**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**KUMASI**

**COLLEGE OF AGRICULTURE AND NATURAL RESOURCES**

**FACULTY OF AGRICULTURE**

**DEPARTMENT OF HORTICULTURE**



# ASSESSMENT OF POSTHARVEST LOSSES IN CITRUS (*Citrus sinensis (L) Osbeck*) IN THE BIRIM NORTH DISTRICT: A CASE STUDY OF ADVENTIST DEVELOPMENT AND RELIEF AGENCY(ADRA) SUPPORTED CITRUS FARMERS.

**BY**

**MOSES KWASI AKYEM-PEPRAH**

**JUNE, 2012**

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**A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSc. POSTHARVEST TECHNOLOGY) DEGREE**

**BY**

**MOSES KWASI AKYEM-PEPRAH**

**JUNE 2012**

DECLARATION

I hereby declare that, except for references to other people's work which have been duly acknowledged, this write-up, submitted to the School of Research and Graduate Studies, KNUST, Kumasi is the result of my own original research and that this thesis has not been presented for any degree elsewhere



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## ABSTRACT

The main objective of this study was to assess the level of postharvest losses of citrus fruits on ADRA supported farmers field in the Birim North District and at the major markets where the wholesalers operate. A survey was conducted using questionnaire on 100 ADRA supported farmers and 11 wholesalers. An in-depth study was also carried out on 6 selected farms and fruits from these selected farms were tracked to the wholesale markets to determine the extent of losses through field counts on the farm and at the wholesale market. The study revealed that 20.2% of the fruits were lost after harvest at the farm gate. Similarly at the wholesale market, losses of 5.6% were recorded. Regression analysis on the factors contributing to postharvest losses at the farm gate indicated that the total loss is influenced by method of harvesting, handling practices, length of storage period and precooling practices adopted on the field. The study showed that 48% of the farmers harvest is sold to wholesalers, 26% to processors and 15% went to retailers. Out of the fruits purchased from farmers, 82.1% of the fruits were sold to retailers by the wholesalers. The rest were lost through postharvest losses, pilfering and gifts. Weeding constituted the major management cost of farmers which contributed 57% of the tree management cost. Harvested fruits were exposed to the sun for an average period of 5 days at the farm gate, a day during transportation and an average of 3 days at the market. Generally, fruits were transported for an average distance of 197 km from the hinterland to the major markets. It was also revealed through the study that 10 major criteria are used by wholesaler for selecting marketable fruits at the farm gate. Farmers estimated their production cost per acre as GH¢ 405 with an estimated income of GH¢ 2148 whiles the value of fruits lost at the farmer level amounted to GH¢ 445. Wholesalers earned GH¢ 4602 per trip compared

with their operational cost of GH¢ 520. Postharvest loss at the wholesale market was valued as GH¢605.



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## LIST OF ABBREVIATIONS

ADRA- Adventist Development and Relief Agency

BNDA- Birim North District Assembly

FSC- Food Supply Chain

GEPC- Ghana Export Promotion Council



FAO- Food and Agriculture Organization

MOFA- Ministry of Food and Agriculture

UNCTAD- United Nations Conference on Trade and Development

USAID - United States Agency for International Development

USDA- United States Department of Agriculture

# CHAPTER ONE

## 1.0 INTRODUCTION

Citrus is one of the major fruits cultivated globally for its fruit juice. Although there are certain areas of high concentration in terms of production, the leading areas of production for the international fresh market are in the Mediterranean regions of which Spain is the dominant. Brazil however, is the leading exporter of juice in the world. According to United Nations Conference on Trade and Development, citrus ranks first in terms of value in the international fruit trade (UNCTAD, 2011).

The crop belongs to the family Rutaceae and its species are highly diversified leading to the development of many cultivars which results from hybridization and mutations. The tree is evergreen and produces fruits of different forms and sizes (from round to oblong). The fruit is fragrant, juicy and full of flavor. A cross section of the fruit reveals layers consisting of an outer skin or rind known as epicarp (yellow to orange in color) which together with the white mesocarp layer are responsible for protecting the fruit against physical damage. The internal part, also known as pulp, is segmented and contains juice sacks which are rich in vitamin C and soluble sugars (Ofosu-Budu *et al*., 2007).

The Adventist Development and Relief Agency (ADRA) is a Non-Governmental Organization which has been operating in Ghana since 1983 (ADRA Ghana Official website, 2012). ADRA with the support of United States Agency for International Development (USAID) sponsored a Food Security Project which was implemented in nine regions of the country (ADRA, 1996). The project intervention targeted the establishment of 3215 ha of citrus plantations in the Eastern, Ashanti, Central and Greater Accra Regions

by 4649 farmers between 1996 and 2004 (ADRA, 1996). Under this project support was provided to farmers in a form of citrus seedling (late Valencia budded on rough lemon), fertilizer, land preparation, seed maize for intercrop, pesticides and training. The strategy adopted was to use tree crops as a way of ensuring sustainable or long-term income to farmers (ADRA, 1996). Citrus was chosen for over other tree crops in the forest zone because when well maintained it can be productive for over thirty (30) years and performs better on wide range of soils from light, medium and heavy soils (Manner *et al.,* 2006).



Despite the huge potential of the crop in terms of yield and value, farmers are unable to realize the expected income on their investment as a result of several factors which include; high cost of farm maintenance, disease and pest infection, unreliable marketing avenues, and post-harvest losses. As the Birim North district had the highest support from the project in terms acreage planted, it is expected to have transformed the lives of beneficiary farmers seven years after the end of the project (ADRA, 2008).

Since the intervention of ADRA's food security project was meant to reduce poverty and increase income levels of rural farmers, any practice that will result in losses both on and off the field should be critically considered in order to realize the project objective (ADRA, 1996). Various forms of losses occur along the production and distribution chain (Parfitt *et al.,* 2010). This has to be quantified and valued in order to evaluate losses incurred by the citrus farmers. The main objective of this study was, therefore, to assess the level of postharvest losses in citrus from ADRA supported farmers field in the Birim North District.

The specific objectives were to:

- determine the extent of losses, in terms of quantity and value, that occur at the farmer and the wholesaler levels;
- document the criteria used in selecting wholesome fruits by wholesalers at the farm gate;
- determine the major causes of losses at the farm gate and at the level of wholesaler.



# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 History of Citrus Production in Ghana

Citrus is said to have originated from South East Asia from where it spread to other parts of the world since prehistoric times. The oldest known reference of citrus appeared before 800BC in Sanskrit literature and is now cultivated in tropical, subtropical and temperate regions from latitude 40°N to latitude 40°S (Baldwin, 1993; Moore, 2001).

The major commercial cultivars available for cultivation are sweet orange (*Citrus sinensis* (L) Osb.), tangerines (*Citrus reticulata* Blanco), lemon (*Citrus limon* Burm.f.), lime (*Citrus aurantifolia* Swingle), grapefruit (*Citrus paradise* Macf), pumelo (*Citrus grandis* Osb.) and other hybrids (Murata, 1997).

In Africa, citrus spread from the North Africa to other parts of the continent (Wikipedia, 2012). Ofosu-Budu *et al.* (2007) reported that commercial production of the crop in Ghana began in 1913 where the West Indians established 5.2 ha of the seedling at Asuansi Agricultural Station. Presently, sweet orange plantations can be found in the forest areas of Eastern region (Kwaebibirem, Birim South, Birim North, West Akim districts), Central region (Assin Fosu, Twifo-Hemang-Lower Denkyira, Asebu-Kwamankese, Jukwa districts), Ashanti region (Ejisu Juaben, Ahafo Ano South and Atwima districts) and Volta region (Hohoe, Jasikan, Kpando districts).

Sweet orange production in Ghana has been developed along two main fronts: Wholly private farms and through ADRA food security project which was sponsored by the

USAID (Ofosu-Budu *et al*., 2007). Estimated total citrus production in Ghana in 2004 was 630,763 MT, with Birim North contributing 22.4% that is second after Kwaebibirem (Ofosu-Budu and Nyamekye- Boamah, 2004).

Majority of the fruits produced in the country are consumed locally as fresh fruits. However, reports from the Ghana Export Promotion Council indicates that 15,213MT of fresh fruits valued at US$671 were exported mainly to neighboring countries like Burkina Faso, Togo and Cote d'Ivoire (GEPC, 2005). Few companies are involved in the processing of the fruits into juice in the country and notable among them are PINORA Limited based at Asamankese, Athena Foods in Tema and FRUITYLAND Limited also operating at Assin Nyankomase in the Central Region (Ofosu Budu *et al*., 2007). Apart from the purchases made by the major fruit processing companies, the fresh fruit market occurs at two main levels. These are the bulkers (wholesalers) who buy in large quantities at the farm gate and transport to urban markets and the retailers who buy in hundreds from the bulkers and sell the peeled fruits to consumers (Ofosu Budu *et al*., 2007).



## 2.2 Development of Citrus Fruits

Botanically, citrus is classified as a special type of berry termed 'hersperidium' (Baldwin 1993; Spiegel-Roy and Goldschmidt, 1996). The fruit develops from a superior ovary with all the tissues derived from the ovary (Albrigo and Cater, 1997; Soule and Grierson, 1986). Citrus ovary is made of 6 to 20 carpels which are united to form locules. The

development of the fruit from the flower stage takes 6-18 months depending on the type or cultivar (Soule and Grierson, 1986).

Morphologically, the fruit is composed of two major sections; the pericarp also known as the peel or rind and the edible portion referred to as the pulp. The peel can further be separated into the external coloured portion (the epicarp or flavedo) and the internal white layer of the peel (mesocarp or albedo) (Spiegel-Roy and Goldschmidt, 1996). The flavedo consist of a waxy layer, a mixture of cutin, pigments in a form of chloroplast or chromoplast and oil glands. The white portion (albedo) consists of large lobed cells with numerous large intercellular spaces and scattered vascular elements. The tissues of albedo consist of large spaces which are spongy in nature. Both the albedo and flavedo (peel) contain a higher concentration of bitter principles and pectin than other parts of the fruits (Albrigo and Cater, 1977; Izquierdo and Sendra, 2003).

The edible portion (pulp) consists of segments, the ovarian locule which are enclosed in a locular membrane and filled with juice sacs (Spiegel-Roy and Goldschmidt, 1996). The main composition (in terms of percentage) of citrus are 85-90% water, 6-9% sugars and less than 2% for acids, pectin, minerals essential oils, fiber, protein and fat (Izquierdo and Sendra, 2003).



## 2.3 Nutritional Value and Uses of Citrus Fruits

Citrus fruit is known as one of the most important sources of vitamin C (ascorbic acid), folic acid and dietary fiber. Citrus fruit is fat free, sodium free and cholesterol free which are associated with cardio vascular diseases. They have substantial quantities of

potassium, calcium, folate, thiamin, phosphorus, magnesium, and copper which also help to reduce heart diseases and types of cancer. The soluble solids of oranges are made up of soluble sugars and organic acids which are stable compounds (Lee and Kader, 2000).

The juice composition depends on the species, cultivar, climate, rootstock, and cultural practices. Analysis done on three major varieties of citrus gave varied attributes of each variety as indicated in Table 1.



Table1: Nutritional facts about citrus fruit.

| | Orange | Grapefruit | Tangerine |
|---|---|---|---|
| Weight (g) | 131 | 236 | 84 |
| Energy (kcal) | 62 | 78 | 37 |
| Fibre content (g) | 3.1 | 2.5 | 1.7 |
| Ascorbic acid (mg) | 70 | 79 | 26 |
| Folate (mcg) | 40 | 24 | 17 |
| Potassium (mg) | 237 | 350 | 132 |

Source: Gutherie and Picciano,1995.

There has been an increasing demand for the commodity in the world market because of consumers preference for sources of food with low fat, high minerals and vitamin C (Whitney and Rolfes, 1999). The vitamin C content of citrus is more than the minimum daily requirement of 60 mg in 240 ml of juice (Nagy *et al*., 1993; Brown, 2000; USDA 2000).

Citrus fruits are either consumed as fresh fruit or utilized as processed products or by products. The juice is the main product of citrus, however, there are other by-products that are produced commercially. This includes essential oils, d'limonene, terpenes, aromatic liquids and citrus pulp pellets. These by-products are used in the chemical and solvent industry, cosmetic and perfumery industry flavor and fragrance industry and the animal feed industry (FAO, 2001).



## 2.4 Global Food Losses and Waste

The term food loss is used for the reduction of edible food mass throughout the part of supply chain that specifically leads to edible food for human consumption. This loss take place at all stages of the supply chain that is at production, postharvest and processing stages. However, food losses that occur during the final stages of the food supply chain (retail and consumption) are referred to as food waste (Parfitt *et al*., 2010).

Various forms of losses are identified in the food supply chain but these can be categorized into five groups;

- Agricultural Production losses: This involves losses that occur as a result of mechanical damage and/or spillage during harvesting operation (e.g. threshing or fruit picking), sorting after harvesting.
- Postharvest handling and storage losses: This results from losses due to spillage and degradation during handling, storage and transportation between farm and distribution.

- Processing losses: losses occurring as a result of spillage and degradation during industrial or domestic processing. These losses may be due to sorting before processing, washing and accidental spillage.
- Distribution losses: losses occurring within a market system as in wholesale markets, retail markets, and supermarkets.
- Consumption losses: This is a losses and waste realized during consumption and at the household level (Parfitt *et al.*, 2010).



FAO estimated waste percentages for various commodity groups in each step of the food supply chain (FSC) for sub-Saharan Africa in Table 2.

Table 2: Estimated/assumed waste percentages for each commodity group in each step of the Food Supply Chain (FSC) for sub-Saharan Africa.

| | Agricultural production | Postharvest handling and storage | Processing and packaging | Distribution | Consumption |
|---|---|---|---|---|---|
| Cereals | 6% | 8% | 3.5% | 2% | 1% |
| Root& Tubers | 14% | 18% | 15% | 5% | 2% |
| Oilseed &Pulses | 12% | 8% | 8% | 2% | 1% |
| Fruits &Vegetables | 10% | 9% | 25% | 17% | 5% |
| Meat | 15% | 0.7% | 5% | 7% | 2% |
| Fish & | 5.7% | 6% | 9% | 17% | 2% |

| | | | | | |
|---|---|---|---|---|---|
| Seafood | | | | | |
| Milk | 6% | 11% | 0.1% | 10% | 0.1% |

Source FAO, 2011

## 2.5 Effect of Production Practices on Postharvest Quality of Fruits

Practices adopted for crop production have a tremendous influence on the storage life and quality of fruits. The cultivar used in planting also has effect on the postharvest life of a fruit or vegetable. A study conducted in New York by comparing postharvest losses of California Navel and Florida Valencia oranges recorded total losses of 4.2 and 3.2 percent in samples of California naval and Florida Valencia oranges. In this same study it was realized that 75 percent of losses resulted from effect of parasitic fungi and rind breakdown. Mechanical damage accounted for losses that were not attributed to parasitic fungi (Ceponis and Butterfield, 1973). Herner (1989) reported some environmental factors such as soil type, temperature, frost, rainy weather as major factors that affect the storage life and quality of fruits and vegetables. It was also found out in a study that carrots grown on muck soils do not store well compared to carrots planted on lighter upland soils. Ferguson *et al.* (1999) also enumerated among other preharvest factors that result in postharvest disorders as;

- Position of fruit on the tree
- Climatic conditions during production
- Crop load on the tree
- Mineral and carbohydrate nutrition of the developing fruit
- Water relations

- Response to temperature.

Kader (1988) mentioned temperature and light intensity as the two most important climatic factors that have very strong influence on the nutritional quality of fruits. These factors determine the level of ascorbic acid, carotene, riboflavin, and thiamine. In general, low light intensity results in lower level of ascorbic acid. Temperature influences uptake and metabolism of plant nutrients as transpiration is known to increase with higher temperatures. Rainfall determines water supply to crops grown under rain fed conditions and can influence the composition of harvested fruits which also has an impact on the fruits susceptibility to mechanical damage during harvesting and other handling operations (Kader, 1988).

Carlos *et al.* (1995) found out that management practices such as irrigation, mineral nutrition, tree training, pruning and fruit thinning influence population of rotting organisms, water loss, mechanical bruising and physiological disorders. Kader (1988) mentioned a number of cultural practices which when adopted determine the quality of a fruit and subsequently it's postharvest life. Among the influential cultural practices reported included the choice of rootstock used for citrus seedling development, mulching, irrigation and fertilization. High calcium levels in fruits has been linked to longer postharvest life as a result of reduced rates of respiration and ethylene production, delayed ripening, increased firmness and reduced incidence of physiological disorders and decay (Ferguson *et al*., 1999). In contrast to calcium, Arpaia (1994) reported that high levels of nitrogen on other hand leads to shorter postharvest life due to increased susceptibility to mechanical damage, physiological disorders and decay. Generally, increasing nitrogen and /or phosphorus supplied to citrus trees results in lower acidity

and ascorbic acid content of the citrus fruit whiles increasing potassium increases acidity and ascorbic acid content (Lee and Kader, 2000).

## 2.6 Harvesting Practices that Affect Postharvest Decay

Method of harvest of a produce, the type of container used to collect the produce, type of container used in hauling and condition of roads that are used to transport fruits contribute to the quality of produce offered to consumers and postharvest decay. In addition to these factors, Asrey *et al.* (2008) cautioned that the maturity stage of fruits is of critical importance as any deviation from the optimum harvesting stage may cause considerable loss in terms of quantity, quality and monetary inputs. Citrus fruits are non-climacteric and since they do not continue to ripen after harvest, it is always appropriate to harvest at optimum maturity as the immature or over-matured fruits results in the supply of inferior quality (Barry and Giovannoni, 2007). According to Baldwin (1993), the rind colour is not a good indication of maturity and reliable maturity indices adopted for citrus include juice content, total soluble solids (TSS or Brix), titratable acidity (TA) and the ratio of TSS to TA. Generally, a Brix/TA ratio of 8-10 is accepted as the minimum value and 10-16 accepted as good quality. If the fruits remain unharvested, the Brix increases whiles the acidity decreases until the fruit becomes overripe (Samson, 1986). Kader *et al.* (1985) also reported that in addition to these indices, fruit colour and size are used. Hand harvesting, according to Michailides and Manganaris (2009) is ideal for highly perishable commodities though it has a high cost and is time consuming. However, various forms of mechanical harvesting systems which include trunk shake-

and-catch and continuous canopy shake-and-catch systems are used in the other less perishable crops.

Citrus is considered as a moderately perishable fruit with shelf life ranging between 2 and 20 weeks (depending on the type). Postharvest losses of citrus in developing countries have been estimated to be 23-33 percent (Coursey, 1983). However, high losses (42.5%) have been recorded in Libya. This, Tamzini *et al.* (1992), attributed to factors such as; immaturity and over maturity at harvest, mechanical damage during harvesting, transportation and distribution of fruits, water loss as a result of poor handling, decay (blue and green mold) and insect damage caused mainly by Mediterranean fruit fly.

