvest and post-harvest handling which made the crop highly perishable. The susceptibility of the sweet potato tubers to

moisture loss could therefore be said to be one of the main factors affecting the perishability of the tubers under marketing conditions.

5.4 Effect of organic extracts in the control of tuber sprouting

The sprouting index of the tubers measured indicated that Ogyefo recorded the highest sprouting index of 4.55%, followed by Monami (3.35%) and Tekhad the least spout index of 3.18%. The differences in sprouting observed are due to varietal differences. This means that Tek can be stored longer and can maintain its quality better than Ogyefo and Monami. In the organic plant extract treated, tubers, neem seed extract recorded more sprouting (5.04%) than ginger extract (2.87%).

Sprouting of tubers result in the conversion of starch to sugar to provide energy for the growth of the new sprouts. This made the tuber sweeter but the appearance of the sprout and loss of starch reduced the tuber value. Ghazavi and Houshmond (2010) attested to this fact when they reported that tuber sprouting caused further harm to the stored tubers resulting in significant loss in quality. According to Amoah *et al.* (2011) low sprouting in stored tubers were desirable, however, sprouting might also be an indication of loss of potency of a plant extract's ability to inhibit sprouting of the tubers. It could therefore be said that, the ginger extract gave a better sprout inhibition than the onion and the neem extracts.

5.5 Effect of organic extracts in the control of tuber weevils

Of all the three sweet potato varieties, Monami was the most prone to weevil attack and therefore recorded the highest weevil damage of 4.37 % compared to that of Tek(3.22%) and Ogyefo(3.01 %). This implied that Monami was most preferred by

sweet potato weevils in relation to the other two varieties. In assessing the efficacy of the three extract in controlling weevil attack in storage, the ginger extract treated tubers recorded higher damage(3.96%) than neem (3.28%) and onion (2.37%) treated tubers.

Sweet potato weevil (*Cylas* spp.) is known to be the most important insect pest of the storage tuber. Weevil infestation renders the tuber unsalable due to the bitter tasting phyto alexins produced as a result of the defence mechanism of the tubers. The larvae of this weevil burrow deep into the tuber and therefore are reported as a serious problem worldwide (Chalfant *et al*., 1990). Ghazavi and Houshmond (2010) reported that pests attack on stored tubers causes a significant loss in quality of the tubers.

Observations made by Kroschel and Koch (1996) and Raman *et al*. (1997), indicated that covering potato tubers with *Lantana camara* reduced tuber moth. Also, Amoah *et al.* (2011) reported that *Lantana camara* treated tubers produced better resistance against weevils.

Similar observation could be made from this study since the plant extract treated tubers gave a better resistance to weevil attack than the control. It can therefore be concluded that, the three plant extracts used were able to control the weevils to an extent and therefore reduced the severity of the damage as to render the tubers completely unwholesome for consumption.

5.6 Shelf life studies of tubers

The shelf life studies conducted shows that there were significant varietal differences and these significant differences were between Ogyefo(59 days) and Tek(48 days). The sweet potato variety Ogyefo stayed longer (59 days) than Monami (55 days) and

Tek (48 days) varieties. Ogyefo had moderate moisture content, moderate loss weight, recorded less decay and weevil damage. This may have contributed to its extended life as was seen in the shelf life. The Tek variety on the other hand had less weight loss, high moisture and sugar content which is a good substrate for microbial growth which favors rot organisms, , might have contributed to the high decay. This might have contributed to the short storage life recorded by the Tek sweet potato variety.Wills *et al.* (1998) attributed the shelf-life of fresh produce to be dependent on the extent of damage caused to the tuber during harvest, transportation and storage; and the avenue created for microbial entry.

According to Hayma (1982) the process of curing promote healing of sweet potato tubers similar to that used in other roots and tubers such as cassava (Rickard, 1985) and yam (Passam and Rickard, 1979). He further indicated that during the process of curing, a layer of cork cells, a few cell layers thick, is formed around the roots and tubers which greatly reduces the desiccation process and largely prevents infection by bacteria and fungi.

5.7 Effect of organic extracts in the control of tuber decay

The decay recorded in both Tek and Monami sweet potato varieties were significantly higher (50 %) than that of Ogyefo variety (25%). The differences can be due to individual ability to resist infection and injuries caused to tubers during harvesting and handling operations. In tubers treated with plant extracts, Ginger and onion treated tubers recorded significantly higher decay (50%) than in the neem treated tubers (25%) and the control (25%). At the end of storage period neem treated tubers

had the highest sprouting index of 5.14% followed by control 3.91% Onion treated tubers had the lowest sprouting index of 3.28%..

Rotting of sweet potato renders the tubers unsalable due to attack by both fungal and bacterial pathogens. Amienyo and Ataga (2007) in their studies using indigenous plant extract for protecting injured tubers reported significant reduction in rot development of *Aspergillus flavus, Aspergillus niger, Fusarium oxysporum, Fusarium solani, Botryodiplodia theobromae,* and *Rhizopus stolonifer* by the application of *Zingiber officialis, Annona muricata, Gacinia cola, Alchornea cordifolia* and *Allium sativum*. Udo *et al.* (2001) reported that garlic extracts inhibited growth and sporulation of fungal pathogens on sweet potato and yam. Okigbo and Nmeka (2005) also used leaf extracts of *Xylopia aethiopica* and *Zingiber officinale* to control yam tuber rot caused by *F. oxysporum, A. niger,* and *A. flavus.* The high percentage decay observed in this study can be attributed to the concentration of the plant extract used in treating the tubers and subsequent breakdown of the active ingredient in the extract resulting in loss of potency with time.

