KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

INSTITUTE OF DISTANCE LEARNING

DEPARTMENT OF HORTICULTURE

EVALUATION OF POST HARVEST HANDLING AND MARKETING OF MANGO (*Mangifera indica)* IN GHANA (A CASE STUDY IN NORTHERN REGION)

BY

AKURUGU GORDEN KWABENA

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A Thesis submitted to the Department of Horticulture, Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree

Of

MASTER OF SCIENCE (POSTHARVEST TECHNOLOGY)

BY

AKURUGU GORDEN KWABENA

NOVERMBER, 2011

DECLARATION

I certify that all the work contained in this dissertation in my own except references made to other people work which has duly acknowledged, and that this research has not been submitted before for any degree in any university or college.

AKURUGU GORDEN .K …… …….

(PG 3120409) SIGNATURE DATE

CERTIFY BY:

DR. (MRS) N S. OLYMPIO …… …….

(SUPERVISOR) SIGNATURE DATE

CERTIFY BY:

DR.B.K. MAALEKUU …… …….

(HEAD OF DEPARTMENT) SIGNATURE DATE

DEDICATION

“This thesis is dedicated to my beloved sister, husband and son, Mr. and Mrs. Amalba and Kelvin and my wife Mrs. Emelia Akurugu and daughter Natlie Akurugu.

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I wish to acknowledge God most high as the ultimate sources of all wisdom and providence and guidance in this work that has been completed. May blessed be His name forever.

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My sincere thank go to my wife Mrs.Emelia Akurugu and daugther Natlie Akurugu for their support , cooperation and sacrifice during time of challenges

ABSTRACT

A survey was conducted in the Northern Region of Ghana to evaluate the postharvest handling of mango fruits from the farm gate to the market. Data from the survey were analyzed using Statistical Package for Social Sciences (SPSS) version 17 to determine the factors that contribute to postharvest losses of mango fruits in the region. The study revealed that the varieties being cultivated by the farmers in the Region for both export and local markets were; Keitt, Amelie, Kent and Zill. It was also realized that sellers purchase these varieties at the full ripe stage, therefore compelling farmers to harvest at that stage and causing fruits to deteriorate faster. Besides both the farmers and sellers store the harvested mango fruits in baskets, boxes, spread on floor or heaped on the ground, which causes fruit to senescence early. The causes of postharvest losses in the Northern region among mango farmers and sellers were found out to be poor harvesting practices, storage and packaging methods. The results also showed that anthracnose disease affect the matured fruits on the field especially Keitt, which compelled majority of the farmers to remove the plants from their fields. The findings and recommendations of the study will therefore help address the postharvest handling of mango fruits in the Region.

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CHAPTER ONE

1.0 INTRODUCTION

The mango fruit (*Mangifera indica* L.) is one of the most popular fruit in many countries among millions of people in the world. In the tropical areas, it is considered to be the choicest of all indigenous fruits. Mango as an emerging tropical fruit is produced in over 90 countries worldwide with a production of over 28.51 million metric tonnes in 2005. Asia accounts for approximately 77% of global mango production, and the Americas and Africa account for approximately 13% and 9%, respectively (FAOSTAT, 2007). Currently, only about 3% of the world production of mango is traded globally representing a noticeable increase over the quantities traded 20 years ago (Evans, 2008).

The plant is an evergreen tree grown throughout subtropical and tropical regions. It is considered to be the oldest and best in the world market (Singh, 1960).

Mango belongs to the Anacardiaceae family to which cashew nut and some other fruit crops belong (Samson, 1986). The genus is a native to South-East Asia and consists of 62 species. About 16 of these have edible fruits but apart from mango, only *M. caesia, M. foetida and M. odorata* are regularly eaten, although they strongly taste of turpentine (Samson, 1986).

The name *Mangifera indica*, assigned by Linne, suggests an Indian origin but this is not at all certain. It is more likely that the origin lies in the Burma-Malesian region. Yet the name is appropriate, as this fruit has been cultivated in India for more than four hundred years (Samson, 1986). From here it spread to other countries in the region. Persian sailors took it to East Africa, probably in the tenth century A.D. and Portuguese travellers in the 16 century brought the mango to West Africa and South America. Since then the mango has been introduced into every tropical country in the world.