In Ghana, most farmers harvest fruits through violently shaking of the tree for the fruits to drop on the ground before they are collected in baskets for haulage into a central point. Ofosu Budu *et al.* (2007) enumerated some of the effects of this practice as bruises through impact on the hard surface, piercing sharp ends of shrubs which create openings for secondary infections. Eaks (1961), in a study on the effect of dropping citrus fruits on hard smooth surfaces from a height revealed that Valencia and naval oranges respond to increase respiration rate when dropped from different heights. A 24 inch drop caused a respiration rate of 140% and 48 inches drop (190%) compared with the control of 100%.

### 2.7 Effect of Mechanical Damages on Quality of Fruits

Fresh fruits suffer from mechanical damages during harvesting, handling, transportation and distribution. Studies conducted on tomatoes revealed that losses resulting from this

can range from 15-68% (Cerponis and Butterfield, 1974). According to Barchi *et al*. (2002), mechanical injuries are major cause of decay of fresh fruits and vegetables and estimated postharvest losses in the chain between grower and consumer around 30-40%. Singh and Xu (1993) reported that as many as 80% of apples were damaged during a simulated transportation by truck. A study on produce losses revealed that an estimated value of fresh fruits and vegetables in the United States of America was between US$268 million and US$ 380 million (Pierson *et al*., 1982).



O'Brien *et al*. (1963) identified two critical factors affecting the bruising of fruits during transportation. These are the magnitude of the force or impact and the number of times this force is repeated at a given location in addition to the initial condition of the fruit. Fisher *et al*. (1990) found out that apple bruising during transportation is influenced by the quality of the road, the travelling distance and the type of container used in packaging. Berardinelli *et al*. (2003) also reported that the vibration due to transportation are influenced by road roughness, distance, travelling speed, load and some characteristics of the truck such as suspension and the number of axles. Jones *et al*. (1991) established a model in explaining mechanical damages to fruits during transportation of horticultural crops and mentioned vibration from the transport vehicle as they traverse on undulating road as a major factor among other factors that result in mechanical damages to the crops.

Mechanical damage occurring during postharvest handling is considered as a form of stress on the fruit. This results in physiological and morphological changes such as increase in respiration and ethylene production, cell rupture and ion leakage (Valero *et al*., 2002). When plant organs are subjected to vibration or mechanical damage, it

usually leads to increase respiration rate compared to uninjured fruits. This also results in the oxidation of acids to enhance the respiration (Mao *et al.,* 1995). Ascorbic acid content of tangerines is found to vary with the mechanical damage. Moretti *et al*. (1999) in a study also observed a decrease of Vitamin C content by 16% when tomato is injured.

### 2.8 Postharvest Disorders of Citrus



Citrus undergo some physiological disorders which ultimately affects its quality during storage and the period of marketing. These disorders are affected by preharvest and postharvest factors. The major preharvest factors include nutrient deficiencies, sunburn and wind scars. Significant among the postharvest factors include temperature, humidity, atmospheric gas composition and mechanical stress (Grierson, 1986; Murata, 1997). According to Mukhopadhyay (2004), citrus fruits are susceptible to many diseases which are caused by pathogens such as fungi, bacteria, viruses, viroids, phytoplasmas, spiroplasmas and nematodes. Decay is one of the major factors that limit the storage life of citrus and fugal infections account for greater portion of losses in harvested fruits (Davies and Albrigo, 1994; Schirra *et al*., 2000). The major postharvest fungal diseases are green mould, blue mould, sour rot, grey mould, Alternaria rot and brown rot (Giudice, 2002).

## 2.9 Techniques for Extending Storage Life of Citrus Fruit

Temperature and the duration of storage affect the storage life and quality of citrus. According to Ladaniya (2004) the rate of decay is slower at low temperature. Some techniques that have been used to prolong the storage life of citrus include;

- Application of fungicides (e.g. Thiabendazole (TBZ) at 0.5%. This has been used in the control of many postharvest fungal diseases and proved effective (Cabras *et al*., 1999; Verma and Tikoo, 2003).
- Application of gibberellic acid (GA3) at either preharvest or postharvest has the tendency of delaying maturation and senescence of citrus fruit (Coggins *et al*., 1969)
- Continuous low temperature storage is important for maintaining the quality of fresh products such as fruits, vegetables and ornamentals. The quality of fresh produce declines after harvest because they have living tissues which continue to respire after harvest (Kitinoja and Kader, 1995).

## 2.10 Effect of Temperature and Relative Humidity on Storage Life of Fruits

Optimal storage temperature is essential in maintaining product quality. When tropical fruits are stored at temperatures below15°C and above 0°C, they can easily be damaged by chilling injury. High humidity is also needed to prevent water loss and protect the freshness of the fruit during low temperature storage. As most fungi do not grow under relative humidity of 90%, a higher relative humidity of 90% is usually recommended for most tropical crops (Hatton, 1990). According to Paull (1999), keeping fruits within an optimum range of temperature and relative humidity is crucial in maintaining quality and

minimizing postharvest losses. Delays between harvesting and cooling can result in direct losses (due to water loss and decay) or indirect losses (loses of flavour and nutritional quality). Temperatures which are several degrees above the ambient temperature especially when exposed to the direct sun can result in high losses. A study conducted on tropical crops in Jamaica showed that optimal storage conditions vary for different types of fruits and this must be considered in order not to compromise the quality of harvested fruits (Beattie *et al.*, 1989). The recommended temperature and relative humidity for some tropical fruits grown in Jamaica is shown in Table 3.



Table 3: Recommended temperatures and relative humidity conditions for the storage of some fruits grown in Jamaica

| Fruit | Temperature °C | Relative humidity % | Storage life (days) |
|---|---|---|---|
| Avocado | | | |
| Green mature | 3-7 | 85-90 | 14-56 |
| Ripening fruit | 13-15 | 85-90 | 14-56 |
| Banana | 13-15 | 90-95 | 7-28 |
| Breadfruit | 13-15 | 85-90 | 14-42 |
| Cashew apple | 0-2 | 85-90 | 35 |
| Guava | 5-10 | 90 | 14-21 |
| Jackfruit | 13 | 85-90 | 14-42 |
| Mandarin | 4-7 | 90-95 | 14-28 |
| Mango | 13 | 90-95 | 14-21 |
| Orange | 0-9 | 85-90 | 56-84 |

| | | | |
|---|---|---|---|
| Papaya | 7-13 | 85-90 | 7-21 |
| Sapodilla(Naseberry) | 15-20 | 85-90 | 14-21 |
| Tamarind | 7 | 90-95 | 21-28 |
| Sweet and soursap | 5-7 | 85-90 | 28-42 |

Source: Beattie *et al*., 1989



# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

The research work was carried out in three stages. In the first stage, a survey was conducted to assess the extent of citrus postharvest losses on the farms of ADRA client farmers in the Birim North district using a well-structured questionnaire. The second stage was also a survey to assess the level of postharvest at the wholesaler's level using the same questionnaire. The third stage was an in-depth study on losses by counting the losses and tracking fruits from six selected farms to the market.



### 3.1 LOCATION

The Birim North District, (Figure1) which has New Abirem as its capital is one the twenty-one administrative districts in the Eastern Region of Ghana. It is bordered to the north by Kwahu West Municipal, to the west by Asante Akyem South and Adansi South Districts all in the Ashanti Region, to the south by Birim South District and to the east by Atiwa and Kwaebibirem Districts. The District lies within the forest belt of Ghana and experiences substantial amounts of precipitation. It has a double maxima rainfall pattern with the first rainfall season starting from late March to early July and the second season from mid-August to late October. The average annual rainfall received in the district is between 1500mm and 2000mm. Temperatures range between an average minimum of 25.2 degree Celsius and a maximum of 27.9 degree Celsius and relative humidity of about 55-59 per cent during the entire year (BNDA, 2010). These prevailing conditions make the district suitable for the cultivation of crops that adapt well to forest

conditions which include tree crops like cocoa, oil palm, citrus and the food crops include maize, plantain, cassava, cocoyam, and vegetables. This district was selected for the study because it had the highest concentration of farmers and ranks first in terms of resources allocated for ADRA/USAID citrus project (ADRA, 2008).



## 3.2 SURVEY

### 3.2.1 Farmer Level.

One hundred farmers were randomly selected from a list of three hundred ADRA supported farmers in the district for the study. Eight communities were selected for the survey out of the 16 ADRA project communities. Communities selected for the study were Akrofonso, Ntronang, Abirem, Botwekrom, Adadekrom, Amuana Praso, Nyafoman and Amanfokrom. Before the questionnaire was administered, training was conducted for four enumerators from the district directorate of Ministry of Food and Agriculture to enable them assist in the administration of the questionnaire effectively. The questionnaire was then pretested and the necessary corrections made before the final administration.

The questionnaire (Appendix 51) was prepared to study among other things the following parameters;

a. The extent to which citrus production contributed to farmers income.

b. The benefits farmers realized from the citrus farming

c. Challenges encountered in citrus production

d. Major buyers and the quantities they purchased

e. Knowledge of farmers on recommended cultural practices

f. Cost of production

g. Fruit management

h. Postharvest losses



### 3.2.2 Survey of Wholesalers

The same questionnaire was administered to all the eleven major citrus wholesalers in the records of the district directorate of MOFA. The questionnaire was meant to solicit for information relating to;

a. Quantities purchased

b. Sources of funding for the citrus business

c. Operational cost

d. Mode of transportation of fruits to market center

e. Causes of fruit losses

f. Market standards for fruits

g. Postharvest losses.

### 3.3 IN-DEPTH STUDY

#### 3.3.1 Farmer level

Six farmers field were randomly selected for the in-depth study of postharvest losses at the farm gate. Farms were selected from Amuana Praso, Amanfokrom, Nyafoman, Prasokuma, Akrofonso and Afosu. On each of the six farms, ten (10) trees out of a hundred (representing approximately a tenth of an acre) were randomly selected and tagged prior to harvest and used for assessment of losses on the farm. (Plate 1)

On the day of harvesting, the ten selected trees were cleared of all dropped fruits before harvesting. Harvesting was done using the farmers own practices through shaking of branches and use of hooks mounted on long sticks in plucking fruits.

All harvested fruits were gathered under each tree and farmers were allowed to select the marketable ones from the bulk using their own criteria (Plate 2).

The rejected fruits from the bulk under each tree were counted and the figure extrapolated to cover the farm size for the estimation of total number of fruits that were rejected on the entire field after collection (Plate 3).

After all fruits had been bulked at a central point, the wholesalers selected the marketable ones from the heap using the criteria as pertains in the market.

The estimated losses on the farm were added to the total number of fruits that were rejected at the bulking point (Plate 4) after the wholesalers had selected from the heaped marketable fruits.

The percentage loss to the farmer was then computed by using the formula below;

$$\% \text{ loss (L)} = \frac{F+B}{T}$$

Where F= Estimated loss on the farm

B= Fruits left at the bulking point after selection by wholesalers

T= Total number of fruits harvested (Fruits left on the farm plus fruits rejected at the bulking point plus fruits selected to the wholesale market)

Source: FAO (2012)

Average from the six selected farms was then computed to represent the postharvest loss at the farmer level.

Plate 1: Tagging of selected trees prior to harvesting

Plate 2: Farmers selecting from harvested fruits

Plate 3: Rejected fruits left on the farm

Plate 4: Heaped fruits before sorting (left) and rejected fruits after sorting (right)

### 3.3.2 Wholesaler level

Postharvest losses at the wholesale level were estimated by tracking fruits from the selected farms to the buying center. The four buying centers where the fruits were marketed were in Koforidua in the Eastern region, Madina, Agbogbloshie and Tema community 1 markets in the Greater Accra Region.

At each buying center, the total number of fruits sold to retailers and the number rejected were monitored and counted till sales were completed.

The percentage loss was determined by dividing the total number of fruits rejected by retailers, fruits lost in transit and fruits lost through pilfering by total number of fruits lifted from the farmer's field.

$$\% \text{ loss } (L) = \frac{R+T+P}{D}$$

Where R= Fruits rejected by retailers at the wholesale market

T= Fruits lost in transit

P= Fruits lost through pilfering

D= Total number of fruits lifted from the farmers field

FAO (2012)

Average from the six markets was determined to represent the postharvest loss at the farmer wholesaler level.

### 3.4 STATISTICAL ANALYSIS

Data from the survey were analysed statistically using Statistical Package for the Social Scientist (SPSS). The results were presented in a tabular form showing percentage.

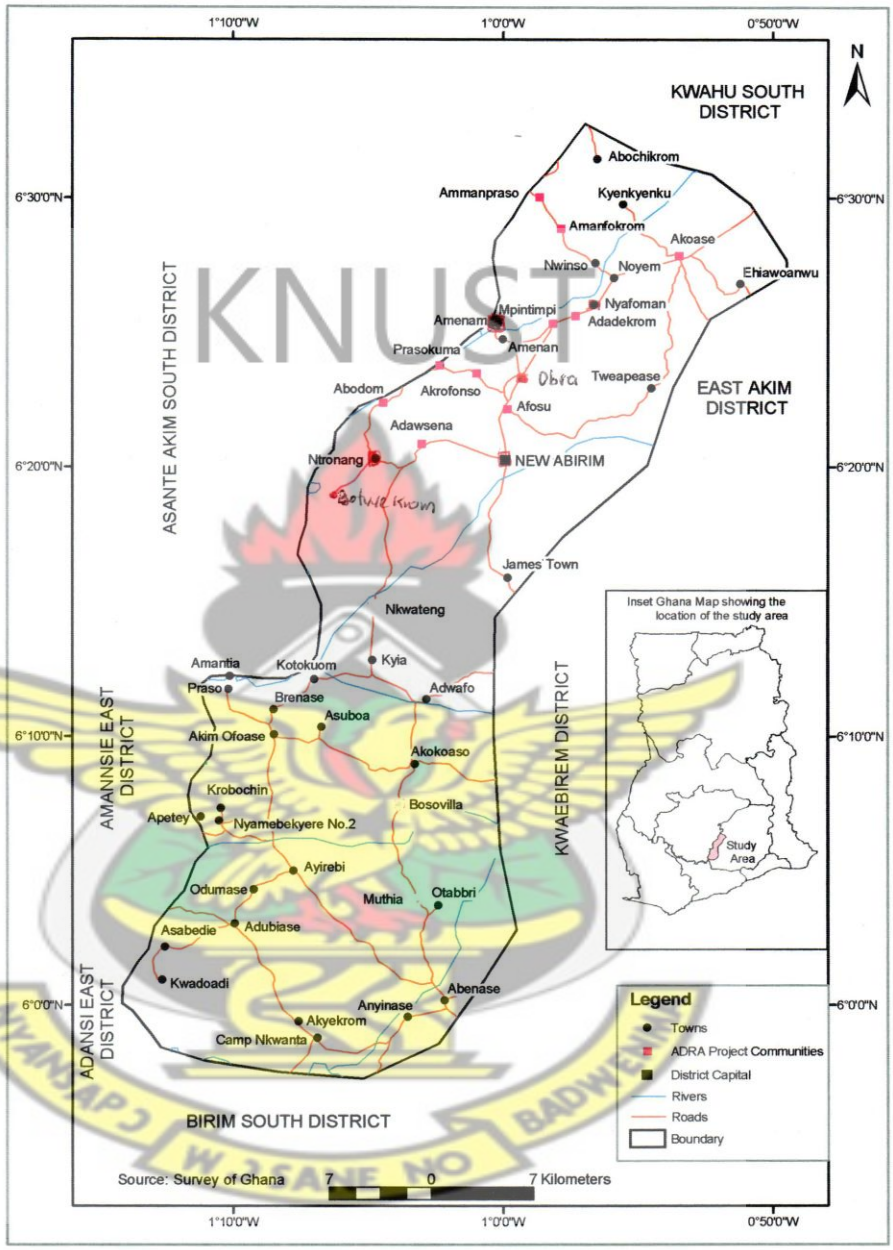


Figure 1: A map of the study area: Birim North District

# CHAPTER FOUR

## 4.0 RESULTS

### 4.1 FARMER LEVEL SURVEY

Results on the survey of farmers are presented in tables, pie charts and bar graphs covering issues on profile of respondents, occupation, production information, fruit management and challenges.



#### 4.1.1 Profile of Farmers

##### 4.1.1.1 Gender of Farmers

Figure 2 indicates the sex of the respondents. Out of the one hundred farmers interviewed during the survey, 67% were males whiles 33% were females.


Figure 2: Gender of farmers

#### 4.1.1.2 Age of Farmers

Age distribution of ADRA client farmers interviewed is presented in Figure 3. From the survey, 1% of the respondents were between the ages of 20-29 years, 16% between 30-39 years, 21% between 40-49 years, 28% were between 50-59 years and 34% of the farmers were within 60 years and above.

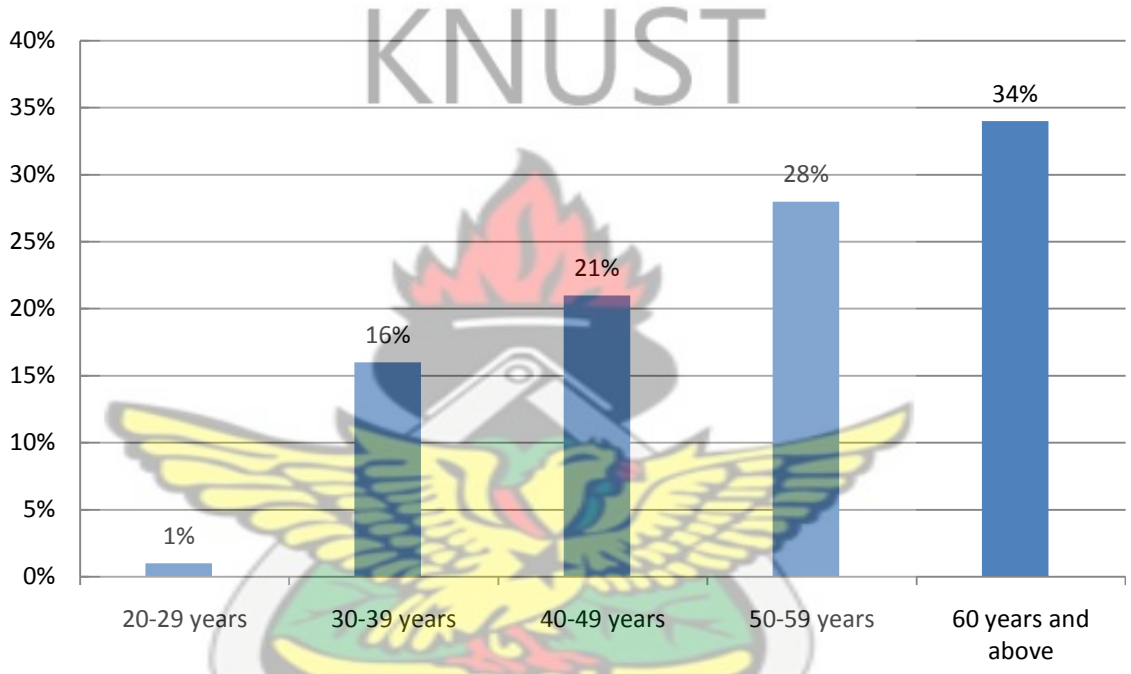


Figure 3: Age of farmers

#### 4.1.1.3 Educational Level of Farmers

The highest educational level achieved by farmers has been presented in Figure 4. Most of the respondents had basic education (64%). Twenty percent had no formal education, farmers with secondary education forming 13% whiles 3% had tertiary education.