The fungal pathogens isolated from the rots included *Ceratocystsfimbriat**a,*** *Macrophormina phaseolina* and**.** *Rhizopus stoloniferAspergillus niger* Clark and Hoy (1994) in their studies identified several fungi to be associated with rotting of sweet potato tubers. These fungal pathogens included *Monilochaetes infuscans, Fusarium oxysporum, Ceratocysts fimbriata, Rhizopus stolonifer, Macrophomina phaseolina, Fusarium solani* and *Botryodiplodia theobromae*. Also, Onuegbu (2002) implicated *Penicillium* sp., *Certocystis fimbriata, Diaporthebatatalis, Aspergillus niger* and *Aspergillus flavus* as fungi responsible for decay of sweet potato tubers. Amienyo and

Ataga (2007) on the other hand, reported *Mortierella ramanniana, R. stolonifer, Mucor pusillus, Botrytis cinerea, Erysiphe polygoni* and *A. flavus* to be responsible for posts harvest fungal rots of tubers.

Snowdon (1991) indicated that these fungi create local discoloration and disruption of surrounding tissues of infected tubers resulting in changes in appearance, deterioration of texture and possibly flavour or taste. Clark and Moyer (1988) were of the view that these rot fungi cause post harvest losses, reduction in the market value and misfortune to farmers. On the other hand, Singh *et al*. (2008) and Tester *et al.* (2005) indicated that factors such as ambient temperature, light and air moisture as well as mechanical damage of tubers also accelerate the degradation of the tubers.

5.8Anti-fungal Activity of plant extracts *in vitro* on sweet potato rot organisms

The radial growth of all the rot fungi.*Rhizopus stolonifer,*and, *Aspergillus flavus*were significantly inhibited by the three test plant extracts: neem seed, ginger rhizome and onion bulb. Among the extracts neem had a significantly greater percentage inhibition of 62.5% than those of ginger and onion which had 49% and 37.7% respectively against mycelia growth of *Rhizopus stolonifer*There were significant difference in the performance of the plant extracts against both,*Rhizopus stolonifer*and *Aspergillus flavus.* This indicates that all the extracts have fungitoxic potential, though none of these had 100% inhibition of the radial growth of the mycelia in the Petri dish within the period of observation .

This study revealed that fungitoxic compounds were present in *neem seed,ginger rhizome*, *onion bulb* extracts since they were able to inhibit the growth of the fungi tested This agrees with earlier reports of Suleimana. (2010) on the inhibition of growth and sporulation of fungal pathogen *Alternaria solani* on Yam.by*neem* extract.

Additionally, it agrees with the fungicidal properties of water extracts of ginger rhizome which inhibited growth of *Fusarium* spp., *Colletotrichum* spp. and *Curvularia* spp. by its water extract by 70.0%, 71.0% and 64.2%, respectively (Krishnapillai, 2007.)

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSIONS

The results obtained from screening of the different plant extracts confirm the therapeutic potency of some plants and their use in disease control. The results of the present study support the folkloric usage of the plants extract and suggest that some of the plant extracts possess compounds with antimicrobial properties and that can be used as a botanical in the control of sweet potato tubers. Tubers treated with neem seed extract showed superior properties in terms of reduced weight loss, had relatively high dry matter content, low levels of decay and longer shelf life. Onion bulb extract treated tubers on the other hand showed low weight loss, high sugar content, high moisture content, moderate sprouting and low weevil damage. However, tubers treated with ginger extract relatively retain more moisture, low sprouting and moderate shelf life. It can therefore be concluded that treating the sweet potato tubers with plant extract resulted in improved storability. Comparably, neem extract was the most efficacious with regards to the matrices of parameter studied.

6.2 RECOMMENDATIONS

It is recommended that further studies should be conducted using other plant extracts in controlling storage weevils and decay pathogens of sweet potato. Also, the effect of the plant extract on the sensory attribute of the sweet potato tubers must be investigated

REFERENCES

Abdelgaleil, S.A.M. and Nakatani, M. (2003).Antifeeding activity of limonoids from.

Abdelgaleil, S.A.M., Okamura, H., Iwagawa, T., Sato, A., Miyihara, I., Doe, M. and Nakatani, M. (2001). Khayanolides rearranged phragmalin limonoid antifeeddants from *Khaya senegalensis*. *Tetrahedron*57 (1): 119–126.

Ademola, I.O., Fagbemi, B.O. and Idowu, S.O. (2004). Evaluation of antihelminthic activity of *Khaya senegalensis*---- extracts against gastro intestinal nematodes of sheep: in vitro and in vivo studies. *Vet. Parasitology*.122 (2): 151–164.