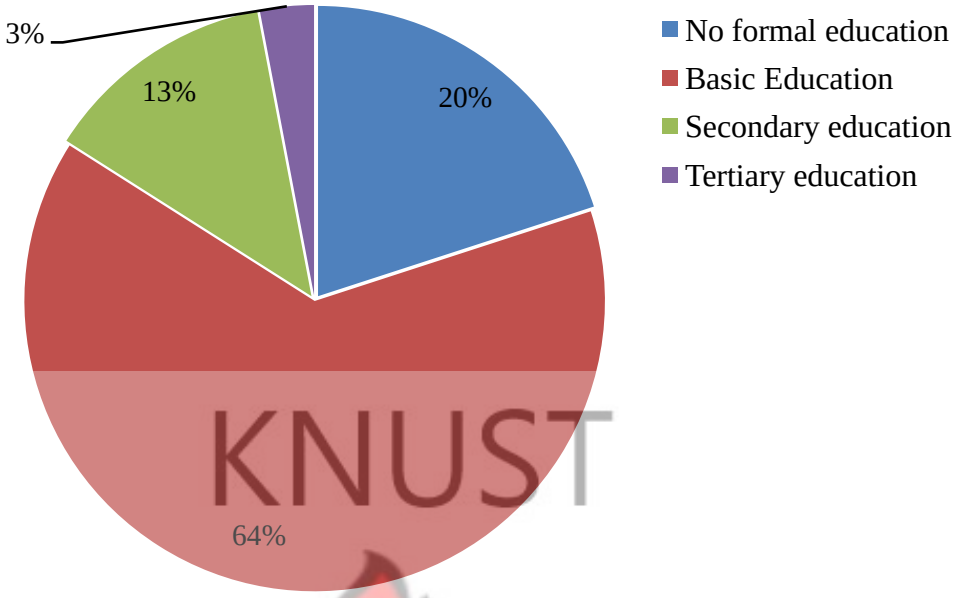


Figure 4: Educational level of farmers

### 4.1.2 Occupational Information

#### 4.1.2.1 Primary Occupation of Farmers

Farming was the primary occupation of 96% of the respondents with driving, oil palm processing, trading and civil service, each engaging 1% of the respondents.

Apart from citrus cultivation, 40% of the respondents were engaged in cocoa production, 38 % in oil palm 22% in food crop production.

#### 4.1.2.2 Main Sources of Income of Farmers

Figure 5 represents the distribution of annual income of respondents. Tree Crops (cocoa and oil palm) contributed 43.1% of farmers' annual income. Citrus provided 18.9%, food crops (plantain, maize, cassava) contributed 17.2%. Non-farming activities (mainly

distillery, trading and processing) provided 15.2% and family remittances formed 5.6% of respondents' income.

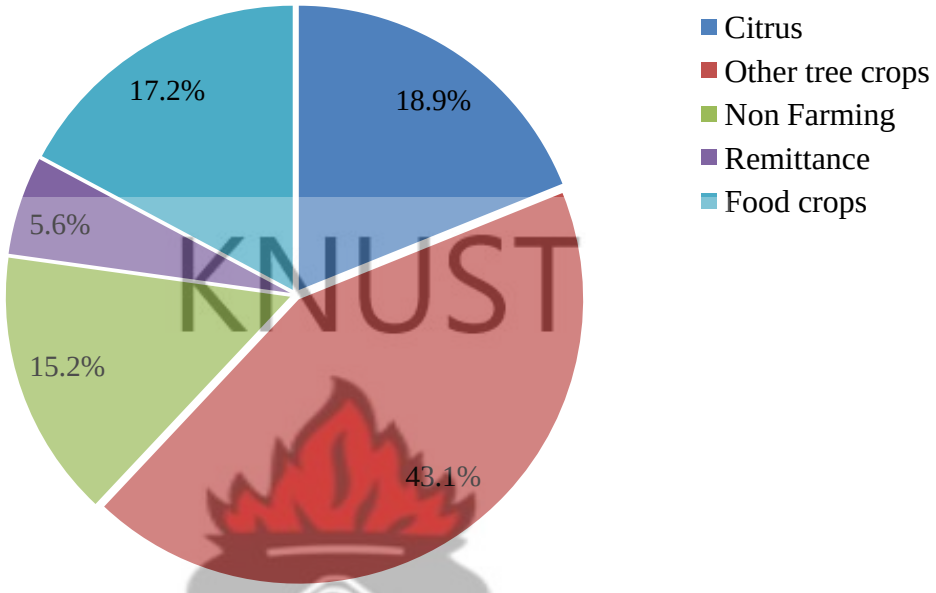


Figure 5: Sources of annual income of farmers.

#### 4.1.2.3 Benefits Derived From Citrus Production

Figure 6 shows the distribution of the various benefits farmers derived from citrus production. Sixty-five percent of the farmers indicated that it was a form of employment and income to support the family, it served a future security and long term investment for 14% of respondents whiles 8% used the income to either build or renovate their houses. Seven percent enjoyed eating it and 6% utilized their income in expanding other businesses.

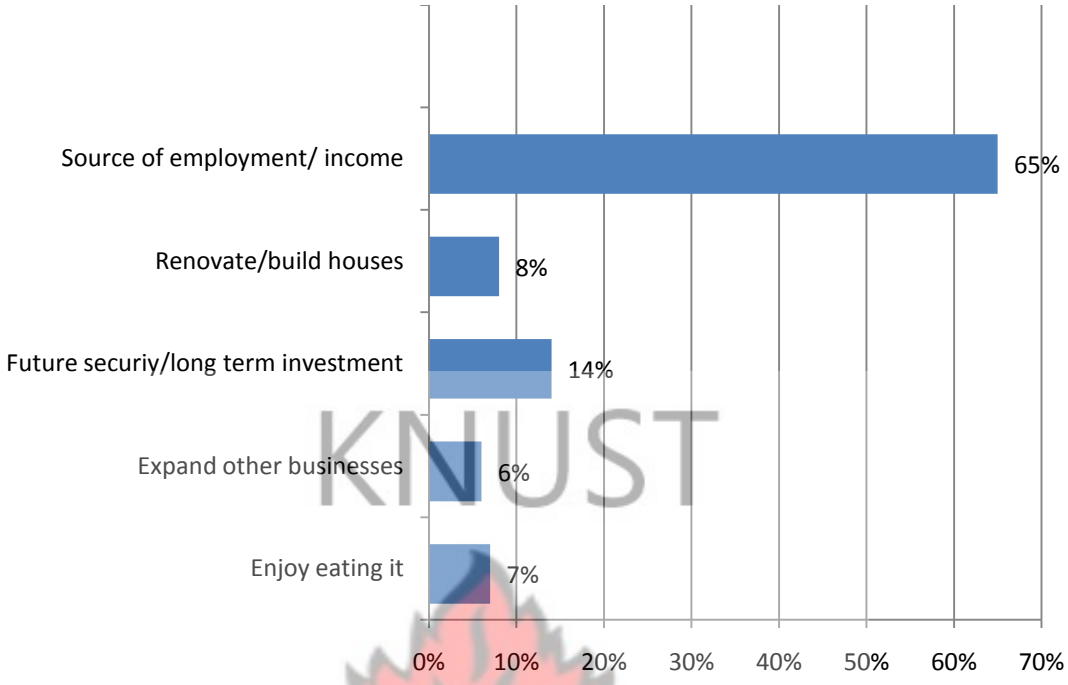


Figure 6: Benefits derived from citrus production.

#### 4.1.2.4 Major Challenges in Citrus Production

Figure 7 is a summary of farmers responses to major challenges encountered in production. Disease and pest infestation constituted 30.8% of the challenges, 29.6% had difficulty marketing of harvested produce whiles 15.6% of challenges were on high cost of production. Poor road network to farming communities represented 14.2% and postharvest losses 9.8%.

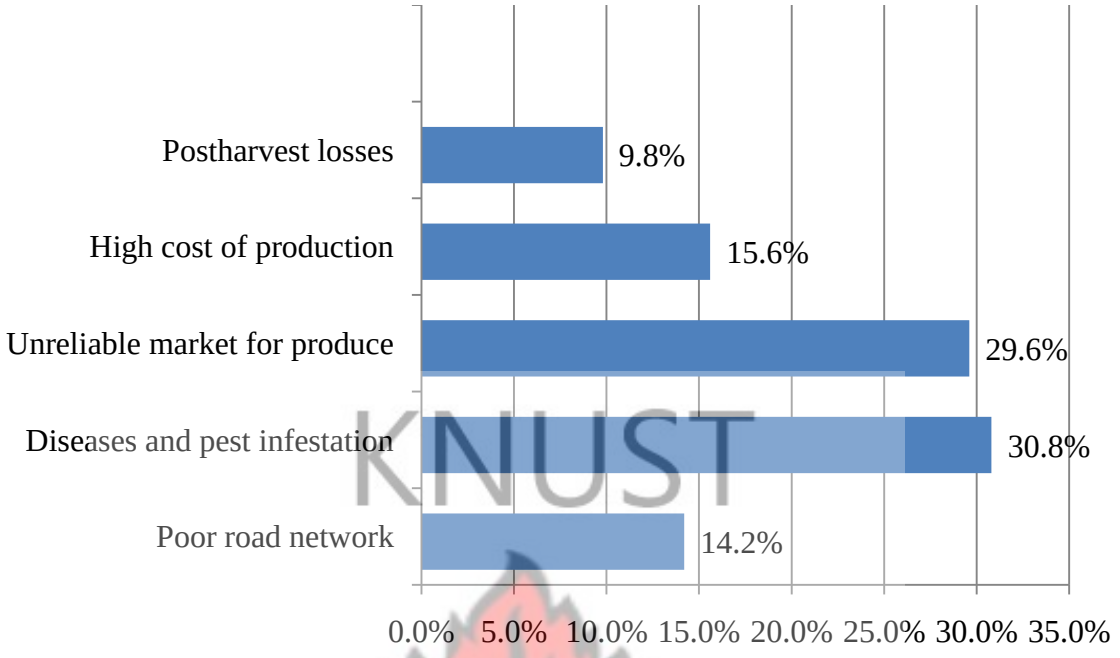


Figure 7: Challenges in citrus production

### 4.1.3 Production Information

#### 4.1.3.1 Training of Farmers.

All the respondents have had some form of training in citrus production. Table 4 shows the various training farmers have had and the institution that provided the training. Training ranged from land preparation, planting, tree management, harvesting, postharvest management and marketing at no cost to the farmers.

Table 4: Types of trainings given to farmers

| Type of training | Institution that provided the training | Year of training | Cost to farmer |
|---|---|---|---|
| Land Preparation | ADRA, MoFA | 1996-2002 | Free |
| Planting | ADRA, MoFA | 1996-2002 | Free |
| Tree Management | ADRA, MoFA | 1996-2004 | Free |
| Harvesting | ADRA, MoFA, Research Institution, Processing Companies | 1997-2006 | Free |
| Postharvest management | ADRA, MoFA, Research Institution, Processing Companies. | 1997-2011 | Free |
| Marketing | ADRA, MoFA, Processing Companies, Other NGOs | 1998-2011 | Free |



#### 4.1.3.2 Management Practices Adopted by Farmers and the Corresponding Cost

Table 5 gives details of management practices adopted by respondents and the corresponding cost per acre. Most farmers cleared their farm of weeds twice in a year, costing GH¢100. None of the respondents applied fertilizer or controlled diseases on the

trees within the year. Insect pest control cost GH¢25, pruning GH¢ 20, and removal of mistletoes GH¢30.

Table 5: Major management practices and the cost

| Management practice | Average frequency/year | Average cost/acre.(GHC) |
|---|---|---|
| Weed control | Twice a year | 100 |
| Fertilizer application | None | 0 |
| Pest control | Once a year | 25 |
| Disease control | None | 0 |
| Pruning | Once a year | 20 |
| Removal of mistletoe | Once a year | 30 |
| Total | | 175 |



#### 4.1.3.3 Channels for Distribution of Harvested Fruits during the Major Season (December, 2011-March, 2012)

Figure 8 presents channels through which harvested fruits were disposed off during the major harvesting season (December, 2011-March, 2012). Most of the fruits (49.3%) were sold to wholesalers, processors purchased 29.0% of fruits, and retailers bought 11.9% of the produce. Postharvest losses accounted for 7.6% whiles gifts /home consumption and pilfering accounted for 1.1% each.

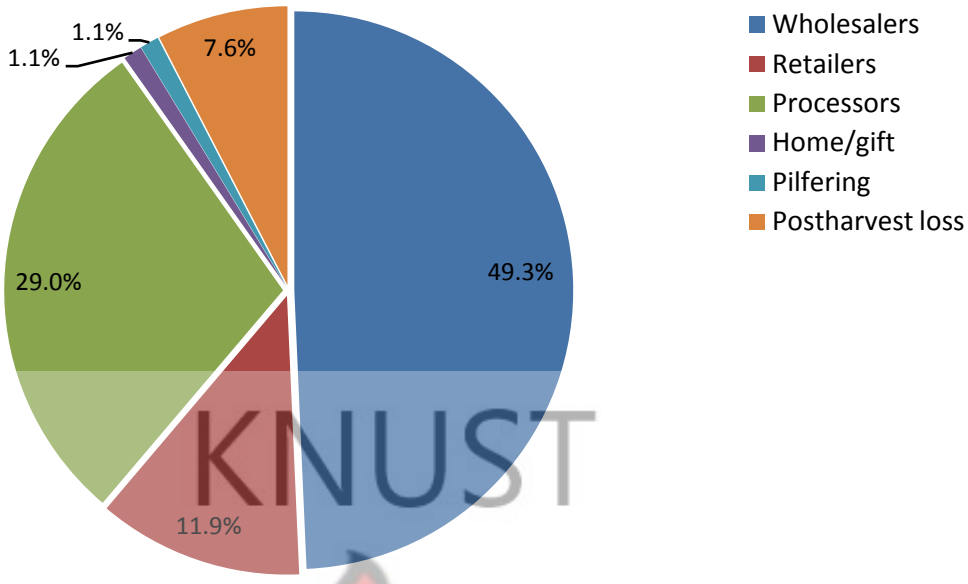


Figure 8: Channels for fruit distribution (major season)

**4.1.3.4 Channels for Distribution of Harvested Fruits during the Minor Season. (August, 2011-October, 2011)**

Outlets for distributing harvested produce during the minor season is presented in Figure 9. Wholesalers purchased the bulk of the fruits (45.4%), processors purchased 22.4%, retailers bought 16.4% with post harvested losses accounting for 14% of the harvested produce. Fruits lost through pilfering constituted 1.0% whiles 0.7% was giving out as gift and home consumption.

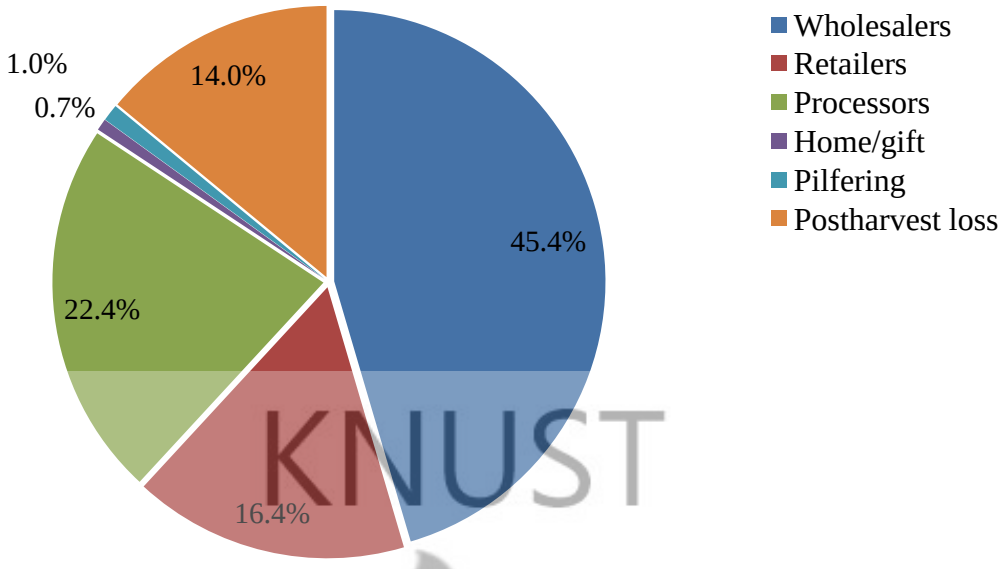


Figure 9: Channels for fruit distribution (minor season)

#### 4.1.3.5 Major Activities at Harvest and their Estimated Cost

Table 6 presents the major activities undertaken by farmers at harvest and cost involved. Generally, an average of GH¢100 was spent on harvesting an acre of farm, GH¢80 for carting the fruits and GH¢ 50 for loading.

Table 6: Major cost at harvest

| Operation | Mandays used | Rate/manday (GH¢) | Cost(GH¢) |
|---|---|---|---|
| Harvesting | 10 | 10 | 100 |
| Carting/heaping | 8 | 10 | 80 |
| Loading | 5 | 10 | 50 |
| Total | 23 | | 230 |

#### 4.1.3.6Average Quantity of Fruits Disposed through the Channels and their Value.

Table 7 is a summary of average quantity disposed through various channels per farmer in a year and the value of the produce.

Table 7: Average quantity of fruits disposed off in the year per farmer and value

| Outlet | Mean quantity of fruits/acre | Percentage of total number of fruits | Value (GH¢) |
|---|---|---|---|
| Wholesalers | 61,377 | 48 | 2,148 |
| Processors | 34,042 | 26 | 936 |
| Retailers | 17,300 | 14 | 605.50 |
| Postharvest losses | 12,705 | 10 | 445 |
| Pilfering | 1,360 | 1 | 47.60 |
| Home/gift | 1254 | 1 | 37.60 |
| Total | 128,038 | 100 | |

### 4.1.4 Fruit Management

#### 4.1.4.1 Harvesting Period

Figure 10 illustrates the months in which the fruits were harvested in the major season. Most of the fruits (73.2%) of the fruits were harvested in January 2012, 20.6% in February 2012 and 6.2% in December 2011.

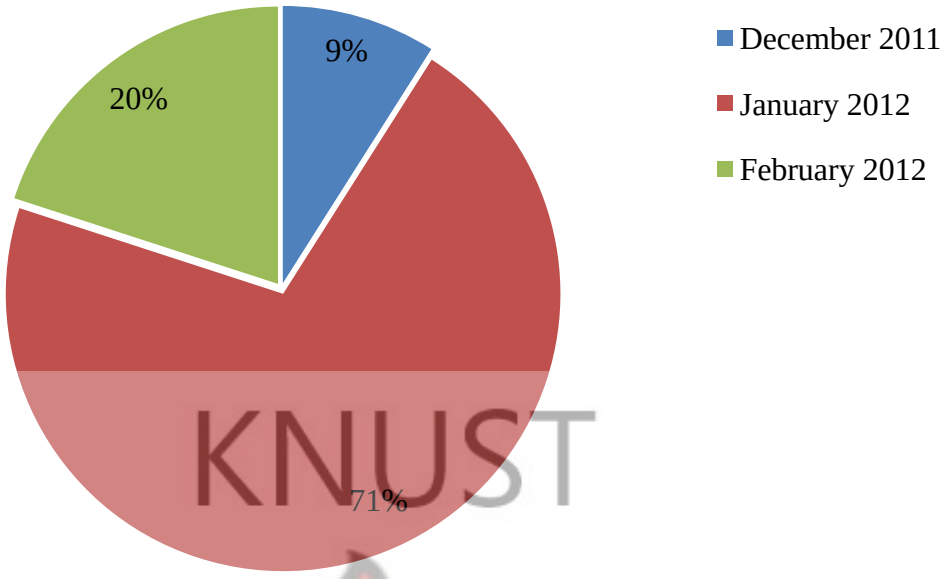




Figure10. Harvesting period

**4.1.4.2 Harvesting Methods**

Various harvesting methods used by the respondents have been presented in Figure 11. Sixty-six percent shook the branches of the tree for the fruits to drop with an estimated loss of 12 %. Twenty-three percent used hooks mounted on woody sticks in harvesting resulting in estimated postharvest loss 5% whiles 11% harvested the fruits by plucking with hand for others to catch resulted in an estimated loss of 2%.

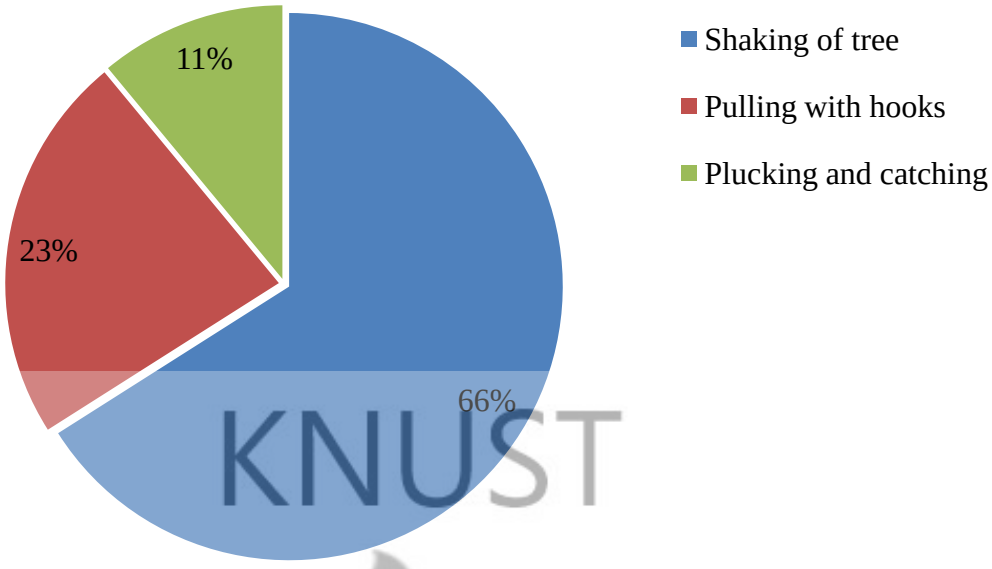


Figure 11: Method of harvesting

#### 4.1.4.3 Length of Period of Keeping Fruits in the Field.

Table 8 is a summary of the number of days the fruits were kept on the farm and in heaps prior to transportation to the market center. On average, fruits were kept on the farm for three days after harvest resulting in an estimated loss of 10% whiles they were heaped for another two days before they were transported to the market center also resulting in an estimated loss of 5%.

Table 8: Number of days of keeping fruits at the farm gate.

| Location | Average number of days of storage | Estimated percentage loss |
|---|---|---|
| On the farm | 3 | 10% |
| Heaps before transportation | 2 | 5% |
| Total | 5 | 15% |

#### 4.1.4.4 Protection of Harvested Fruits from the Sun.

Results from the survey showed that 72% gave no protection to the harvested fruits from the sun whiles 28% protected the harvested fruits from the sun by using dry leaves, fresh leaves or keep fruits under shady trees (Figure 12).

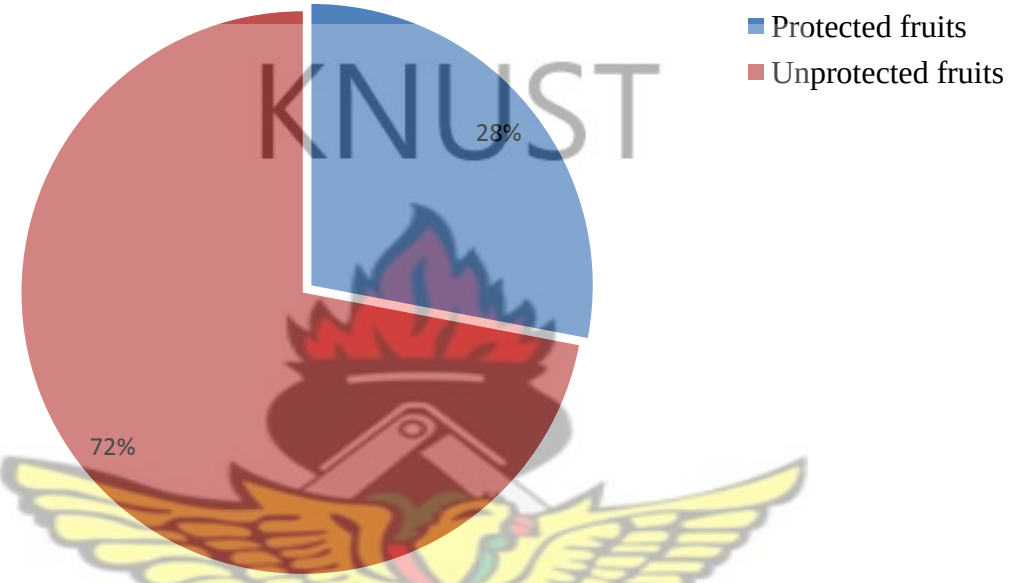


Figure 12: Protection of harvested fruits from sun.

#### 4.1.4.5 Causes of Injuries to Fruits

Figure 13 illustrates the major causes of injuries to fruits of farmers. Twenty-five percent of the injuries were caused by poor harvesting methods like shaking of branches and 21% by over heaping of fruits, 20% was attributed to diseases and pest infestation, 18% were destroyed through cracks and piercing whiles 16% were injured as a result of bad handling practices.

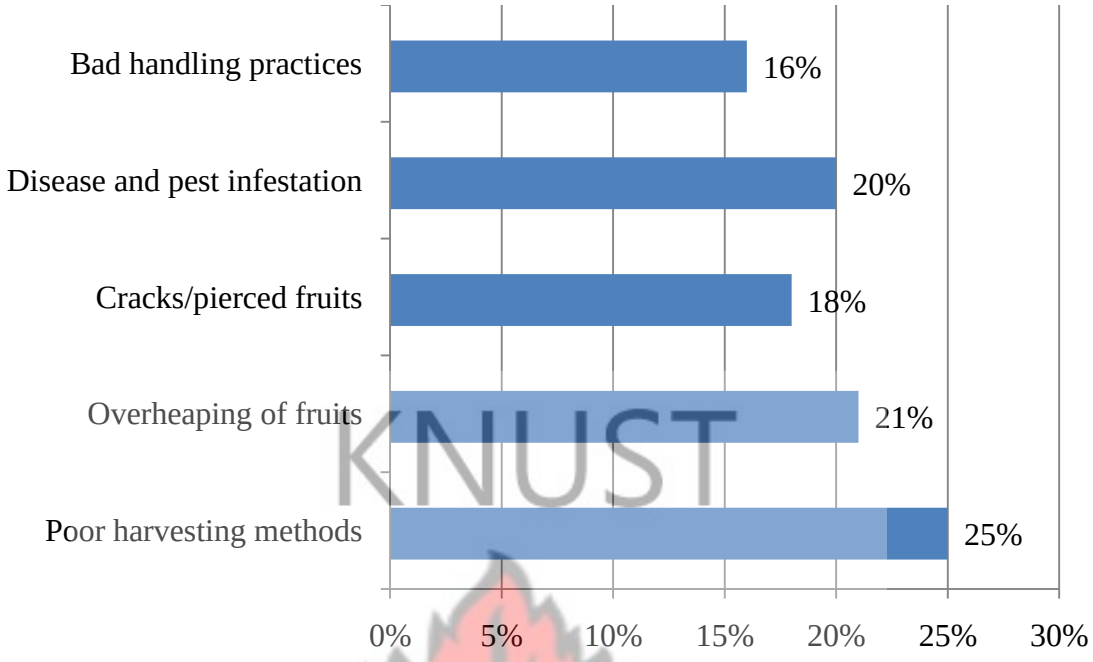


Figure 13: Causes of injuries to fruits.

#### 4.1.4.6 Ways of Preventing or Minimizing Injuries of Fruits

The respondents suggested a number of ways through which injuries can be minimized or prevented. The various suggestions have been expressed in Figure 14. Thirty-eight percent minimized injuries through protection of fruits against fruit flies prior to harvesting with insecticides,18.2% reduce injuries through proper handling of fruits, 16% adopted the use of pheromone traps to minimize bruises on fruits, 14.5% reduced piercing of fruits through thorough weeding of undergrowth and 13.3% reduced injuries through the adoption of proper harvesting methods.

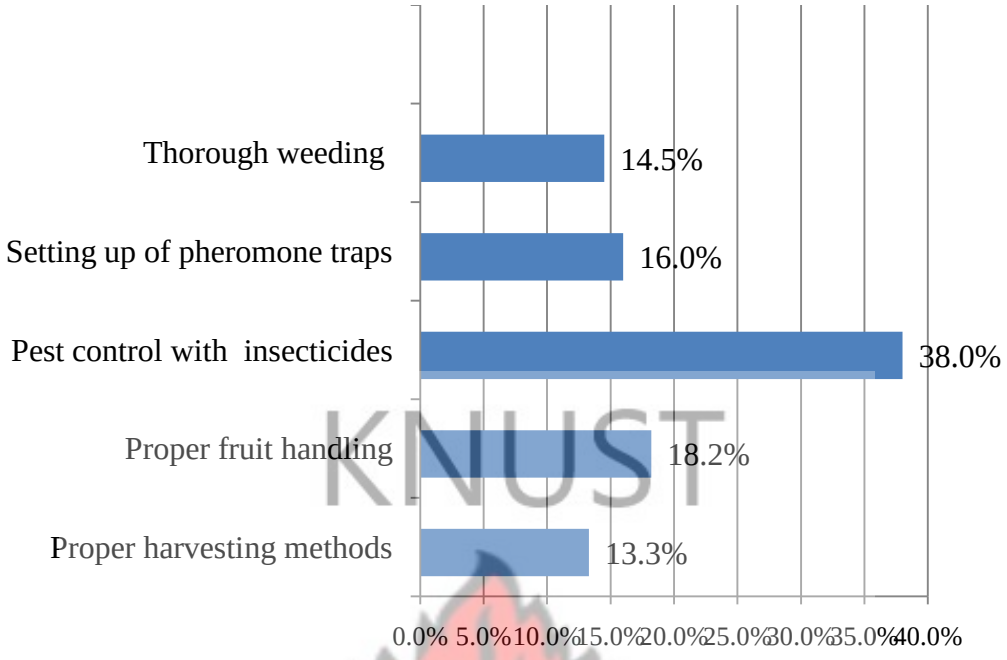


Figure 14: Ways by which injuries are minimized.

#### 4.1.4.7 Regression Analysis on Causes of Injuries to Fruits at the Farmer Level

From the regression analysis (Table 9) the model was 98.9% accurate in predicting changes or variations in the percentage of harvested fruits that were lost ($r^2$=0.989). Factors such as harvesting method, fruit handling practices, precooling and the length of storage period (Table 10) contributed to the percentage loss of harvested fruits. The ANOVA table (Appendix 21) shows that the regression model is significant and can be used for future predictions (P<0.05).

Table 9: Model summary from regression analysis

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .995[a] | .991 | .989 | .247 |

a. Predictors: (Constant), percentage of the fruits lost attributed to harvesting method, length of storage period, fruit handling , precooling?

Table 10: Coefficients from regression analysis[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 37.461 | .494 | | 75.790 | .000 |
| | Percentage of fruits lost through harvesting method | -.480 | .025 | -.610 | -19.562 | .000 |
| | Percentage lost through length of storage period | -.940 | .057 | -.438 | -16.607 | .000 |
| | Percentage lost through handling practices | -1.239 | .156 | -.255 | -7.927 | .000 |
| | Percentage lost through exposure to sun | .189 | .039 | .124 | 4.848 | .000 |

a. Dependent Variable: total percentage of harvested fruits lost

## 4.2 WHOLESALER LEVEL SURVEY

### 4.2.1 Profile of Respondents

#### 4.2.1.1 Age of Wholesalers

Figure 15 presents the age distribution of wholesalers interviewed. The age group of 30-39 years constituted 45.5%, between 40-49 years 45.5% and between 50-59 years, 9.1%.

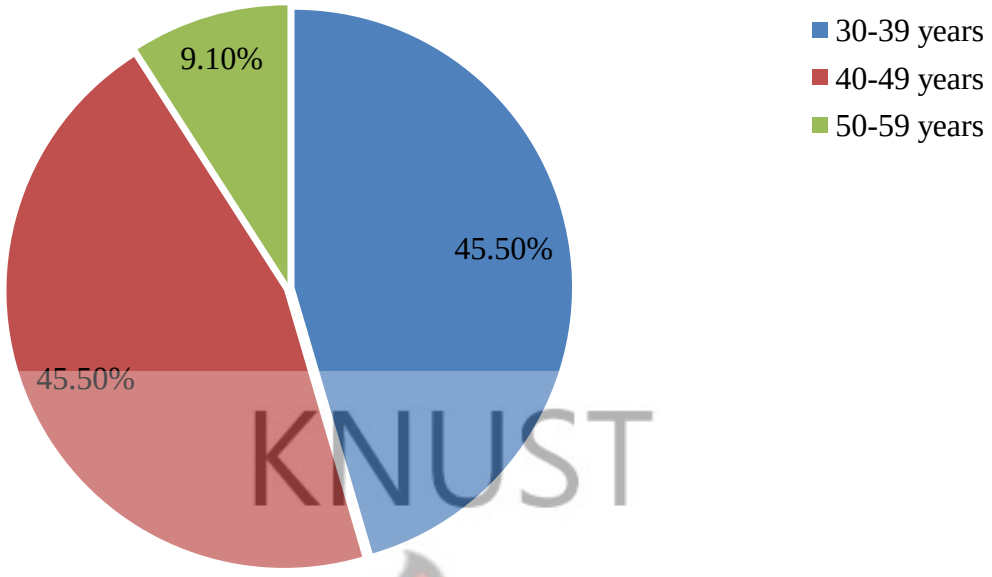


Figure 15: Age distribution of wholesalers.

#### 4.2.1.2 Highest Educational Qualification of Wholesalers

The highest educational level of respondents is shown in Figure 16. Those with basic education constituted 81.8 %, 9.1% secondary school, whiles 9.1% had no formal education.

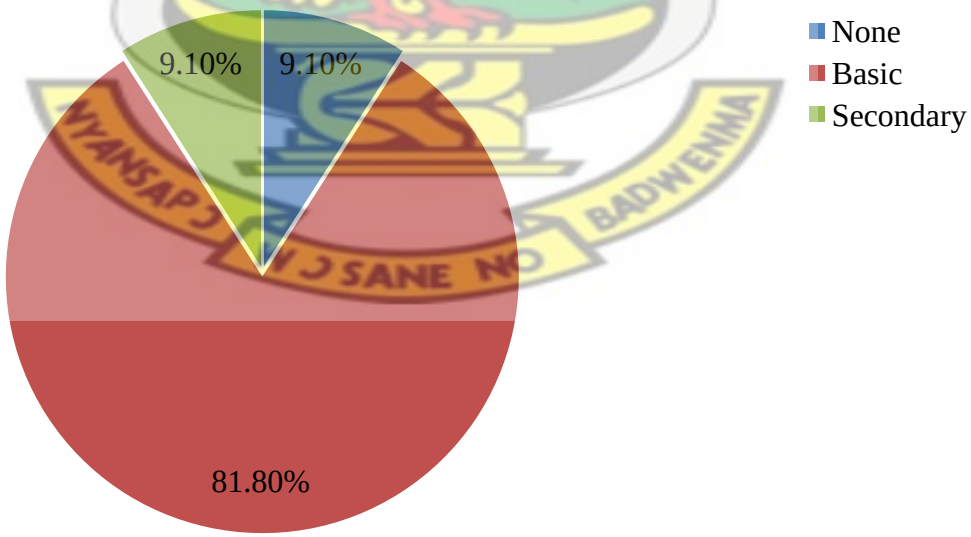


Figure 16: Highest educational level of wholesalers.

### 4.2.2 Occupational Information

#### 4.2.2.1 Other Produce Purchased by Wholesalers

Apart from citrus purchases, wholesalers were involved in the purchases of other commodities. Figure 17 presents other major crops the wholesalers were engaged in. From the survey, 60% of the wholesalers purchased banana and plantain from the communities, 20% cola nuts, 10% for pineapple and 10% for other crops.

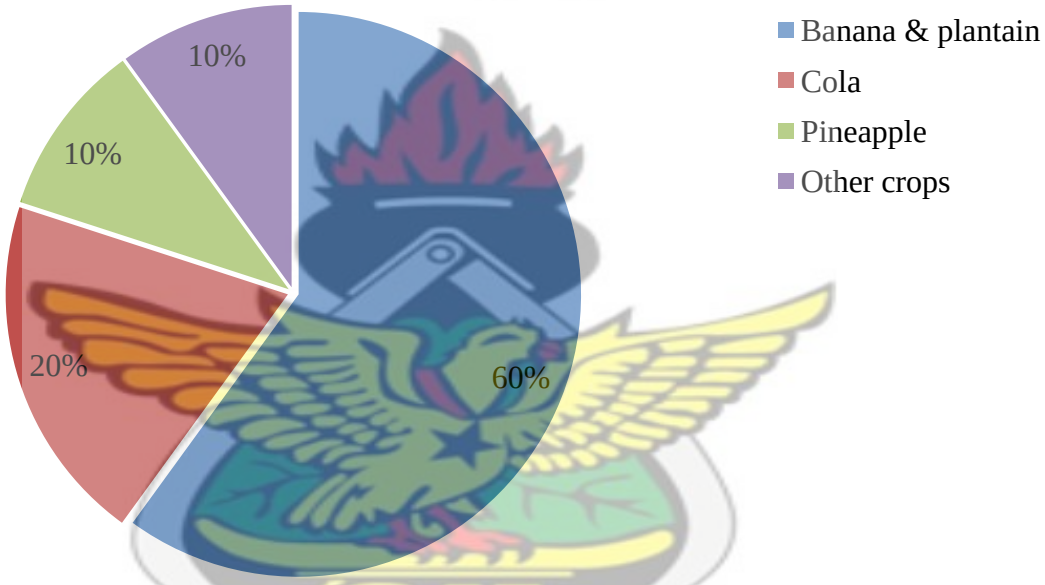


Figure 17: Other produce purchased by wholesalers

#### 4.2.2.2 Main Source of Income for Wholesalers

Figure 18 illustrates the main sources of income for the wholesalers. Citrus contributed 39% of the respondents' income, non-farming activities 34.3% whiles other crops together contributed 26.7%.