Agbo FM, Ene LSO (1994). Sweet Potato situation and priority Research in west/ central Africa. C IP proceedings of the workshop held atDouala, Cameroon 27-29th July 1992 pp. 27-34.

Agrois, G.N. (2005). Plant pathology (5th ed.). London, UK: Elsevier Academic Press. p 952. Alternaria Solani CausalOrganism of Yam Rots

Ahmad, I. and Beg, A. (2001). Antimicrobial phytochemical studies on 45 Indian medicinal plants against multi-drug resistant human pathogens.*J. Ethnopharmacol*. 7: 113–123.

Alvarez, M.N. (1996). Sweet potato and the African Food Crisis, Tropical Root Crops.Proceedings of the 3rd Triennial Symposium of the International Society for Tropical Root Crops, Owerri. Pp. 66-69.

Amadioha, A.C. 1999. Evaluation of some plant extracts against *Colletotrichum lindermuthianum*. Arch. Phytopathol. Plant Protect. 32 (2): 141–149.

Amadioha, A.C. and V.I. Obi (1998).Fungi toxic activity of extracts of *Adiradichta indica* and *Xylopia aethiopica* on *Colletotrichum lindemuthianum* in cowpea. J. Herbs, Spice and Medicinal Plants (In press*).*

Amienyo CA, Ataga AE (2006).Post-harvest fungal diseases of sweet potato(*Ipomoea batatas* Lam) tubers sold in selected markets in Rivers State, Nigeria. Sci. Afr. 5(2): 95-98.

Amienyo, C.A. and Ataga, A.E. (2007). Use of indigenous plant extracts for the protection of mechanically injured sweet potato [*Ipomoea batatas* (L.) Lam] tubers. *Scientific Research and Essay* 2 (5): 167-170.

Amoah, R.S., Teye, E. Abano, E.E. and Tetteh, J.P. (2011). The storage performance of sweet potatoes with different pre-storage treatments in an evaporative cooling barns. *Asian Journal of Agricultural Research*5(2): 137-145.

Amusa, N.A., A.A. Adegbite, S. Muhammed and R.A. Baiyewu (2003).Yam diseases and their management in Nigeria.African Journal of Biotechnology Vol. 2(12).497- 502 p.

AOAC (Association of Official Analytical Chemists). 1990. Official methods of analysis. 12th ed. Washington D.C.

Arinze, A.E. (1985). The Action of Polygalacturonase and Cellulose Enzymes of B. theobromae on Yams and Sweet potatoes.*Phytopathol. Zeit*144:234-242.

Bamaiyi, L.J. and Bolanta, F. 2006. Evaluation of *Khaya senegalensis* products in the control of Tribolium castaneum on stored sorghum. Arch. Phytopathol. Plant Protect. 39 (2): 99–103.

Bamaiyi, L.J., Ndams, I.S., Toro W.A. and Odekina S. 2006.Effect of mahogany (*Khaya senegalensis*) seed oil in control of *Callosobruchus maculatus* on stored cowpea. Plant Protect. Sci. 42 (4): 130–134.

Barnett H.L. and B.B. Hunter (1972).Illustrated Genera of Imperfect Fungi.3rd Edition.BurgessPublishing Company.

Bartz, J.A. and Brecht, J. K. (2005). Postharvest physiology and pathology of vegetables 92nd ed.). Marcel Dekker, Inc., New York, USA. p. 744.

Bdliya, B.S. and Langerfeld, E. 2005 b. Soft rot and Blackleg [*Erwinia carotovora* ssp. atroseptica (Van Hall) Dye] of potato as affected by inoculum density and variety. Nigerian J. Plant Protect. 22: 65–75.

Bdliya, B.S., Dahiru, B. 2006. Efficacy of some plant extracts on the control of potato tuber soft rot caused by *Erwinia carotovora* ssp. carotovora. J. Plant Protection Res. 46 (3): 285–294.

Betoni, J.E.C., R.P. Mantovani, L.N. Barbosa, L.C. Di-Stasi and A. Fernandes (2006). Synergism between plant extract and antimicrobial drugs used on *Staphylococcus aureus* diseases. Mem. Inst.Oswaldo Cruz, 101. 387-390pp. Chichester, Britain.

Briggs, W.H and Goldman, I.L. (2002).Variation in economically and ecologically important trait in onion plant organs during reproductive development.*Plant Cell and Environment*25: 1031 - 1036.

Chalfant, R.B., Jansson, R.K., Seal, D.R. and Schalk, J.M. (1990).Ecology and management of sweet potato insects.*Annual Review of Entomology*35: 157-180.

CIP (2006). Annual report: Strengthening assets, enhancing impact. Available from: http://www.cipotato.org/publications/pdf/003914.pdf. [accessed date 25th August, 2011].

Clark, C.A. and Hoy, M.W. (1994). Identification of Resistances in sweet potato to Rhizopus soft rot using two inoculation methods. *Plant Disease*78(11): 1078-1081.

Clark, C.A. and Moyer, (1988).Compendium of Sweet Potato Disease. Am. Phytopathol. Soc. St Paul MN. p. 74.