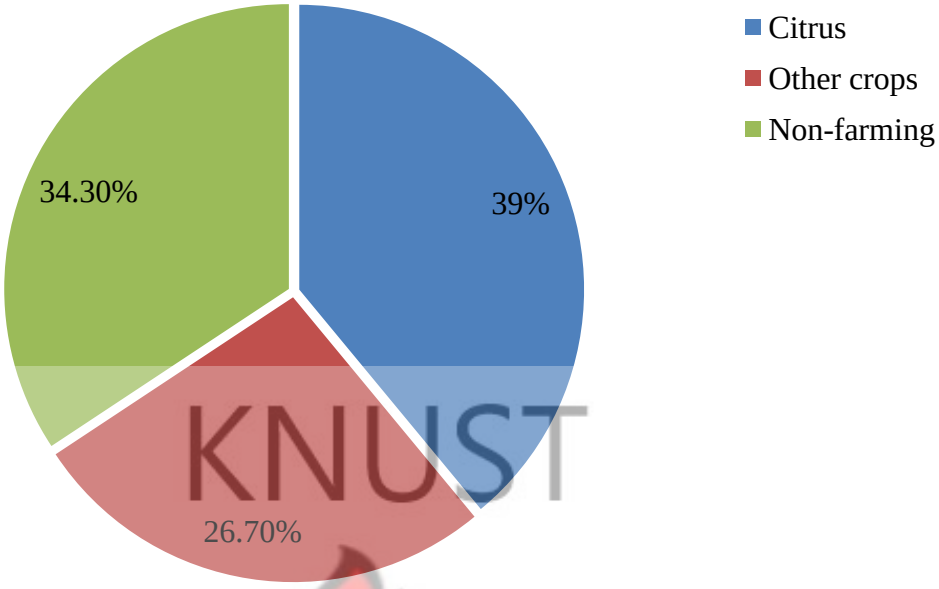


Figure 18: Main source of income for wholesalers

#### 4.2.2.3 Major Challenges Faced by Wholesalers

The main challenges faced by wholesalers have been presented in Figure 19. High labour and transportation cost constituted 30.4% of the challenges, low capital for purchases formed 25.4%, postharvest was 18.2%, frequent breakdown of vehicles due to poor road network constituted 16.9% whiles pilfering at the market was 9.1%.

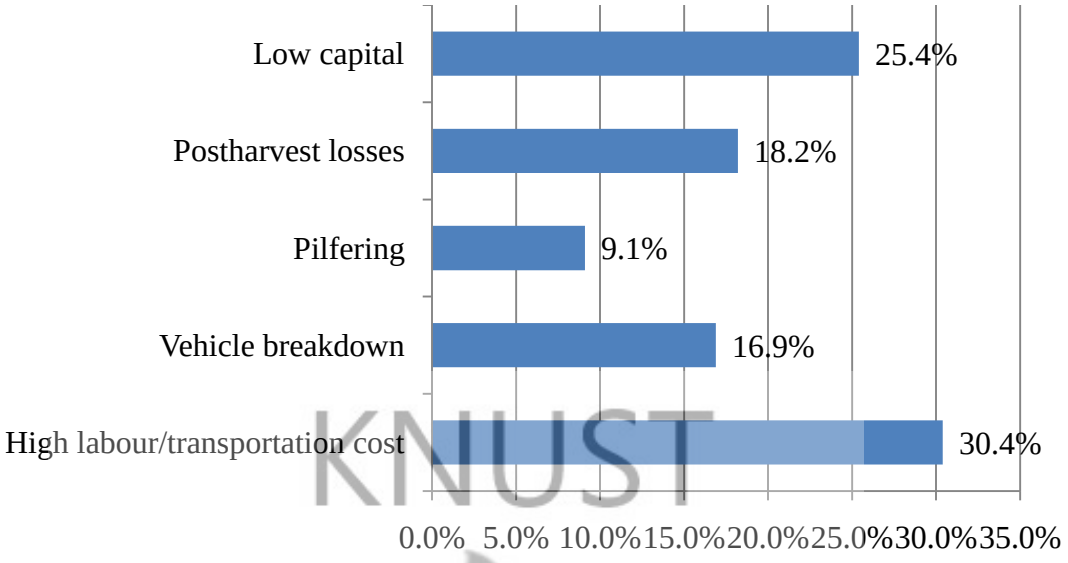


Figure 19: Major challenges faced by wholesalers

### 4.2.3 Fruit Management

#### 4.2.3.1 Channels for Distributing Fruits at the Wholesale Level During the Major and Minor Seasons.

Table 11 presents channels through which fruits purchased by wholesalers were disposed off during the major and minor harvesting season. Most of the fruits (77.8%) were sold to retailers, postharvest losses accounted for 10.8% of the fruits purchased, 8% were lost through pilfering and 3.4% given out as gift during the major season. In the minor season however, retailers purchased 82.1%, postharvest losses accounted for 11.9%, pilfering 5% and 1% was given out as gift.

Table 11: Channels for distribution of fruits

| Outlet | Percentage distributed through channel(Major season) | Percentage distributed through channel (Minor season) |
|---|---|---|
| Retail market | 77.8 | 82.1 |
| Home/gift | 3.4 | 1 |
| Pilfering | 8 | 5 |
| Postharvest losses | 10.8 | 11.9 |



#### 4.2.3.2 Average Quantity of Fruits Disposed through the Channels and their Value.

Table 12 gives details of average quantity disposed through various channels per trip by wholesaler trip and the corresponding value of the produce.

Table 12: Average quantity of fruits disposed off per trip and value

| Outlet | Mean number of fruits | Percentage of total harvest | Value (GH¢) |
|---|---|---|---|
| Wholesalers | 0 | 0 | 0 |
| Processors | 0 | 0 | 0 |
| Retailers | 54144 | 79.5 | 4602 |
| Postharvest losses | 7644 | 11.2 | 650 |
| Pilfering | 4660 | 6.8 | 396 |
| Home/gift | 1685 | 2.5 | 143 |
| Total | 68133 | 100 | 5791 |

#### 4.2.3.3 Sources of Finance for Wholesalers

The main sources of finance for wholesalers and average amount involved is presented in Table 13.

Table 13: Sources of finance for wholesalers

| Source of funding | Average amount obtained in 2011 (GH₵) | Percentage of wholesalers having access |
|---|---|---|
| Bank | 2000 | 18 |
| Own savings | 3300 | 55 |
| Money lenders | 0 | 0 |
| Relations | 1000 | 27 |
| NGOs | 0 | 0 |
| Government agency | 0 | 0 |
| Other (specify)……. | 0 | 0 |

#### 4.2.3.4 Major Activities Undertaken by Wholesalers and their Estimated Cost

Table 14 presents the major operations undertaken by wholesalers, average mandays used for the activity, rate and cost involved by wholesalers per trip. In total wholesalers spend GH₵520 to cart a truck load of 6 tonnes of fruits from the field to the market.

Table 14: Major cost of wholesalers per trip

| Operation | Mandays used | Rate/manday | Cost (GH¢) |
|---|---|---|---|
| Sorting | 4 | 10 | 40 |
| Loading | 5 | 8 | 40 |
| Transportation | 1 | 400 | 400 |
| Assembling | 4 | 8 | 40 |
| Total | | | 520 |



#### 4.2.3.5 Criteria for Selecting Fruits for the Wholesale Market

The responses of wholesalers on conditions under which fruits are rejected for the wholesale market are summarized below;

- Rotten fruits (Plate 5)
- Small sized fruits (Plate 6)
- Green or immature fruits (Plate 7)
- Insect infested fruits (Plate 8)
- Diseased and spotted fruits (Plate 9)
- Dry fruits (Plate 10)
- Over matured fruits (Plate 11)
- Irregular shaped fruits (Plate 12)
- Damaged fruits(cracked, punctured) (Plate 13)
- Wrinkled fruits (Plate 14)

Plate 5: Rotten fruits

Plate 6: Small sized fruit (left) average sized fruit (middle) big sized (right)

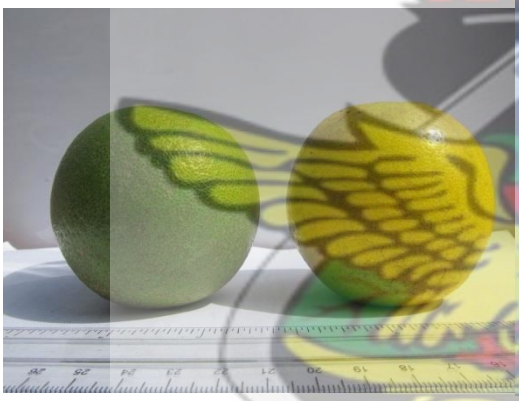

Plate 7: Green/immature fruit (left) mature fruit (right)

Plate 8: Insect infested fruit

Plate 9: Diseased/spotted fruits

Plate 10: Cut section of dry fruit (left) and juicy fruit (right)

Plate 11: Over matured fruit (left) and fresh fruit (right)

Plate 12: Irregular shaped fruit (left) and regular shaped fruit (right)

Plate 13: Damaged fruit.(punctured/pierced)

Plate 14: Wrinkled fruit

#### 4.2.3.6 Factors Influencing the Quality of Citrus Fruits

The main factors considered by the wholesalers as contributing to poor quality of citrus fruits were;

- Preharvest pest and disease problems
- Heat build up within heaped fruits
- Lack of sheds at the market center leading to exposure of fruits to direct sunlight
- Poor road network linking farming communities to market centers.
- Over loading of vehicles



#### 4.2.3.7 Length of Period of Storing Fruits at the Wholesaler Level

Table 15 is the summary of average number of days fruits were kept in various locations before they were sold and the estimated losses at these locations. On average, fruits were heaped two days on the field before transportation to the market with an estimated loss of 10%. Transportation from the field to the market took a day with an estimated loss of 6%. Averagely, fruits were heaped at the market center during distribution to retailers for three days resulting in an estimated loss of 9%.

Table 15: Number of days of keeping fruits in various locations

| Location | Average number of days of storage | Estimated percentage loss |
|---|---|---|
| Heaps before transportation to market center. | 2 | 10% |
| In the vehicle | 1 | 6% |
| Heaps at the market center | 3 | 9% |

#### 4.2.3.8 Protection of Fruits from the Sun at the Wholesale Market.

Figure 20 shows that only 27% of wholesalers provided some protection for harvested fruits from the sun by covering the heaped fruits with fresh, dried leaves or with polythene sheets. The rest (73%) leave their fruits unprotected.


Figure 20: Protection of fruits from the sun at the wholesale market

#### 4.2.3.9 Transportation of Harvested Fruits to Market

All the respondents transported the fruits in open trucks with average capacity of six tonnes over an average distance of 197km to the Greater Accra Region and 118 km to Koforidua in the Eastern Region.

#### 4.2.4.0 Causes of Injuries to Fruits

Figure 21 presents the major causes of injuries to fruits of wholesalers. Poor roads linking the communities to market centre accounted for 27.3%. Possible heat build up in

the heaped fruits as a result of exposure to sun resulted in 27.3% of the injuries , 18.2% by poor handling practices during loading and offloading of trucks, 18.2% due to overloading of vehicles while 9.0% might have been caused by insect damage prior to harvesting.

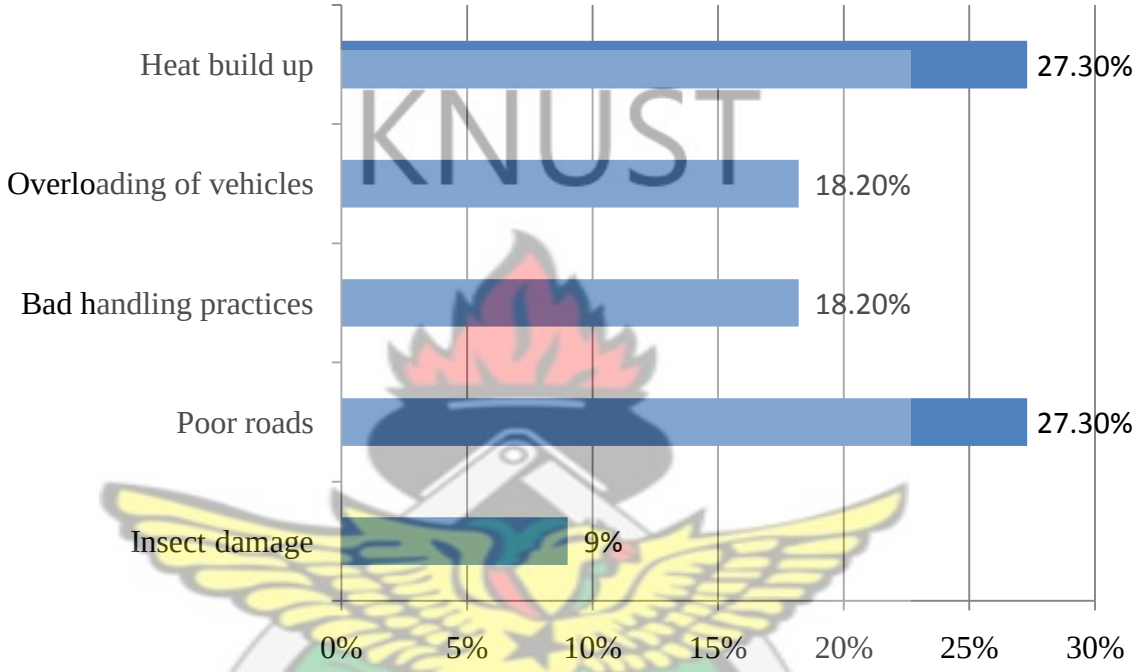


Figure 21: Causes of injuries to fruits at the market

#### 4.2.4.1 Ways of Preventing or Minimizing Injuries at the Wholesaler Level

Wholesalers response on ways of minimizing or preventing injuries is shown in Figure 22. Responses indicated that provision of shed at the market place to minimize exposure of fruits to the sun constituted 25%, 21% of the views indicated that careful fruit handling during loading and offloading can help in reducing injuries. Improving road transportation through reconstruction and maintenance of feeder roads formed 21% of the responses whiles 18% of the responses showed that injuries can be prevented through

control of field pest prior to harvesting. Spreading of fruits on a wider area to minimize the load on fruits can reduce 15% of the injuries.

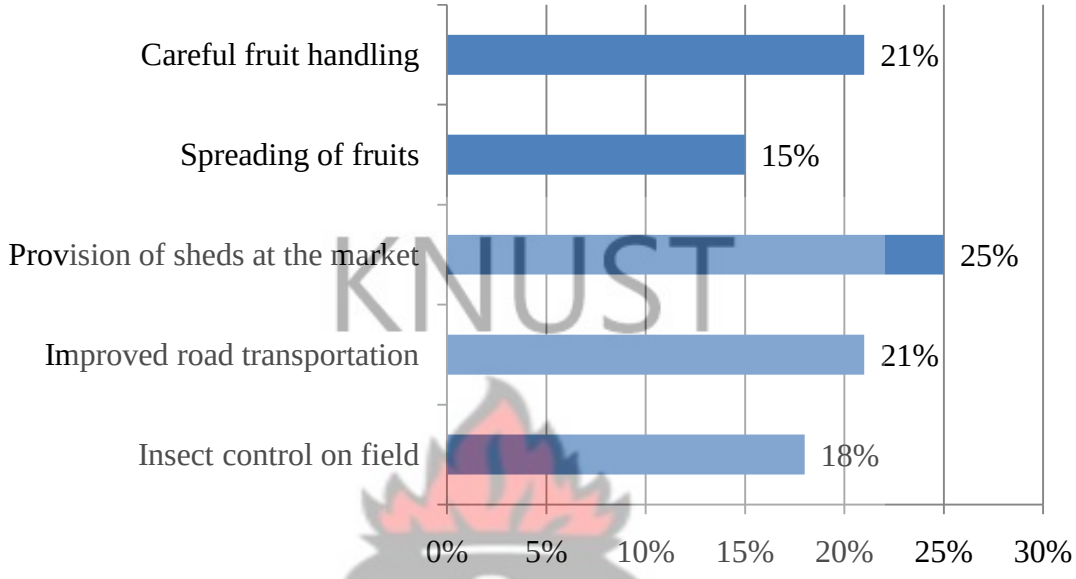


Figure 22: Ways of minimizing injuries on fruits.

### 4.3 IN-DEPTH STUDY AT FARMER AND WHOLESALER LEVEL

Results from the in-depth study conducted at the farmer and wholesaler level on the six selected farms have been summarized in the Table 16. Average postharvest loss of 20.2% was recorded at the farmer level whiles 5.6% was recorded at the wholesale level.

Table 16: Estimated postharvest losses on the farm and at wholesale level.

| Farm Location | % postharvest loss at the farmer level | | | Market location& distance(km) | % postharvest loss at the wholesaler level | | |
|---|---|---|---|---|---|---|---|
| | Total number of fruits | Number of fruits lost | % loss * | | Total number of fruits | Number of fruits lost | % loss ** |
| Amuana Praso | 44,852 | 7,925 | 17.7 | Madina (193 km) | 36,927 | 1,278 | 5.2 |
| Amanfokrom | 41,082 | 9063 | 22.1 | Agbogloshie (178 km) | 33,881 | 2,297 | 6.8 |
| Nyafoman | 34,980 | 6,746 | 19.3 | Koforidua (114 km) | 28,234 | 1,634 | 5.8 |
| Prasokuma | 48,591 | 10,451 | 21.5 | Tema (212 km) | 38,140 | 3,140 | 8.2 |
| Afosu | 44,775 | 8049 | 18 | Koforidua (122 km) | 36,726 | 1,726 | 4.7 |
| Akrofonso | 30,274 | 7213 | 23.8 | Madina (206 km) | 23,061 | 865 | 3.8 |
| Estimated average post harvest loss | | | **20.2** | | 196,969 | 10,940 | **5.6** |

*Formula for estimating postharvest loss at the farmer level;

$$\% \text{ loss } (L) = \frac{F+B}{T}$$

Where F= Estimated loss on the farm

B= Fruits left at the bulking point after selection by wholesalers

T= Total number of fruits harvested(Fruits left on the farm+fruits rejected at the bulking point+fruits selected to the wholesale market)



** Formula for estimating postharvest loss at the wholesaler level

$$\% \text{ loss } (L) = \frac{R+T+P}{D}$$

Where R = Fruits rejected by retailers at the wholesale market

T= Fruits lost in transit

P= Fruits lost through pilfering

D = Total number of fruits carted from the farmers field

Average from the six markets was determined to represent the postharvest loss at the farmer wholesaler level.

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 Farmer Level Survey

Citrus farming among ADRA supported farmers in the Birim North district is dominated by males who constitute 77% of the farmers interviewed. This might be due to the drudgery involved and the financial requirement for the plantation management. Records available at ADRA indicated that there was deliberate effort to encourage more women to enroll in the project as the initial response of women to the project was not encouraging.

Most of the participating farmers were within the age bracket of 50-59 years which constituted the active and energetic working class at the time of project implementation. Fifteen years after cultivation, the farmers are still harvesting and the plantations serve as financial security to the farmers.

Eighty-four percent of the farmers either had no formal education or only basic education. This might have contributed to their stay in the community over the past fifteen years to take care of the plantations as there is minimal chance of securing other lucrative employment in the urban centers.

The survey revealed that citrus production is one of the major income earners for most ADRA client farmers in the Birim North district of the Eastern Region and contributed 18.9% of the annual income of the farmers. Cocoa and oil palm cultivation together contributed 43.10% of the farmers' income. The dominance of cocoa and oil palm can

be attributed to the existence of very efficient marketing systems for cocoa and oil palm in the district. There is the presence of licensed cocoa buying companies in all the communities in the district. Similarly, Ghana Oil Palm Development Company operates an out grower scheme in the district and has established a number of buying centers in the district where farmers are paid promptly for their produce. In contrast, citrus purchases are dominated by wholesalers who purchased 48% of the fruits from farmers. These wholesalers have been described by farmers as unreliable and do not have the capacity to make outright payment. It is expected that with a well-structured market, as pertains for cocoa and oil palm, the crop has a high potential to reduce poverty in the district. Citrus production is a major source of employment and income for 65% of the farmers. It also offers employment to a large number of the youth in the district who are engaged in farm maintenance, harvesting, carting, loading and transportation of fruits to the market.

Various forms of trainings were organized for the farmers by ADRA, Ministry of Food and Agriculture, research institutions, processing companies and other non-governmental organizations working in the district. The training covered land preparation, planting, tree management, harvesting, post-harvest management and marketing at no cost to the farmers. The survey however showed that farmers are not adopting all the good practices required to obtain optimum yield. This might be due to the low level of education of the farmers, age, high cost of production, lack of regular monitoring of the plantations after the end of the project and lack of further training to update their skills and knowledge.

Two main season in citrus production (specifically for late Valencia budded on rough lemon); the major (December to March) and minor (August to October). Six main distribution channels identified for harvested produce are wholesalers, retailers, processors, gift/home consumption, pilfering, and postharvest losses. The percentages passing through the various channels vary according to the two seasons. Though higher yields were recorded during the major harvesting season, post harvest losses within the season was low (7.6%) compared with losses recorded at the minor season (14%). This trend is possibly due to the high incidence of Mediterranean fruit fly attack during the minor season.

Results from the farmer level survey estimated postharvest loses at the farm gate during the major season as 14%. The level of postharvest losses recorded at the farm gate may be attributed to non adherence to recommended cultural practices It was observed that though most of the trees were planted about 10-15 years ago, most farmers had never applied fertilizer to the trees either because the farms are located in forest belt and hence contain a lot of organic matter or farmers could not afford to buy. According to Ferguson *et al*. (1999), plant nutrition plays important role in the postharvest life of citrus as high level of calcium in the fruit for instance has been linked to longer postharvest life of fruit as a result of its ability to reduce respiration rate, delay ripening and increase fruit firmness.

The survey showed that though some farmers use insecticides in the control of fruit flies, none of the respondents had ever applied fungicides in the control of fungal diseases that are also prevalent in the area. This might be due to the fact that farmers underestimate

the devastating effects of some fungi that cause diseases like Brown rot, Grey mould and green mould. According to Timmer *et al.* (2000) some of these decay causing fungi infect the fruits prior to harvest but remain latent on the fruit until it is harvested.

Most of the ADRA sponsored farmers harvested fruits either by shaking the branches violently for the fruits to drop or use hooks mounted on long sticks to pluck the fruits or a combination of both. Both methods result in bruising from impact on hard surfaces or get pierced by sharp objects. A study conducted on grapefruits to compare the effect of traditional method of shaking branches with an improved method of avoiding fruit impact on the ground showed that more than 20% of the fruits harvested with the improved methods were in the very good quality grade compared with only 1.5% of the fruits harvested with the traditional method. On the other hand, 20.5% of the fruits harvested with the traditional method were unmarketable whereas 3.9% unimproved method were marketable (Elshiekh and Abu-Goukh, 2008).

The results indicated that farmers use an average of three days to harvest and cart the fruits to a vantage point where they can conveniently be hauled to the market center. Fruits were heaped for two days before they were moved to the market. In addition to this, it was also observed that 72% of the farmers offered no protection to heaped fruits. These conditions might have resulted in possible heat buildup in the heaped fruits which predisposed the fruits to postharvest decay causing fungus and also lead to water loss and shrinkage of the fruits.

Results from the regression analysis on major causes of postharvest in the Birim North district showed that the total post-harvest loss incurred at the farmer level is influenced

by the harvesting method used, method used in assembling the fruits, protection given to fruits from the sun and how long the fruits were kept in storage.

### 5.2 Wholesaler Level Survey

Women constituted 82% of the wholesalers operating in the district and the trade is a major source of income to the wholesalers, however, they are also involved in the purchase of other food crops and cola nuts when citrus is not in season to ensure that their capital for the citrus business is secured during citrus off seasons.

Most of the wholesalers were within the age group of 30-49 as the business is stressful and require a lot of energy and travelling. The highest educational level attained by most of the wholesalers is at the basic level. Wholesalers in the district are not well organized and have had no formal training on the trade. They purchased 5-6 tonne truck load of fruits at a time since they are not well financed. Only 18% of the wholesalers obtained financial support from financial institutions whiles the rest had to fund their business either through relations or their own savings. This situation leads to delays in late payment of fruits purchased and prolonged the period of storage at the farm gate which eventually results high postharvest losses at the farm gate.

Fruits are conveyed in open trucks at any time of the day for an average period of one day, offloaded the following day and are stored for three days at the market in the open. These conditions led to possible heat build up in the fruits which affected the quality,

rate of respiration of the fruits and rate of decay (Ladaniya, 2004). The average post harvest loss recorded by the wholesalers was 11.2%.

The study showed that ten criteria were used by wholesalers in selecting fruits for the wholesale market. Thus fruits having one or more of the following features were rejected by the wholesalers at the farm gate; rotten, small sized, immature, insect infested, diseased, dry, over matured, irregular shaped damaged and wrinkled. Some of these substandard fruits can be attributed to inappropriate cultural practices used by farmers such as lack of fertilization and pest control (Kader, 2008). The value of these unwholesome fruits according to the survey was four hundred and forty-five Ghana Cedis (GHC 445.00). This amount is very significant considering farmers production and harvesting cost per acre in a year as GHC 405.

### 5.3 In-Depth Study at the Farmer and Wholesaler Levels.

#### 5.3.1In-depth Study at the Farmer Level

Two types of losses were identified and investigated in the in-depth study conducted at the farmer level. These are harvesting and storage losses

Harvesting loss (14.6%) was determined by counting the number of unmarketable fruits under the trees after harvesting. This was largely due to the method of harvesting used by farmers resulted in high impact of the fruits on the ground. Ofosu-Budu *et al.* (2007), reported that when fruits drop on the ground from a considerable height, it leads to certain physiological activities within the fruit that results in the release of more carbon

dioxide. The bruises or mechanical injuries create opening for the entry of pathogens that cause postharvest decay. Better harvesting methods are available, though they are labour intensive and expensive, it is justifiable adopting them considering the monetary value of about 20% of fruits that are lost to the farmers through postharvest losses. These methods include climbing the tree and harvesting the fruits into jute sacks and gently lowering them on the ground for sorting and haulage as proposed by Ofosu-Budu *et al*. (2007). Avoiding harvesting practices that minimizes impact of fruit on the ground can improve upon the postharvest and marketable quality of the fruits.

Storage loss of 5.6% was recorded at the bulking point. Storage losses could be attributed to some bad fruit management practices adopted by farmers. It was evident that only 28% of the farmers offered some form of protection to the fruits against the heat from the sun. This condition can possibly result in heat buildup in the heap which can subsequently predispose the fruits to decay causing to fungi. Fruits were stored in insanitary conditions for an average of five days on the field before transportation to the market. The length of storage period impacts negatively on the quality of fruits as harvested fruits, being living tissues, continue to respire after harvest ( Kitinoja and Kader, 1995)

The in-depth study revealed that an average of 20.2% of the fruits are lost at the farm gate which is close to the range to the range of 23-33 % reported by Coursey (1983) for developing countries.

The difference between the survey postharvest estimate of 7.6% (Major season) and the in-depth study estimate of 20.2% (major season) might be due to;

- Low level of education of the farmers interviewed. As much as 20% had no formal education whiles 64% had basic education.
- Farmers unable to recall exactly their observations months after the activity had taken place as about 34% of ADRA client farmers interviewed were above sixty years.
- Figures given by farmers were based on field observations rather than actual count.



### 5.3.2 In-Depth Study at the Wholesaler Level

At the wholesaler level, the in-depth study identified two types of losses, transit and storage losses. Transit loss which accounted for 1.6% of the losses at the wholesaler level could be attributed to bad loading practices, poor road network, type and condition of the vehicle, bad off loading practices and pilfering.

Storage loss at the wholesale market could be due to exposure of fruits to sun at the market as 72% did not provide any form of protection against the heat from the sun. In addition to this there is the possibility of fugal attack as the fruits were displayed on the bare ground for an average period of three days at the wholesale market.

In total, results from the in-depth study estimated average postharvest loss at the wholesale market as 5.6%, which may be considered high considering the fact that extensive selection criteria were used at the farm gate. The high loss may be attributed to a number of factors that affect the quality of the fruits between the farmer and the consumer. These include;

i. Poor handling practices during carting, loading and off loading which result in injuries and other mechanical damages to the fruit.

ii. Fruits were transported on poor roads for an average distance of 197km between the hinterland and the urban market. Several factors accounts for mechanical damages and losses to fresh fruits and vegetables. One these factors are vibration from the transport vehicle as they traverse on undulating roads (Jones *et al.,* 1991).

iii. Exposure of the fruits to the sun for an average of a day in the vehicle and three days at the market might have lead to a possible heat build up in the heap beyond the optimum temperature required for citrus fruit storage. Similar work done by Paull (1999) indicates that temperatures of several degrees above the ambient temperature, especially, when fruits are exposed at direct sunlight results in high losses.

# CHAPTER SIX

## 6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

### 6.1 Summary and Conclusion

The research work was carried out to assess the level of postharvest losses in citrus (late Valencia budded on rough lemon) on ADRA supported farmers fields in the Birim North district and also in the wholesale market. The work was done in three phases; farmer level survey, wholesaler level survey and an in-depth study to access the extent of postharvest losses that occur at the farm gate and at the wholesale market.

The farmer level survey revealed that 48% of the harvested fruits were sold to wholesalers, 26% to processor and 14% to retailers. Farmers estimated their losses during the major season at the farm gate at 7.6% and 14% at the minor season. Detailed work through an in-depth study on postharvest losses during the major season on six farms revealed that postharvest losses at the farm gate was 20.2%. Two main types of losses were identified at the farm gate; harvesting and storage losses. These losses were attributed to lack of protection to the fruits against the heat from the sun and the length of period of storing the fruits on the farm, harvesting method and handling practices (loading and off loading).

Wholesalers used ten main criteria in the selection of fruits for the wholesale market. Fruits were rejected based on one or more of the underlisted features;

- Rot
- Small size

- Green or immature
- Damages/injuries (cracked, punctured)
- Insects pest infestation
- Wrinkle
- Diseased and spotted
- Dry fruits
- Over maturity
- Irregular shape



Fruits were conveyed for an average distance of 197km from the farming communities to the wholesale markets (Greater Accra Region) in uncovered trucks and displayed in the sun for an average of three days at the market. These resulted in the postharvest loss of 5.9% at the wholesale market. At the wholesale market, two types of losses were identified which are transit and storage losses. The major factors that resulted in losses at the wholesale market included bad road network linking the farming communities to the market centers, pest infestation on the field, exposure to sun and poor handling practices during loading and off loading.

The study revealed that an estimated production cost of GH¢ 405 is incurred by farmers resulting in an income of GH¢ 2148 per acre and the value of fruits lost after harvest was GH¢ 445. Wholesalers earned GH¢ 4602 per trip compared with their operational cost of GH¢ 520. Postharvest loss at the wholesale market was valued as GH¢605.

### 6.2 Recommendations

In the light of the monetary value of produce lost through postharvest, effort has to be made by policy decision makers, processors, research institutes to educate farmers and wholesalers on the following that can prolong the storage life of the fruits.

i. Handling of harvested fruits with care during harvesting, carting, loading, transportation and off loading in order to prevent or minimize bruises or wounds.
ii. Harvested fruits must not be exposed to the sun but shade must be provided on the farm and at the market.
iii. Moisture build up in the heap must be reduced by spreading out the fruits.
iv. Thorough sorting must be done to eliminate defective fruits (diseases, mechanically damaged fruits) in order to minimize reinfection of other fruits.
v. Well ventilated stackable crated must be introduced into the citrus trade to transport fruits from the hinterland to the markets. This is necessary to minimize crashes of fruits under the heaps.
vi. Fruits must be loosely covered with tarpaulin whiles creating avenue for free air circulation in order to minimize heat build up during fruit transportation.
vii. Fruits must be transported during the cooler hours of the day (either in the early morning or late in the evening).

## REFERENCES


**ADRA (1996)** *Adventist Development and Relief Agency, Technical proposal for Title II Food Security Program (PL 480 Title II).* Submitted to USAID.

**ADRA (2008**). *Adventist Development and Relief Agency, Technical report on GPS mapping of farms.* Submitted to USAID.

**ADRA/GHANA Official website (2012)**, *About ADRA Ghana* [online].Available from http://www.adraghana.org/site/index.php

**Albrigo, L.G. and Carter, R.D. (1977).** Structure of citrus fruits in relation to processing. *In Citrus Science and Technology, vol.1*. Nagy, S. and Veldhuis, M.K. (Eds). The AVI publishing company, Westport, CT, pp. 33-73.

**Arpaia, M.L. (1994)**. Preharvest factors influencing postharvest quality of tropical and subtropical fruits.HortScience **29:** 982-985

**Asrey R., Patel V.B., Singh S.K. and Sagar V.R. (2008)**. Factors affecting fruit maturity and maturity standards-A review. Journal of Food Science and Technology **45**: 381-90.

**Baldwin, E.A. (1993). Citrus fruit**. ***In*: Seymour, G.B., Taylor, J.E., Tucker.G.A**.(Eds.), *Biochemistry of Fruit Ripening*. Chapman & Hall, London, UK.pp107-149.

**Barchi, G.L., Berardinelli, A.,Guarnieri, A.,Ragni L. and Totaro Fila C. (2002).** Damage to loquasts by vibration-simulating intra state- transport. Biosystems Engeneering, **86**: 495-502.

**Barry, C.S. and Giovannoni, J.J. (2007).** Ethylene and fruit ripening, Journal of Plant Growth Regulators **26**: 143-159.

**Beattie, B.B., McGlasson, W.B and Wade N.L. (1989).** Postharvest diseases of horticultural produce volume 2: Tropical Fruit. Information Serries Q 194020. State of Queensland Department of Primary Industries, Brisbane Australia.

**Berardinelli, A., Donati, V.,Giunchi, A.,Guarnieri A. and Ragni, L.(2003)**. Effects of transport vibrations on quality indices of shell egg. Biosystems Engineering **86**: 495-502

**BNDA (2010).** Birim North District Assembly Medium Term Development Plan (2010-2013)

**Brown, A. (2000).** *Understanding Food, Principles and Preparations.* Wadsworth, Thomas Learning, USA.

**Cabras, P., Schirra, M., Pirisi, F.M., Garau, V.L. and Angioni, A. (1999).** Factors affecting imazalil and thiabendazole uptake and persistence in citrus fruits

following dip treatments. Journal of Agricultural and Food Chemistry **47:** 3352-3354.

**Carlos, H.C., Mitchell, F.G. and Johnson, S. (1995).** Factors in fresh market stone fruit quality. Postharvest News and Information **6**: 217-222

**Ceponis, M.J. and Butterfield J.E. (1974)**. Market losses in Florida cucumber and bell pepper in metropolitan New York. Plant Dis. Rep. **58**: 553-560.

**Ceponis, M.J. and Butterfield J.E. (1973).** The nature and extent of retail and consumer losses in apples, oranges, lettuce, strawberries and potatoes marketed in greater New York, *USDA Mktg. Res. Rpt*. No. 996.

**Coggins, C.W., Lewis L.N. and Knapp, J.C.F. (1969).** Gibberellin-delayed senescence and essential oil changes in the Naval orange rind. Journal of Agricultural and Food Chemistry **17**: 807-809.

**Coursey, D.G. (1983).** Post Harvest losses in perishable foods of the developing world, pp 485-514. *In*: Lieberman, M. (Ed) Postharvest physiology and crop preservation. Plenum press, New York.

**Davies, F.S. and Albrigo, L.G. (1994).** Environmental constraints on growth, development & physiology of citrus, Citrus: crop production science in horticulture 2. CAB International, Wallingford, UK. pp 52-82.

**Eaks, I.L. (1961).** Techniques to evaluate injury to citrus fruit from handling practices. Proc. Am. Soc. Hort. Sci. **78**: 190-196

**Elshiekh, F.A. and Abu-Goukh A.A. (2008).**Effect of harvesting method on quality and storability of grapefruits. U. of K.J. Agric.Sci. **16(1),** pp1-4.

**FAO (2012)** *Storage losses and their estimation* [online]. Available from: http://www.fao.fao.org/docrep/x5048e/x5048E05.htm. [Accessed on February 17, 2012]

**FAO (2011)**.Global Food Losses and Food Waste. Extent, Causes and Prevention. Study conducted for the international congress 'Save Food'. Food and Agriculture Organization of the United Nations, Rome.

**FAO (2001).** Principles and practices of small-and medium-scale fruit juice processing. Agricultural Services Bulletin 146. Food and Agricultural Organization of the United Nations, Rome.

**Ferguson, I., Volz, R., and Woof, A. (1999)**. Preharvest factors affecting physiological disorders of fruits. Postharv. Biol. Technol **15**: 255-262.

**Fisher, D., Craig, W. and Ashby, B.H.(1990).** Reducing transportation damage to grapes and strawberries. Journal of Food Distribution Research **21**: 193-2002.

**Ghana Export Promotion Council (2005).** Comparison of export performance of non-traditional products for the period January-December 2002 and 2003.

**Giudice, V.L. (2002).** Pest and diseases.*In*: Dugo, G., Di Giacoino, A. (Eds), *Citrus: the genuscitrus.* Medicinal and aromatic plants-industrial profiles; v.26: Taylor & Francis, London; New York pp.49-62.