Clark, C.J., V.A. McGlone and R.B. Jordan. 2001. Detection of brownheart in 'Braeburn' apple by transmission NIR spectroscopy. Postharvest Biol. Technol. 28: 87–96

Collins, W.W. 1997. Root vegetables: New uses for old crops. p. 533-537. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Dalisay, R.F., Divinagracia, G.G and Mendoza, E.T. (1987). Screening sweet potato roots for resistace to Java black rot caused by *Diplodia tubericola* (Ell. & Ev.)Taubenh.*Phillipp. J. Crop Sci*12(1): 33-37.

Data, E.S., Diamente, J.C. and Eronico, P.S. (1987).Postharvest Handling and Storability of Sweet potato Roots.International Sweet Potato Workshop. Visayas State College of Agriculture, Philippines. pp.19.

Degras, L. (1993). *The Yam: A Tropical Root Crop*, 1st ed. MacMillan, London.

disease in banana *(Musa acuminata*).KMITL Sci. J. 4(1): 20-31pp

Duke, J.A. (1983). Handbook of energy crops.Unpublished. Available from: http://www.hort.purdue.edu/newcrop/duke_energy/ipomoea_batatas.html#Yields%20and%20Economics. [Accessed: 26th August, 2011].

Duku, I.G. (2005). The effects of defoliation and post-harvest handling techniques on the shelf-life of sweet potato. M.Phil. Thesis, University of Cape Coast.

Ekwenye, U.N. and Elegalam, N.N. (2005). Antibacterial activity of ginger (*Zingiber officinale* Roscoe) and garlic (*Allium sativum* L.) extracts on *Escherichia coli* and *Salmonella typhi*. *Journal of Molecular Medicine and Advanced Science*1(4): 411-416.

Emechebe, A.M. and Alabi, O. (1997). Evaluation of aqueous extracts of parts of some plants for the control of cowpea diseases at Samaru. In: "Report on Legumes and Oil Seeds Research Programme". 21–25 September 1997, Samaru Cropping Scheme Meeting, Samaru, Zaria, Nigeria, 77 pp.

Erturk, U., B. Akbuclak and M.H. Ozer. 2003. Quality changes of some apple cultivars stored in normal atmosphere forlong Period . Acta Hort. 599: 665 – 672.

Ewell PT, Matuura J (1991). Tropical Root crops in a developing Economy.Proceeding of the 9th symposium of the International Society for Tropical Root crops 20-26 Oct 1991 Accra. Ghana.

Ewell, P.T., and Matuura, U. 1994. Sweet Potato in the Food Systems of Eastern and Southern Africa. In: *Tropical Root crops in a Developing Economy*, Proceedings of the 19th Symposium of International Society for Tropical Root Crops. Accra pp. 531.

FAO (1990). Nutritive value of sweet potato: Root, Tubers, Plantains and Bananas in human nutrition. FAO of the United Nations, 1: b42-43

FAO (1997).FAO production yearbook of 1997. Rome, Italy. p. 51.

FAO(2008): Food and Agricultural commodities production. FAOSTAT database.Available at http://faostat.fao.org/site/339/default.aspx. (Access date: 28.08.2011).

FAOSTAT (2011).Crop production worldwide 2010 data.Food and Agriculture Organization of the United Nations.

Foster S. and C.X. Yue (1992). Herbal Emissaries: Bringing Chinese Herbs to the West. Rochester, Vt: Healing Arts Press

Fowler, M.H. and Stabrawa, A.M. (1993).*Sweet Potato Marketing In Uganda: Results of a Rapid Appraisal*. Chatham, UK: Natural Resources Institute. (Unpublished).

Gavalheiro, O.J., A. Santos, I. Recasens, C. Larrigancliere and A. Silvestre. 2003. Quality of the postuguese 'Bravo de Esmolfe' apple after normal cold storage or controlled atmosphere and two shelf life periods. Acta Hort. 1: 395-400.

Ghafir, S. A. M., S.O. Gadalla, B.N. Murajei and M.F. El-Nady. 2009. Physiological and anatomical comparison betweenfour different apple cultivars under cold-storage conditions. Afric. J. Pl. Sci. 3: 133-138

Ghana District (2012).Gomoa East Districts. Available from: http://ghana districts.com/ districts/?r=3&_=183&sa=6030. Accessed date: 26/03/2013.

Ghana Statistical Service (2008).Ghana Living Standards Survey Report of the fifth round (GLSS 5).Ghana Statistical Service, Accra, Ghana.p. 146.

Ghana Statistical Service (2012).2010 Population and Housing Census final

results.Ghana Statistical Service, Accra, Ghana.p. 15.

Ghazavi, M.A. and Houshmand, S. (2010). Effectd of mechanical damage and temperature on potato respiration rate and weight loss.*World Applied Science Journal*8(5): 647-652.

Goldman , I.L., Schwarz, B.S. and Kopelberg, M. (1995). Variability in blood platelet inhibitory activity of Allium (Alliaceae) species accessions.*Am Y Bot*82: 827-832.

Golokumah, I.K. (2007). Curing of sweet potato roots with farmers in Korofidua community in the Cape Coast Municipality. B.Sc. Thesis, University of Cape Coast.

Hall, A.J. and Devereau, A.D. (2000). Low-cost storage of fresh sweet potatoes in Uganda: lessons from participatory and on-station appraoches to technology choice and adaptive testing. *Outlook on Agriculture*29: 275-282.