**Grierson, W. (1986).**Physiological disorders.*In:*Wardowski, W.F., Nagy, S., Grierson, W. (Ed), Fresh Citrus Fruits. AVI Publishing Co., Westport, CT. pp 361-378.

**Gutherie, H. and Picciano, M. (1995).** *Human Nutrition*. St Louis, Mo. USA, Mosby.

**Hatton, T.T (1990).** Reduction of chilling injury with temperature manipulation. *In*: Wang, C.Y. (Ed.), *Chilling Injury of Horticultural Crops.* CRC Press, Inc, Boca Raton, Fla. pp 268-280.

**Herner, R.C. (1989).** Sources of loss cited during postharvest handling .Great Lakes Vegetable Growers News. May. p16.

**Izquierdo, L and Sendra, J.M. (2003).** Citrus fruits: Composition and characterization. Encyclopedia of food sciences and nutrition. *In*: Caballero.B. (Ed). Academic Press, Oxford. pp 1335-1341

**Jones, C.S., Holt J.E. and Schoorl, D. (1991).** A model to predict damage to horticultural produce during transport. J. Agric. Engin. Res 50: 259-72

**Kader A. A. (1988).** Influence of preharvest and postharvest environment on nutritional composition of fruits and vegetables. pp18-32. *In*; Quebedeaux ,B. and Bliss, F.A.(Eds). Horticulture and Human Health, Contributions of Fruits and Vegetables. Prentice-Hall, Englewood Cliff, NJ.

**Kader, A.A., Kasmire, R. F., Mitchell, F.G., Reid M.S., Sommer, N.F. and Thompson J.F. (1985).** Postharvest technology of horticultural crops. Univ. of Calf., DANR special publ. No. 3311. p192.

**Kitinoja, L. and Kader A.A. (1995).** Temperature and relative humidity control, Small-scale postharvest handling practices. A manual for horticultural crops. Department of Pomology, University of California Davis; California, pp 89-111.

**Ladaniya, M.S. (2004).** Citrus: Postharvest cold chain. *In*: Dris, R., Niskanen, R., Jain, S.M. (Eds). *Crop Management and Postharvest Handling of Horticultural Products: Fruits and Vegetables*, vol. 2. Science Publishers, Inc., Enfield (NH), Plymouth UK.pp 239-276.

**Lee, S.K. and Kader, A.A. (2000)**. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology **20**, 207-220.

**Manner H.I., Bucker R.S., Smith V.E., Ward D. and Elevitch C.R. (2006).***Citrus species* (Citrus) ver. 2.1. In Elevitch C.R. (ed). Species profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR) Holualua Hawai [Online]. Available from: http//www.traditionaltree.org. [Accessed on March 15 2012].

**Mao, L., Ying, T., Xi Y. and Shan (1995).** Respiration rate, ethylene production and cellular leakage of fig fruit following vibration stress. Hort.Science**30**: 145.

**Michailides, T.J. and Manganoris G.A. (2009)**. Harvesting and handling effects on postharvest decay. Stewart Postharvest Review.pp1-7.

**Moore, G.A. (2001).** Oranges and lemons: clues to the taxanomy of citrus from molecular markers. Trends in Genetics **17**, 536-540.

**Moretti, C.L., Sargent, S.A. and Huber, D.J. (1999).** Delayed ripening does not alleviate symptoms of internal bruising in tomato fruit. Proceedings of the Florida State Horticultural Society, **112**, p.169-171.

**Mukhopadhyay, S. (2004).** Diseases of *Citrus* and their management, *Citrus: Production, Postharvest, diseases and Pest Management.* Science Publishers, Enfield, (NH), USA. Pp 90-196.

**Murata, T. (1997).** Citrus: Mitra, S.K. (Ed), *Postharvest Physiology and Storage of Tropical and Subtropical Fruits*. CAB International, UK. pp 21-40.

**Nagy, S., Chen, C.S. and Shaw P.E. (1993).** *Fruit Juice Processing Technology.* AgScience, Inc., Auburndale, Florida.

**O'Brien, M., Claypool L.L., Leonard S.J., York G.K. and MacGillivray (1963).** Causes of fruit bruising on transport trucks. Hilgardia **35(6)**:113-124.

**Ofosu-Budu, K.G., Monney E.O., Quaye E., Amankwah A., Mintah P., Asare C.M. and Agboka M.(2007)**.*Citrus Production In Ghana*. Agricultural Information Support Unit Press,Accra. pp1- 6.

**Ofosu-Budu, K.G. and Nyamekye-Boamah, K. (2004).**Citrus Production in the Kwaebibrem, West Akim, Birim North and Birim South Districts of the Eastern Region. Survey report submitted to Ministry of Trade and Industries and Presidential Special Initiative, Accra Ghana.

**Parfitt, J., Barthel, M., and Macnaughton, S. (2010).** Food waste within food supply chain; quantification and potential for change to 2050. Phil. Trans. R. Soc. **356**. 3065-3081.

**Paull, R.E. (1999).** Effect of Temperature and Relative Humidity on Fresh Commodity Quality.Postharv. Biol. Technol.**15:** 263-277.

**Pierson, T.R., Aleen, J.W. and McLaughlin (1982).** Produce losses in the U.S. food distribution system. Mich. State. Univ. Agric. Econ. Rpt. 442, E. Lansing Mich.

**Samson, J.A. (1986)**. Citrus, *Tropical Fruits*. Longman Scientific & Technical, Essex, New York. Pp 73-138.

**Schirra, M., D'hallewin, G., Ben Yehoshua S., Fallik, E., (2000).** Host pathogen interactions modulated by heat treatment. Postharvest Biology and Technology **21**; 71-85.

**Singh, S.P. and Xu.M., (1993).** Bruising in apples as a function of truck vibration & packaging. Applied Engineering in Agriculture, **9**: 455-460.

**Soule, J. and Grierson, W. (1986).** Anatomy and physiology *In*: Wardowski, W.F., Nagy, S., Grierson, W. (Eds). *Fresh Citrus Fruit.* The AVI publishing company INC., Westport CT. pp 1-22.

**Spiegel-Roy, P. and Goldschmidt, E.E. (1996).** Reproductive physiology: flowering and fruiting, *Biology of citrus.* Cambridge University Press, Cambridge UK.pp 70-125.

**Tamzini, M.I, Elyatem S.M., Bensaad, Z.M., Fallah H. and Derbak, B. (1992)**.Postharvest losses of horticultural crops in Libya. Proceedings of the first Arab conference on preparation and handling of horticultural crops. Amman, Jordan.

**Timmer, L.W., Garnsey S.M. and Graham J.H (2000)** *Compendium of Citrus Diseases 2nd Edition*. American Phytopathology Society Press, Minnesota, pp.1-36

**UNCTAD (2011)**, *Infocomm market information in the commodities area* [online]. Available from: http://www.unctad.org/infocomm/anglais/orange/market.htm [Accessed on 6th May 2012].

**USDA Agricultural Research Service (2000).** *USDA Nutrient Database for Standard Reference, Release 13. Nutrient Data Laboratory Home Page* [online]. Available from: http://www.ars.usda.gov/ba/bhnrc/ndl [Accessed on June 7 2012].

**Valero, D., Martinez- Romero, D. and Serrano, M. (2002).**The role of polyamines in the improvement of the shelf life of fruit. Trends in Food Science & Technology.**13**. 228-238.

**Verma, V.S. and Tikoo, M.L. (2003).** Seasonal disease profile and chemical management of fungal rot loss of citrus fruits. Annals of Plant Protection Sciences **11**, 79-82.

**Whitney, E. N. and Rolfes, S.R. (1999).** *Understanding Nutrition***.** Eight edition**.** West/Wadsworth, Belmont,Ca., USA, 234p.

**Wikipedia (2012).** Citrus Production [online]. Available from: http://www.en.org/wiki/citrus production. [Accessed on March 8, 2012].

# APPENDICES

## PROFILE OF RESPONDNETS

Appendix 1: Age of farmers

| Age | Frequency | Percentage |
|---|---|---|
| 20-29 years | 1 | 1.0 |
| 30-39 years | 16 | 16.0 |
| 40-49 years | 21 | 21.0 |
| 50-59 years | 28 | 28.0 |
| 60 years and above | 34 | 34.0 |
| Total | 100 | 100.0 |

Appendix 2: Sex of farmers

| Sex | Frequency | Percentage |
|---|---|---|
| male | 67 | 67.0 |
| female | 33 | 33.0 |
| Total | 100 | 100.0 |

Appendix 3: Highest education qualification of farmers

| Qualification | Frequency | Percentage |
|---|---|---|
| No formal | 20 | 2.0 |
| Basic (Pri/MSLC/JHS) | 64 | 64.0 |
| Secondary (SHS/Voc/Tech | 13 | 13.0 |
| Tertiary | 3 | 3.0 |
| Total | 100 | 100.0 |



**OCCUPATIONAL INFORMATION**

Appendix 4: Primary occupation

| Occupation | Frequency | Percentage |
|---|---|---|
| Civil servant | 1 | 1.0 |
| Driving | 1 | 1.0 |
| Farming | 96 | 96.0 |
| Oil processing | 1 | 1.0 |
| Trading | 1 | 1.0 |
| Total | 100 | 100.0 |

Appendix 5: Appendix 5: Other crops cultivated by farmers

| Produce | Frequency | Percentage |
|---|---|---|
| cocoa | 67 | 40.0 |
| Food crops | 37 | 22.0 |
| Oil palm | 63 | 38.0 |
| Total | 167 | 100.0 |



Appendix 6: Main sources of your income of farmers

| Source of income | Frequency | Percentage of total income |
|---|---|---|
| citrus | 41 | 18.9 |
| Other tree crops (cocoa, oil palm) | 94 | 43.1 |
| Non farming (distillering, trading) | 33 | 15.2 |
| Remittance | 12 | 5.6 |
| Food crops | 38 | 17.2 |
| Total | 218 | 100.0 |

Appendix 7: Benefits from citrus production

| Benefit | Frequency | Percentage |
|---|---|---|
| Enjoy drinking it | 11 | 7.0 |
| Expand other businesses | 10 | 6.0 |
| Future security/long term investment | 21 | 14.0 |
| Renovate my house /invested in new building. | 8 | 5.0 |
| Source of employment and income to support family and pay school fees | 96 | 65.0 |
| Total | 146 | 100.0 |



Appendix 8: Challenges in citrus production

| Challenge | Frequency | Percentage |
|---|---|---|
| Poor road network | 31 | 14.2 |
| High cost of production | 34.8 | 15.6 |
| Pests and disease infestation | 68.7 | 30.8 |
| Unreliable market/low price for produce | 66 | 29.6 |
| High postharvest losses | 22 | 9.8 |
| Total | 223 | 100.0 |

Appendix 9: Channels for disposing off harvested fruits during the major harvest season . (December, 2011 – March, 2012).

| Outlet | Mean quantity of fruits | % of total harvest | Value (GH¢) |
|---|---|---|---|
| Wholesalers | 81354 | 49.3 | 2440 |
| Retailers | 19600 | 11.9 | 588 |
| Processors | 47630 | 29 | 1310 |
| Home/gift | 1883 | 1.1 | 56.50 |
| Pilfering | 1821 | 1.1 | 54.63 |
| Post harvest loss | 12595 | 7.6 | 377.85 |
| Total | | 100.0 | |

Appendix10: Channels for disposing off harvested fruits during the minor harvest season .(August, 2011 – October, 2011).

| Outlet | Mean quantity of fruits | % of total harvest | Value (GHC) |
|---|---|---|---|
| Wholesalers | 41400 | 45.4 | 1656 |
| Retailers | 15000 | 16.4 | 600 |
| Processors | 20455 | 22.4 | 562.50 |
| Home/gift | 624 | 0.7 | 18.72 |
| Pilfering | 900 | 1.0 | 27 |
| Postharvest loss | 12815 | 14.1 | 512.60 |
| Total | | 100.0 | |

**PRODUCTION INFORMATION**

Appendix 11: Training on citrus production

| | Frequency | Percentage |
|---|---|---|
| Yes | 100 | 100.0 |
| No | 0 | 0 |
| Total | 100 | 100.0 |



Appendix 12: Major activities practiced by farmers and their estimated costs/acre.

| Operation | Mandays used | Rate / manday (GH¢) | Cost (GH¢) | Estimated losses(%) |
|---|---|---|---|---|
| Harvesting | 6 | 10 | 60 | 10.0 |
| Carting | 5 | 10 | 50 | 8.0 |
| Loading | 7 | 7 | 49 | 5.0 |
| Transportation | | | | |
| Assembling | | | | |
| Distribution | | | | |

Appendix 13: Management practices adopted by farmers

| Practice | Frequency |
|---|---|
| Weed control | 100 |
| Fertilizer | 0 |
| Pest control | 56 |
| Disease control | 0 |
| Pruning | 43 |
| Removal of mistletoes | 52 |



**FRUIT MANAGEMENT**

Appendix 14: Months of harvesting fruits

| Month | Frequency | Percentage |
|---|---|---|
| January | 71 | 71.0 |
| February | 20 | 20.0 |
| December | 9 | 9.0 |
| Total | 100 | 100.0 |

Appendix 15: Harvesting methods

| Method | Frequency | Percentage | Mean estimated loss( %) |
|---|---|---|---|
| Shaking of tree | 66 | 66.0 | 12.0 |
| Pulling fruits with hook | 23 | 23.0 | 5.0 |
| Plucking and catching | 11 | 11.0 | 2.0 |
| Total | 100 | 100.0 | |



Appendix 16: Number of days of keeping fruits in various locations farmers

| Location | Mean number of days of storage | Mean estimated loss(%) |
|---|---|---|
| On the farm | 3 | 10.0 |
| Heaping before transportation to market centre | 2 | 5.0 |
| In the vehicle | - | - |
| Heaping at the market centre | - | - |

Appendix 17: Protection giving to harvested fruits from the sun

| | Frequency | Percentage |
|---|---|---|
| Yes | 28 | 72.0 |
| No | 72 | 28.0 |
| Total | 100 | 100.0 |



Appendix 18: Types of protection giving to harvested fruits

| Material | Frequency | Percentage | Mean number of days. |
|---|---|---|---|
| Covering with fresh leaves | 21 | 75.0 | 2 |
| Covering with dry leaves | 7 | 25.0 | 2 |
| Polythene sheets | - | - | |
| Total | 28 | 100.0 | |

Appendix 19: Causes of injuries to your fruits

| Causes of injuries | Frequency | Percentage |
|---|---|---|
| Poor harvesting method (shaking branches) | 82 | 25.0 |
| Over heaping of fruits | 68 | 21.0 |
| Cracks / pierced fruits | 59 | 18.0 |
| Disease and pest problems | 65 | 20.0 |
| Bad handling practices | 52 | 16.0 |
| Total | 326 | 100.0 |



Appendix 20: Ways of preventing or minimizing injuries of fruits

| Preventions | Frequency | Percentage |
|---|---|---|
| Proper harvesting method | 33 | 13.3 |
| Setting pheromone traps | 39 | 16.0 |
| Spraying with insecticides | 93 | 38.0 |
| Proper fruit handling practices | 44 | 18.2 |
| Thorough weeding | 35 | 14.5 |
| Total | 244 | 100.0 |

Appendix 21: Regression analysis of causes of post harvest loss at the farmer level

Variables Entered/Removed[a]

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | If yes, how do you protect the fruits from the sun? | . | Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). |

a. Dependent Variable: What percentage of your harvested fruits were lost



ANOVA[f]

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 124.839 | 4 | 31.210 | 510.964 | .000[a] |
| | Residual | 1.161 | 19 | .061 | | |
| | Total | 126.000 | 23 | | | |

a. Predictors: (Constant), What percentage of the fruits lost can be attributed to cracks/piercing?, How long did you keep the fruits in storage?, How efficient was the carting method used?, how do you protect the fruits from the sun?Excluded Variables[f]

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics |
|---|---|---|---|---|---|---|
| | | | | | | Tolerance |
| 1 | How did you harvest the fruits? | .288[a] | . | . | 1.000 | .111 |
| | What percentage of fruits lost can be attributed to pest infestation? | 3.767[a] | . | . | 1.000 | .001 |

a. Predictors in the Model: (Constant), What percentage of the fruits lost can be attributed to cracks/piercing?, How long did you keep the fruits in storage?, How efficient was the carting method used?, how do you protect the fruits from the sun?

**PROFILE OF WHOLESALERS**

Appendix 22: Age of wholesalers

| Age | Frequency | Percentage |
|---|---|---|
| 30-39 years | 5 | 45.5 |
| 40-49 years | 5 | 45.5 |
| 50-59 years | 1 | 9.1 |
| Total | 11 | 100.0 |



Appendix 23: Sex of wholesalers

| Sex | Frequency | Percentage |
|---|---|---|
| Male | 2 | 18.2 |
| Female | 9 | 81.8 |
| Total | 11 | 100.0 |

Appendix 24: Highest education qualification of wholesalers

| Qualification | Frequency | Percentage |
|---|---|---|
| None | 1 | 9.1 |
| Basic (Pri/MSLC/JHS) | 9 | 81.8 |
| Secondary (SHS/Voc/Tech | 1 | 9.1 |
| Total | 11 | 100.0 |

**OCCUPATIONAL INFORMATION OF WHOLESALERS**

Appendix 25: Other produce purchased by wholesalers

| Produce | Frequency | Percentage |
|---|---|---|
| Banana /Plantain | 9 | 46.0 |
| Cola | 5 | 24.0 |
| Other food crops | 4 | 17.0 |
| pineapple | 2 | 13.0 |
| Total | 20 | 100.0 |



Appendix 26: Main sources of your income of wholesalers

| Source of income | Frequency | Percentage of total income |
|---|---|---|
| citrus | 9 | 39.0 |
| Other crops | 6 | 26.7 |
| Non farming (distillering, trading) | 8 | 34.3 |
| Remittance | | - |
| Others | | - |
| Total | 23 | 100.0 |

Appendix 27: Benefits in citrus trade

| Benefit | Frequency | Percentage |
|---|---|---|
| Food for the family | 4 | 21.1 |
| Source of income | 10 | 52.6 |
| Pay school fees | 2 | 10.5 |
| Renovate or build my house | 2 | 10.5 |
| Source of employment | 1 | 5.3 |
| Total | 19 | 100.0 |



Appendix 28: challenges in citrus trade

| Challenge | Frequency | Percentage |
|---|---|---|
| High cost of labour/transportation | 5 | 30.4 |
| Vehicle breakdown due to poor road | 3 | 16.9 |
| Pilfering at the market | 2 | 9.1 |
| High postharvest losses | 3 | 18.2 |
| Low business capital | 5 | 25.4 |
| Total | 18 | 100.0 |

Appendix 29: Channels for disposing off fruits in market during the major harvest season ?(December, 2011 – March, 2012)

| Outlet | Mean quantity of fruits | % of total harvest | Value (GHC) |
|---|---|---|---|
| Wholesalers | | | |
| Retailers | 65058 | 77.8 | 4554 |
| Processors | | | |
| Home/gift | 2843 | 3.4 | 199 |
| Pilfering | 6690 | 8.0 | 468 |
| Postharvest loss | 9031 | 10.8 | 632 |
| Total | 83622 | 100.0 | 3040 |

Appendix 30: Channels for disposing off fruits in market during the minor harvest season ?(August, 2011 – October, 2011)

| Outlet | Mean quantity of fruits | % of total harvest | Value (GHC) |
|---|---|---|---|
| Wholesalers | | | |
| Retailers | 43171 | 82.1 | 4317 |
| Processors | | | |
| Home/gift | 526 | 1.0 | 53 |
| Pilfering | 2629 | 5.0 | 263 |
| Postharvest loss | 6257 | 11.9 | 626 |
| Total | 52583 | 100.0 | 3400 |

**PRODUCTION INFORMATION OF WHOLESALERS**

Appendix 31: Training on citrus trade

| | Frequency | Percentage |
|---|---|---|
| Yes | 0 | 0 |
| No | 11 | 100.0 |
| Total | 11 | 100.0 |



Appendix 32: Source of finance for wholesalers

| Source of funding | Average amount obtainedin 2011 | Repayment period | Interest rate |
|---|---|---|---|
| Bank | 2000 | 1 year | 26.50 |
| Own savings | 3300 | | |
| Money lender | | | |
| Relations | 1000 | | |
| N G Os | | | |
| Government agency | | | |
| Other(specify)……. | | | |

Appendix 33: Major activities of wholesalers and their estimated costs

| Operation | Mandays used | Rate / manday GH¢ | Cost GH¢ |
|---|---|---|---|
| Harvesting | | | |
| Carting | | | |
| Heaping | | | |
| Sorting | 4 | 10 | 40 |
| Grading | | | |
| Packaging | | | |
| Loading | 5 | 8 | 40 |
| Transportation | 1 | 400 | 400 |
| Assembling | 4 | 8 | 32 |



**FRUIT MANAGEMENT BY WHOLESALERS**

Appendix 34: Number of days of keeping fruits in the wholesale market

| Location | Number of days of storage | Estimated loss(%) |
|---|---|---|
| Heaping before transportation to market centre | 2 | 10.0 |
| in the vehicle | 1 | 6.0 |
| heaping at the market centre | 3 | 9.0 |

Appendix 35: Protection giving fruits at the wholesale market

| | Frequency | Percentage |
|---|---|---|
| Yes | 3 | 27.3 |
| No | 8 | 72.7 |
| Total | 11 | 100.0 |



Appendix 36: Mode of transportation of fruits from the farm to the market

| Vehicle | Number of days to offload | Frequency | Percentage | Estimated loss(%) |
|---|---|---|---|---|
| Trucks (covered) | 0 | | | |
| Trucks (open) | 1 | 11 | 100 | 8.0 |
| Mini buses | 0 | | | |
| Taxis | 0 | | | |

Appendix 37: Causes injuries to your fruits at the wholesale market

| Causes of injuries | Frequency | Percentage |
|---|---|---|
| Insect damage | 3 | 9.0 |
| Poor road network | 10 | 27.3 |
| Poor handling (loading and offloading) | 6 | 18.2 |
| Over loading | 6 | 18.2 |
| Heat build up | 10 | 27.3 |
| Total | 35 | 100 |



Appendix 38: Ways of preventing or minimizing injuries to fruits at the wholesale market.

| | Frequency | Percentage |
|---|---|---|
| insect control on the field | 7 | 18 |
| Improved road transportation | 8 | 21 |
| Careful fruit handling | 8 | 21 |
| Spreading of fruits | 5 | 15 |
| Provision of shed at the market | 10 | 25 |
| Total | 24 | 100 |

Appendix 39: In-depth Study Data from Farm 1 (Farmer Level)

Name of Farmer: Noah Owusu Location: AmuanaPraso

Farm Size: 1 acre Year Planted: 1997

Date Harvested: 18/1/2012 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 644 | 74 | 718 |
| TREE 2 | 802 | 58 | 860 |
| TREE 3 | 875 | 106 | 981 |
| TREE 4 | 759 | 39 | 798 |
| TREE 5 | 1217 | 64 | 1281 |
| TREE 6 | 922 | 52 | 974 |
| TREE 7 | 653 | 48 | 701 |
| TREE 8 | 718 | 32 | 750 |
| TREE 9 | 574 | 51 | 625 |
| TREE 10 | 776 | 46 | 822 |
| TOTAL | 7940 | 570 | 8501 |

Estimated number of fruits rejected on the farm: 6270

Total number of fruits heaped: 38,582

Total number of fruits selected from the heap to the market: 36,927

Total number of fruits rejected from the heaped fruits: 1655

Date fruits were loaded: 22/7/2012

Appendix 40: In-depth Study Data from Farm 1 (Wholesaler Level)

Name of Wholesaler:YaaAnimah Market location: Madina Market

Date Sales Begun: 23/1/2012 Date Sales was completed: 26/1/2012

Name of farmer: Noah Owusu Enumerator: OseiDarko

Total number of fruits transported from field to market: 36,927

| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 8700 | 112 |
| 2 | 14200 | 318 |
| 3 | 7400 | 353 |
| 4 | 4700 | 495 |
| TOTAL | 35000 | 1278 |

Number of fruits lost in transit: 649

Appendix 41: In-depth Study Data from Farm 2 (Farmer Level)

Name of Farmer: Daniel Ansong Location: Amanfokrom

Farm Size: 1acre Year Planted: 2002

Date Harvested: 14/12/2011 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 816 | 104 | 920 |
| TREE 2 | 806 | 128 | 934 |
| TREE 3 | 443 | 33 | 476 |
| TREE 4 | 372 | 67 | 439 |
| TREE 5 | 1008 | 39 | 1047 |
| TREE 6 | 712 | 28 | 740 |
| TREE 7 | 914 | 22 | 936 |
| TREE 8 | 1118 | 86 | 1204 |
| TREE 9 | 412 | 20 | 432 |
| TREE 10 | 1306 | 74 | 1380 |
| TOTAL | 7907 | 601 | 8508 |

Estimated number of fruits rejected on the farm: 6611

Total number of fruits heaped: 34,471

Total number of fruits selected from the heap to the market: 32,019

Total number of fruits rejected from the heaped fruits: 2452

Date fruits were loaded: 7/12/2011

Appendix 42: In-depth Study Data from Farm 2 (Wholesaler Level)

Name of Wholesaler:FaustinaOfosua Market location: Agbogbloshie

Date Sales Begun: 8/12/2011 Date Sales was completed: 9/12/2011

Name of farmer: Daniel Ansong Enumerator:Akyem-Peprah

Total number of fruits transported from field to market: 33881



| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 27500 | 1381 |
| 2 | 3784 | 544 |
| TOTAL | 31284 | 1862 |

Number of fruits lost in transit: 435

Appendix 43: In-depth Study Data from Farm 3 (Farmer Level)

Name of Farmer: Joseph Wiafe Location: Afosu

Farm Size: 1acre Year Planted: 1997

Date Harvested: 10/1/2012 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 1024 | 76 | 1100 |
| TREE 2 | 682 | 53 | 735 |
| TREE 3 | 806 | 42 | 848 |
| TREE 4 | 626 | 49 | 675 |
| TREE 5 | 784 | 39 | 823 |
| TREE 6 | 815 | 106 | 921 |
| TREE 7 | 653 | 71 | 724 |
| TREE 8 | 947 | 51 | 998 |
| TREE 9 | 457 | 32 | 489 |
| TREE 10 | 673 | 57 | 730 |
| TOTAL | 7467 | 576 | 8043 |

Estimated number of fruits rejected on the farm: 6,336

Total number of fruits heaped: 38,439

Total number of fruits selected from the heap to the market: 36,726

Total number of fruits rejected from the heaped fruits: 1,713

Date fruits were loaded: 14/1/12

Appendix 44: In-depth Study Data from Farm 3 (Wholesaler Level)

Name of Wholesaler:AbenaDonkor Market location: Koforidua

Date Sales Begun: 16/1/12 Date Sales was completed: 19/1/12

Total number of fruits transported from field to market: 36,726



| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 15,600 | 216 |
| 2 | 12,200 | 452 |
| 3 | 7200 | 383 |
| TOTAL | 35,000 | 1051 |

Number of fruits lost in transit: 675

Appendix 45: In-depth Study Data from Farm 4 (Farmer Level)

Name of Farmer: Charlotte Amanor Location: Nyafoman

Farm Size: Iacre Year Planted: 2002

Date Harvested: 7/1/2012 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 465 | 32 | 497 |
| TREE 2 | 618 | 84 | 702 |
| TREE 3 | 742 | 49 | 791 |
| TREE 4 | 273 | 56 | 329 |
| TREE 5 | 558 | 51 | 609 |
| TREE 6 | 271 | 24 | 295 |
| TREE 7 | 803 | 47 | 850 |
| TREE 8 | 729 | 61 | 790 |
| TREE 9 | 497 | 76 | 573 |
| TREE 10 | 392 | 22 | 414 |
| TOTAL | 5348 | 502 | 5850 |

Estimated number of fruits rejected on the farm: 5522

Total number of fruits heaped: 29,458

Total number of fruits selected from the heap to the market: 28,234

Total number of fruits rejected from the heaped fruits: 1224

Date fruits were loaded: 12/1/2012

Appendix 46: In-depth Study Data from Farm 4 (Wholesaler Level)

Name of Wholesaler: AbenaDonkor Market Location:Koforidua

Date Sales Begun: 13/1/2012 Date Sales was Completed: 16/1/2012

Total number of fruits transported from field to market: 28234

| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 9300 | 113 |
| 2 | 14200 | 257 |
| 3 | 3200 | 612 |
| TOTAL | 26700 | 982 |

Number of fruits lost in transit: 652

Appendix 47: In-depth Study Data from Farm 5 (Farmer Level)

Name of Farmer: KwabenaAdofo Location: Akrofonso

Farm Size: 1 acre Year Planted: 2002

Date Harvested: 14/12/2011 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 258 | 34 | 292 |
| TREE 2 | 265 | 31 | 296 |
| TREE 3 | 256 | 63 | 319 |
| TREE 4 | 722 | 73 | 795 |
| TREE 5 | 641 | 70 | 711 |
| TREE 6 | 672 | 34 | 706 |
| TREE 7 | 178 | 24 | 202 |
| TREE 8 | 623 | 60 | 683 |
| TREE 9 | 580 | 88 | 668 |
| TREE 10 | 758 | 29 | 787 |
| TOTAL | 4953 | 506 | 5459 |

Estimated number of fruits rejected on the farm: 5566

Total number of fruits heaped: 24708

Total number of fruits selected from the heap to the market: 23061

Total number of fruits rejected from the heaped fruits: 1647

Date fruits were loaded: 17/12/2011

Appendix 48: In-depth Study Data from Farm 5 (Wholesaler Level)

Name of Wholesaler: David Asare Market location: Madina

Date Sales Begun: 18/12/2011 Date Sales was completed: 20/12/2011

Total number of fruits transported from field to market: 23061



| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 7400 | 102 |
| 2 | 8900 | 138 |
| 3 | 6300 | 221 |
| TOTAL | 22600 | 461 |

Number of fruits lost in transit: 404

Appendix 49: In-depth Study Data from Farm 6 (Farmer Level)

Name of Farmer: AgyenimBoateng Location: Prasokuma

Farm Size: 1 acre Year Planted: 1997

Date Harvested: 3/12/2011 Enumerator: Akyem-Peprah

| TREE NUMBER | NUMBER OF SELECTED GOOD FRUITS | NUMBER OF FRUITS REJECTED | TOTAL NUMBER OF FRUITS HARVESTED |
|---|---|---|---|
| TREE 1 | 953 | 71 | 1024 |
| TREE 2 | 712 | 63 | 775 |
| TREE 3 | 904 | 78 | 982 |
| TREE 4 | 792 | 57 | 849 |
| TREE 5 | 655 | 46 | 701 |
| TREE 6 | 806 | 82 | 888 |
| TREE 7 | 1102 | 86 | 1188 |
| TREE 8 | 574 | 83 | 657 |
| TREE 9 | 918 | 75 | 993 |
| TREE 10 | 671 | 54 | 725 |
| TOTAL | 8087 | 695 | 8782 |

Estimated number of fruits rejected on the farm: 7645

Total number of fruits heaped: 40946

Total number of fruits selected from the heap to the market: 38140

Total number of fruits rejected from the heaped fruits: 2806

Date fruits were loaded: 8/12/2011

Appendix 50: In-depth Study Data from Farm 6 (Wholesaler Level)

Name of Wholesaler: Esther Larbi Market Location: Tema Community 1 Market

Date Sales Begun: 9/12/2011 Date Sales was Completed: 11/12/2011

Total number of fruits transported from field to market: 38140

| DAY | NUMBER OF FRUITS SOLD | NUMBER OF FRUITS REJECTED |
|---|---|---|
| 1 | 8800 | 818 |
| 2 | 17200 | 1203 |
| 3 | 9000 | 762 |
| TOTAL | 35000 | 2783 |

Number of fruits lost in transit: 357

**Appendix 51: Sample of Questionnaire Used**

Community:…… District: ……..

Interviewer: …….Date:……

Type of stakeholder (Check): Farmer ( ) Wholesaler ( )

**A/ PROFILE OF RESPONDENT**



A1.Name:……

A2.Age: (check as appropriate)

20-29 years( )

30-39 years ( )

40-49 years ( )

50-59years( )

60years and above( )

A3.Sex: (Tick) Male ( ) Female ( )

A4. Religion: Christian ( ) Islam ( ) Traditional Religion ( ) Others ( )

A5.Status in community: Indigene ( ) Migrant ( )

A6.Highest academic qualification: No formal( )

Basic (Pri/MSLC/JHS)( )

Secondary (SHS/Voc/Tech( )

Tertiary ( )

Other(specify)…….( )

A7.Marital status Single ( ) Married ( ) Divorced ( ) Separated () Widowed ( )

A8. Number of dependents: ……

B/ **OCCUPATIONAL INFORMATION**

B1. Occupation: Primary: ……..Others: ……

B2. Which is the major income earner:……

B3. Apart from citrus what other produce do you deal in? .....



B4. What are the main sources of your income?

| Source | Percentage of total income |
|---|---|
| Citrus | |
| Other tree crops | |
| Non farming | |
| Remittances | |
| Food crops | |

B5. Why are you in citrus production (benefits)?

I.……

II.……

III.……

IV.……

B6. What are some of the challenges in citrus production?

I.……

II.……

III.……

IV……

B7. How did you dispose off (market) your harvested fruits during the major harvest season?(December 2011-March 2012)

| Outlet | Quantity(numbers) | Percentage of total harvest | Value(GH¢ |
|---|---|---|---|
| Wholesalers | | | |
| Retailers | | | |
| Processors | | | |
| Home/gifts | | | |
| Pilfering | | | |
| Post harvest loss | | | |
| Total | | | |

B8. How did you dispose off (market) your harvested fruits during the minor harvest season? (August 2011-October 2011)

| Outlet | Quantity(numbers) | Percentage of total harvest | Value(GH¢) |
|---|---|---|---|
| Middlemen | | | |
| Wholesalers | | | |
| Retailers | | | |
| Processors | | | |
| Home/gifts | | | |
| Pilfering | | | |
| Post harvest loss | | | |
| Total | | | |

**C/PRODUCTION INFORMATION**

C1. What is the size of your farm ?

| Farm | Acreage |
|---|---|
| 1. | |
| 2. | |
| 3. | |
| 4. | |
| 5. | |



C2.Have you had any training on citrus production? Yes ( ) No ( )

C3.If the answer to C2 is yes, provide the relevant information in the table below

| Type of training | *Institution that provided the training ( use the key below to answer this column ) | Year of training | Cost to you |
|---|---|---|---|
| Land preparation | | | |
| Planting | | | |
| Tree management | | | |
| Harvesting | | | |
| Post harvest management | | | |
| Marketing | | | |
| Other(specify) | | | |

*Key

ADRA- 1 Processing companies-3 Other NGOs-5

MOFA-2 Research institutes-4 Other farmers-6

C4. How did you finance your citrus business activities last year?

| Source of funding | Amount obtained in 2011 | Repayment period | Interest Rate |
|---|---|---|---|
| Bank | | | |
| Own savings | | | |
| Money Lenders | | | |
| Middle men | | | |
| Relations | | | |
| N G Os | | | |
| Ploughed back profits | | | |
| Government agency | | | |
| Others(specify)…… | | | |

C5. What are the major activities and their estimated costs in your operations?

| Operation | Mandays used | Rate/manday | Cost(GHC) | Estimated losses (%) |
|---|---|---|---|---|
| Harvesting | | | | |
| Carting | | | | |
| Sorting | | | | |
| Loading | | | | |
| Transportation | | | | |
| Assembling | | | | |
| Distribution | | | | |



C6. Which of the following management practices did you practice last year?

| Practice | Record 1 if practiced and 2 if not | *Frequency(use key below) | Cost per acre( GH¢) |
|---|---|---|---|
| Weed control | | | |
| Fertilizer /manure application | | | |
| Pest control | | | |
| Disease control | | | |
| Pruning | | | |

| | | | |
|---|---|---|---|
| Removal of mistletoes | | | |
| Other(specify) | | | |

*Key

Once a year -1

Twice a year-2

Three times a year-3

More than three times-4



C7. In what condition do you consider a citrus fruit to be substandard?

I. _____

II. _____

III. _____

IV. _____

V _____

VI _____

C8.What factors influence the quality of citrus fruits?

I._____

II._____

III._____

IV_____

V. _____

**D/FRUIT MANAGEMENT**

D1.Which month(s) did you harvest your fruits in the current season?

……

D2. How do you harvest the fruits?

| Method | Mark 'X' as appropriate | Estimated loss(%) |
|---|---|---|
| Shaking of tree | | |
| Pulling fruits with hooks | | |
| Plucking and catching | | |
| Other(specify | | |

D3.How long did you keep the fruits in the locations below?

| Location | Number of days of storage | Estimated loss(%) |
|---|---|---|
| On the farm | | |
| Heaping before transportation to market centre | | |
| In the vehicle | | |
| Heaping at the marketcentre | | |
| Others(specify) | | |

D4.Do you protect your harvested fruits from the sun? Yes ( ) No ( )

D5. If yes how?

| Material | Mark‘X’ as appropriate | Number of days covered |
|---|---|---|
| Covering with fresh leaves | | |
| Covering with dry leaves | | |
| Polythene sheets | | |
| Other( specify) | | |



D6. How do you transport the fruits from the farm to the market?

| Method | *Number of days to offload ( use the key below to answer this column ) | Estimated loss (%) |
|---|---|---|
| Trucks(covered) | | |
| Trucks(open) | | |
| Minibuses | | |
| Taxi | | |
| Head loading | | |
| Wheel barrow | | |
| Other(specify) | | |

Key

Same day-1Three days-3

Two days-2More than three days-4

D7. What causes injuries to your fruits?

I……

II……

III……



IV……

V……

D8. How may these injuries be prevented or minimized?

I……..

II……

III……

IV……

V……