Havey, M.Y. (1999).Advances in new Alliums. In: J. Janick (ed), Perspectives in New Crops and New Uses. ASHS Press, Alexandria, VA, pp 374-378.

Hayma, J. (1982). The storage of tropical agriculture products.Agrodok 31. ACP/EEC, Wageningen, The Netherlands. p 73.

Herbs2000. Ginger (www.herbs2000.com/Ginger, date accessed: 9-08-09)

Hu JJ, Nakatani M, Lalusin AG, Fujimura T (2004). New microsatellite markers developed from reported Ipomoea trifida sequences and their application to sweetpotato and its related wild species. Sci. Horticult. 102: 375-386

IITA (1996).Sweet potato.In sustainable food production in sub-Saharan Africa 1; International Institute of Tropical Agriculture (IITA) contribution. pp. 79-83.

its related wild species. Sci. Horticult. 102: 375-386

Kader, A.A. 1992. Post harvest Technology of Horticultural Crops, 2nd ed. Publication 3311. University of California, Division of Agricultural and Natural Resources, Oakland, CA.

Kafaru E. (1994). Immense help formative workshop. In Essential Pharmacology. 1st Ed. Elizabeth Kafaru Publishers: Lagos, Nigeria

Kapinda, R.E., Jeremiah, S.C., Rwiza, E.J. and Rees, D. (1997).*Preferences and Selection Criteria of Sweet Potato in Urban Atreas of the Lake Zone of Tanzania*. Chatham, UK: Natural Resources Institute. (Unpublished).

Kapinda, R.E., Jeremiah, S.C., Rwiza, E.J. and Rees, D. (1997).*Preferences and Selection Criteria of Sweet Potato in Urban Atreas of the Lake Zone of Tanzania*. Chatham, UK: Natural Resources Institute. (Unpublished).

Kapinga, R., Ewell, P., Jeremiah, S. and Kileo, R. (1995).*Farmers Perspectives On Sweet Potato And Implications For Research In Tanzania. A Case Study*. Dar es Salaam: Tanzanian Ministry of Agriculture and International potato Center.

Kenyon, L., Anandajayasekeram, P. and Ochieng, C. (2006). A synthesis / lesson-learning study of the research carried out on root and tuber crops commissioned through the DFID RNRRS research programmes between 1995 and 2005. A report submitted to the Crop Protection Programme (CPP) of the UK Department For International Development (DFID; R1182). p 83.

Khan M.R., Kihara, M. and Omoloso, A.D. (2001).Antimicrobial activity of *Cassia alata*.Fitoterapia,72: 561-564pp *Khaya senegalensis*. *J. Appl. Entomology*. 127 (4): 236–239.

Kim, D.M., Smith, N.L. and Lee, C.Y., 1993, Quality of minimally processed apple slices from selected cultivars. *J. Food Sci.* 58(5): 1115-1117.

Krishnapillai N. (2007). Medicinal value of ginger (*Zingiber officinale*) in Jaffna.Department of Botany, University of Jaffna, Jaffna, Sri Lanka.www.cabi .org/CABI abstract.

Kroschel, J. and Koch, W. (1996).Studies on the use of chemical, botanical and *Bacillus thuringiensis* in the management of the potato tuber moth in potato stores.*Crop Protection*15: 197-203.

Kuhn P.J. and Hargreaves, J.A. (1987).Antifungal substances from herbaceous plants. In: FG Peggs and AG Ayes (eds). Fungal infection of plants.Symposium of the British Mycol. Soc. CambridgeUni.Press.48-129 pp.

Loebenstein, G. and Thottappilly, G. (2009).The sweetpotato.Springer Science.p. 522.

Marthur S.B. and O. Kongsdal (2003).Common Laboratory Seed Health Testing Methods for Detecting Fungi, 2nd Edition.International Seed Testing Association. Switzerland

Meteljan, G (2006). The world healthiest foods (sweet potato), selecting, preparing and enjoying. By Goerge Metelian foundation. Available from: www. whfoods.com. [Access date: 23 Auguest, 2011).

Moritsau, Y., Morioka, Y. and Kawakishi, S. (1992). Inhibitors of platelet aggregation generated by mixtures of Allium species and / or S-alk(ene) nyl-L- cysteine sulfoxides. *J Agri Food Chem*40: 368-372.

Morse S., M. Acholo, McNamara, N. and Oliver, R. (2000). Control of storage insects as a means of limiting yam tuber fungal rots. J. Stored Products Res. 36: 37-45.

Nakamura, C.V., T. Ueda-Nakamura, E. Bando, A.F. Melo, D.A. Cortez and B.P. Dias Filho (1999).Antibacterial Activity of *Ocimum gratissimum* L. Essential Oil.Mem. Inst. Oswaldo Cruz, 94. 675-678 pp.

National Research Council (1992). Neem: A tree for solving global problems. Nationa Academy Press, Washington, D.C. pp 31-38.

Nelson, S. (2009). Rhizopus Soft Rot of Sweetpotato.Plant Disease 68.College of Tropical Agriculture and Human Resources (CTAHR), University of Hawai‘i at Manoa.

Nicole, E.J.M. (1997). The effect of indigenous cultural practices of in-ground storage and piecemeal harvesting of sweet potato on yield and quality losses caused by sweet potato weevils in Uganda. *J. Agric. Ecosyst. Environ*. 64: 191-200.

NSPRI (2002).Utilization of sweet potato.In proceedings of Nigerian Stored Products Research Institute (NSPRI) workshop in participatory technology development methods. Community analysis report on postharvest practices on cassava and sweet potato in Ijagho, Oyun LGA of Kwara state on 6th-7th Sept. 2002. Organized by Capacity Building for Decentralized Development (CCBD).Edited by Ayoola J, Udo-Ekong CR. pp. 11-12.

Nwokocha H.N. (1992). Agronomy of sweet potatoes Root crop Research and Technology transfer training course (Training manual) NRCRI pp. 77-84

Obagwu, J., Emechebe, A.M. and Adeoti, A.A. (1997).Effects of extracts of garlic (*Allium sativum*) bulb, and neem (*Azadirachta indica*) seed on the mycelia growth and sporulation of *Colletotrichum capsici*.*Journal of Agricultural Technology*5: 51–55.

Ody, P. (1997).The Complete Medicinal Herbs. Dorling Kindersley Limited, London, pp 8.

Okigbo R.N. and A.O. Emoghene (2004). Antifungal activity of leaf extracts of some plant species on *Mycosphararella fijiensis* Morelet, the causal organism of black sigatoka disease in banana *(Musa acuminata*).KMITL Sci. J. 4(1): 20-31pp

Okigbo R.N. and F.E.O. Ikediugwu (2000).Studies on biological control of postharvest rot of yam with *Trichoderma viride*.J. Phytopathol. 148: 351-355.

Okigbo, R.N. and Nmeka, I.A. (2005). Control of Yam tuber rot with leaf extracts of Xylopia aethiopica and Zingiber officinale *Afr. J. Biotechnol*. 4(8): 804-807.

Olaitan, O.O (2012). Bio-deterioration of sweet potato (*Ipomoea batatas* L.) in storage, inoculation-induced quality changes, and control by modified atmosphere.*J. Appl. Sci. Environ. Manage*. 16 (2): 189 - 193

Onifade, A., Atum, H.N. and Adebolu, T.T. 2004. Nutrition Enrichment of Sweet Potato (*Ipomoea batatas* L) by Solid Substrate fermentation using Four Fungal species. *Global J. of Pure Appl. Sci*. 10(60): 31-36.

Onuegbu, B.A. (2002). Fundamentals of Crop Protection..Agro-science consult and Extension Unit, RSUT.p. 237. .

Onwueme, I.C. 1982. *The tropical tuber crops : Yams, cassava, sweetpotato, and ocoyams*. English Language Book Society and John Wiley and Sons. Chichester, Britain

Osei-gyamera,E.,2000.Agronomic studies of sweet potato (*Ipomea batatas* L.) in two districts of the Central Region-(2000). M. Phil Thesis, University of Cape Coast

Passam, H.C., Read, S.J. and Rickard, J.E. (1979). Wound repair in yam tubers: physiological processes during repair. *New Phytol* 77: 325-31.

Picha, D.H. (1986). Weight loss in sweet potatoes during curing and storage: contribution of transpiration and respiration. *Journal of the American Society for Horticultural Science*11: 889-892.

Picha, D.H. 1987- Carbohydrate changes in sweet potatoes during curing and storage *Journal of the American Society for Horticultural Science 112 (1), 89-92…*

Raman, K.V., Booth, R.H. and Palacios, M. (1997).Control of potato moth *Phthorimaea opereulella* (Zeller) in rustic potato stores.*Trop. Sci*. 111: 889-892.

Rees, D., Kapinga, R., Mtunda, K., Chilosa, D., Rwinza, E., Kilima, M. Kiozya, H. and Munisi, R. (2001). Damage reduces both market value and shelf-life of sweet potato: a case study of urban markets in Tanzania. *Tropical Science*41: 1-9.

Rees, D., Q.E.A. van Oirschot, R. Amour, E. Rwiza, R. Kapinga and T. Carey, 2003.Cultivar variation in keeping quality of sweet potatoes. Postharvest Biol. Technol., 28: 313-325

Rickard, J.E. (1985). Physiological deterioration in cassava rootsf.*J Sci Food Agric*36: 167-76.

Riveria, J. 2005.Cutting shape and storage temperature affect overall quality of fresh cut papaya cv. Maradol. J. Food Sci.70 (7): 488-489.

Rizvi, S.J.H. and Rizvi, .V. (1992). Allelopathy: basic and applied aspects. Chapman and Hall, UK, pp 480. Root crops 20-26Oct 1991 Accra. Ghana.

Scott, G.J., Best, R., Rosegrant, M. and Bokanga, M. (2000).Root and tuber crops in the global, food system.food system. A vision statement to the year 2020. Lima. Peru: International Potato Center. p. 111.

Singh, D.K. (2012). Toxicology: Agriculture and Environment - Pesticide Chemistry and Toxicology. Bentham Science Publishers, p 150.

Singh, J., McCarthy, O.J., Singh, H. and Moughan, P.J. (2008).Low temperature post-harvest storage of New Zealand Taewa (Maoripotato); Effects on starch physico-chemical and functional characteristices.*Food Chemistry*106(2): 583-596.

Singh, K. K. (2009). Neem a treatise. I.K. International Pvt. Ltd. New Delhi, India, p 546.

SMP (2005). Use plant pesticides to control crop pests and produce healthy crops at low costs. Kenya Agricultural Research Institute.Pp 15.

Snowdon, A. (1991). A Colour Atlas of Post-harvest Diseases and Disorders of Fruits and Vegetables Vol. 1 Wolfe Scientific Ltd. London.p. 302.

Snowdon, A. (2010). A Colour Atlas of Post-harvest Diseases and Disorders of Fruits and Vegetables Vol. 2. Manson Publishing Ltd. Uk.

sporulation of fungal pathogens on Sweet potato and yam by Garlic extract. *Nigeria. J. Bot.* 1-4: 35-39.

Stoll, G. 1998. Natural Crop Protection in the Tropics. AGRECOL, Margraf Verlag, Weikersheim, Germany, 188 pp.

Suleiman, M.N. (2010) Fungitoxic Activity of Neem and Pawpaw Leaves Extracts on alternaria solani causal organism of Yam Rots.

Tester, R.F., Ansell, R., Snape, C.E. and Yusuph, M. (2005). Effects of storage temperatures and annealing conditions on the structure and properties of potato (Solanum tuberosum) starch. *International Journal Biological Macro molecules*36: 1-8.

Tomlins, K.L., Ndunguru, G., Rwiza, E. and Westby, A. (2000).Post-harvest handling, transport and quality of sweet potatoes in Tanzania. *Journal of Horticultural Science and Biotechnology*75: 586-590.

Tortoe, C., Obodai, M. and Amoa-Awua, W. (2010).Microbial deterioration of white variety sweet potato (*Ipomoea batatas*) under different storage structures.*International Journal of Plant Biology* 1(1): 52-55.

Udo, S.E., Madunagu, B.E. and Isemin, C.D. (2001). Inhibition of growth and

van Oirschot, Q.E.A., Rees, D., Aked, J. and Kihurani, A.W. (2000). Cultivar variation in wound healing efficiency of sweet potato and Irish potato and the effect on shelf-life.Presented at the International Society for Tropical Root Crops, Japan 2000.

VITAA, 2005, Vitamin A For Africa http://www.all-about-sweet-potatoes.com/vitaa-sweet-potato.htmlAccessed date: 26/10/2012

Wills, R., McGlasson, B. and Graham, D. (1998).*Post-Harvest: An Introduction to the Physiology and Handling of Fruit, Vegetables and Ornamentals*. Wallingford, UK: CAB International.

Ying, M.C. and Chang, W.S. (1998).Antioxidant activity of general Allium members.*J Agri Food Chem*46:4097-4101.

APPENDICES

Appendix 1: Analysis of Variance Tables

Analysis of Variance Table for weight loss

Source	DF	SS	MS	F	P
reps	2	428.9	214.43		
cultiver	2	4216.2	2108.11	19.97	0.0000
extract	3	3585.4	1195.14	11.32	0.0000
cultiver*extract	6	1845.6	307.61	2.91	0.0106
Error	22	13721.9	105.55		
Total	35	23798.1			
Grand Mean 22.866	CV 44.93				

Analysis of Variance Table for total soluble solids (TSS)

Source	DF	SS	MS	F	P
reps .	2	0.3800	0.19000		
variety	2	11.9450	5.97250	1516.10	0.0000
extract	3	8.2989	2.76630	702.21	0.0000
variety*extract	6	42.5994	7.09991	1802.28	0.0000
Error	22	0.0867	0.00394		
Total	35	63.3100			
Grand Mean 7.6500	CV 0.82				

Analysis of Variance Table for total titratable acidity (TTA)

Source	DF	SS	MS	F	P
reps .	2	0.3800	0.19000		
variety	2	4.3400	2.17000	550.85	0.0000
extract	3	4.4356	1.47852	375.32	0.0000
variety*extract	6	7.1378	1.18963	301.98	0.0000
Error	22	0.0867	0.00394		
Total	35	16.3800			
Grand Mean 4.4667	CV 1.41				

Analysis of Variance Table for tuber firmness

Source	DF	SS	MS	F	P
reps .	2	0.380	0.1900		
variety	2	44.865	22.4325	5694.40	0.0000
extract	3	29.790	9.9299	2520.67	0.0000
variety*extract	6	43.326	7.2210	1833.03	0.0000
Error	22	0.087	0.0039		
Total	35	118.448			
Grand Mean 7.3583	CV 0.85				

Analysis of Variance Table for moisture content

Source	DF	SS	MS	F	P
reps .	2	0.380	0.190		
variety	2	360.875	180.437	45803.4	0.0000
extract	3	115.483	38.494	9771.64	0.0000
variety*extract	6	108.643	18.107	4596.43	0.0000
Error	22	0.087	0.004		
Total	35	585.467			
Grand Mean 59.625	CV 0.11				

Analysis of Variance Table for dry matter

Source	DF	SS	MS	F	P
reps .	2	0.380	0.190		
variety	2	361.095	180.548	45831.3	0.0000
extractt	3	117.916	39.305	9977.54	0.0000
variety*extract	6	103.729	17.288	4388.55	0.0000
Error	22	0.087	0.004		
Total	35	583.208			

Grand Mean 40.608 CV 0.15

Analysis of Variance Table for sprouting index

Source	DF	SS	MS	F	P
rep	2	73.267	36.6336		
variety	2	12.098	6.0489	1.06	0.3643
extract	3	23.742	7.9139	1.38	0.2740
variety*extract	6	19.354	3.2257	0.56	0.7543
Error	22	125.832	5.7196		
Total	35	254.293			

Grand Mean 3.8431 CV 62.23

Analysis of Variance Table for weevil damage

Source	DF	SS	MS	F	P
rep	2	86.054	43.0271		
variety	2	12.967	6.4834	1.37	0.2760
extract	3	23.518	7.8392	1.65	0.2065
variety*extract	6	9.248	1.5414	0.32	0.9169
Error	22	104.447	4.7476		
Total	35	236.234			

Grand Mean 3.5346 CV 61.64

Analysis of Variance Table for tuber decay

Source	DF	SS	MS	F	P
block	2	0.02469	0.01235		
variety	2	0.95765	0.47883	9.17	0.0013
extract	3	0.67894	0.22631	4.33	0.0152
variety*extract6	0.24776	0.04129	0.79	0.5868	
Error	22	1.14883	0.05222		
Total	35	3.05787			

Grand Mean 1.8177 CV 12.57

Analysis of Variance Table for shelf life

Source	DF	SS	MS	F	P
reps	2	6.68	3.340		
cultiver	2	666.76	333.382	8.04	0.0024
extract	3	311.58	103.859	2.50	0.0856
cultiver*extract	6	279.74	46.623	1.12	0.3806
Error	22	912.15	41.461		
Total	35	2176.91			

Grand Mean 53.903 CV 11.95

Analysis of Variance Table for inhibition of Aspergillus

Source	DF	SS	MS	F	P
Treatment	2	681.556	340.778	113.59	0.0000
Error	6	18.000	3.000		
Total	8	699.556			

Grand Mean 44.778 CV 3.87

Analysis of Variance Table for inhibition Rhizopus Stolonifer

Source	DF	SS	MS	F	P
Treatment	2	927.389	463.694	102.41	0.0000
Error	6	27.167	4.528		
Total	8	954.556			

Grand Mean 49.722 CV 4.28

Appendix 2: Questionnaire Administered

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF HORTICULTURE

This questionnaire is design to gather data on sweet potato production and harvesting practices carried out in the Go moa East District in the Central Region of Ghana. The information obtained will be used strictly for academic purpose and will therefore not be disclosed. Please be frank as much as possible in your response,

(Please Tick (√) the appropriate box for your answer or answer accordingly)

Section A: General Background Information

1. Town or village.....
2. Sex a. Male [ ] b. Female [ ]
3. Age.....
4. Educational background.....
5. Farming experience.....
6. Farming system.....
7. Sources of funding.....
8. Size of the farm.....
9. Average number of bags harvested.....
10. Other crops that you grow in addition to sweet potatoes.....

Section B: Information on the Causes of Postharvest Losses in Sweet Potato

11. Which variety of sweet potato do you cultivate

i. Local [ ] ii. Improved [ ] iii. Any other [ ] (specify).....

12. When do you harvest your sweet potato

a. Immediately after tuber formation [ ]

b. When the leaves become yellow [ ]

c. When the vines die off [ ]

13. What methods do you use in harvest your sweet potato

a. Manual [ ] b. Machine [ ]

14. Do you harvest all the crops at a go? a. Yes [ ] b. No [ ]

15. If no (Q.14), how long does it take you to harvest.....

16. Do you use all your produce after harvest? a. Yes [ ] b. No [ ]

17. How do you store your harvested produce (if no in Q.16)

a. In sacks [ ] b. Baskets pits on the floor of a room [ ]

18. Do you cure the tubers before storing? a. Yes [ ] b. No [ ]

19. Do you encounter any rottening during storage? a. Yes [ ] b. No [ ]

20. If yes(Q.19) describe the symptoms

21. Do you know any control measure of the above described rot?

a. Yes [ ] b. No [ ]

22. If yes, state.....

23. For how long do you store your produce?

a. 1-2weeks [ ] b. 3-6weeks [ ] c. 6 weeks [ ]

24. What type of pests attack the sweet potato during storage?

a. Insects [ ] b. Rodents [ ] c. Micro-organisms [ ]

Section C: Government Efforts at Reducing Postharvest Losses in the Area

25. Does MOFA assist you with technologies to control storage rot of sweet potatoes in the area? a. Yes [ ] b. No [ ]
26. Do you patronize it? a. Yes [ ] b. No [ ]
27. If no, what prevents you from patronizing?

    .....

    .....
28. State how the extension services in your area help you to control post-harvest losses of your sweet potato.

    .....

    .....

    .....

THANK YOU!