According to Kaur *et al* (1980) the mango tree is believed to have evolved as canopy layer in the tropical rainforest of Southeast Asia. Mature trees attain heights of up to 30 meters and can survive for more than hundred years. It is an evergreen tree with alternate, oblong ovate leaves that are spirally arranged. Young leaves are characteristically pink to red in colour but become dark green and leathery during development. Older leavers are 12-15cm in length. The inflorescence is erect and widely branched with hundreds of small flowers also pink to red in colour and 6-8mm in diameter. Both female and male flowers are found within a single inflorescence. The pollination is done by insects, in particularly flies (Singh *et al.,* 1962, Jiron and Hedstrom, 1985)

Mango grows in a slightly acidic (5.5-7.5) and well-drained soil, whether it is sandy, loam or clay (Young *et al.,* 1965). It is somewhat tolerant to alkalinity (Kadman *et al.,* 1976). Mango is also drought-tolerant, and can withstand occasional flooding (Singh, 1960). For best flowering and fruit set, good timely rainfall is necessary rather than the total rain fall. Temperature plays an important role in mango flowering and its influence varies with cultivars (Schaffer *et al.,* 1994). Temperatures in the range of 24-30 °C are required for best flowering; however, during fruit development if sufficient water is provided the tree can withstand up to 48 °C. Flower deformation and loss of pollen viability can occur at low temperatures (Popenoe, and long 1957; Issarakraisila *et al*., 1992). Cold temperatures can also limit the growth of the plant and can cause damage or even kill young trees; while it has been reported that older trees can endure up to –4 °C for a few hours with limited damage (Crane and Campbell, 1991)

Mango grows best in the warm climates of the tropics and subtropics. Temperatures between 24 an 28 C are considered to offer the optimum conditions (Krishnamurti *et al*., 1961) A minimum annual rainfall of 1000 mm is required for growth and development,

although the tree is able to resist dry periods for months, extreme humid conditions and temperatures under 0 C is less tolerated.

The development of mango buds is strongly influenced by temperature (Ravishankar *et al*., 1979; Schaffer *et al.,* 1994). Night temperatures between 8 an 15 °C in combination with daytime temperatures below 20 °C typically induce flowering (Ou, 1980; Nunez-Elisea and Davenport, 1994).In the absence of cool temperatures in the tropics, mango trees produce flowers following a drought of 6-12 weeks or more (Pongsomboon, 1991), although it is believed that the primary impact of water stress is to prevent vegetative flushing. Vegetative shoots develop in warm, humid conditions (30 °C day, 25 °C night)

One of the keys to improving mango production in Africa is the identification of cultivars which have good flavour and low fibre content and yet will grow under local conditions. The most important varieties worldwide are, Alphonoso, Haden, Kent, Mulgoba, Pathiri, Neelam, Raspuri and Totapuuri (Kranz , 1981)

In Ghana, fruits and vegetables are abundantly produced during peak seasons but due to lack of proper storage and preservation facilities, the market becomes overstocked during such seasons and a large proportion get rotten before reaching the final consumer. Alzamora *et al*., (2000) has reported that about 30-50% of fruits and vegetables harvested in developing countries including Ghana are never consumed due to spoilage during transportation, storage and processing.

The reduction of post-harvest food losses is a complementary means for increasing food production. This draws its importance not only from a moral obligation to avoid waste, but also because the cost of preventing food losses in general is less than producing a similar amount of food of the same quality. Mango cultivation represents one area within the

horticultural sector which if well developed and provided with the necessary logistics and support can easily become a major foreign exchange earner. This is because the country has the natural conditions that can position the crop as a top export product.

Inhabitants in these areas derive their essential vitamins from green leafy vegetables which are usually scarce during the dry season. At the same period the leafy vegetables are scarce, the mango fruits are also not in season.

In Ghana, mango fruits are primarily consumed in the fresh state usually as dessert and sometimes as a fruit drink or juice.

Consumers tend to prefer fresh fruits and vegetables rather than processed or canned food and postharvest losses of fresh fruits and vegetables are one of the major problems of the food industry (Borrud *et al.*, 1996). Surveys have revealed that a substantial portion of the harvest is wasted annually due to improper harvesting and postharvest practices, disease and lack of facilities and technology to extend storage life. Postharvest losses have been estimated in developed countries to range from 5-25 % while in developing countries it is 20-50 %, depending upon the commodity (Kader, 1992). This continues to cause heavy losses in revenue for the grower, wholesaler, retailers and exporters.

World trade in fresh mango fruit is restricted by the highly perishable nature of this climacteric fruits (Lizada, (1993); Mitra and Baldwin, (1997), that displays characteristic peak of respiratory activity during ripening (Tucker, 1993). Postharvest losses not only reduce the availability of mango, but also result in increase in per unit cost of transport and marketing (Subrahmanyam, 1986).

Thus evaluation of postharvest handling of mango fruits at various stages of the chain would help in identifying the factors responsible for losses. This is in turn would help in

developing measures required at different stages to prevent or reduce such losses and to increase the availability of mango fruits in the Northern region for domestic consumption and export market

The project is therefore aimed at evaluating the major Postharvest handling problems associated with Mango (*Mangifera indica L)* fruits from the farm gate to the market, in the Northern Region of Ghana.

The specific objectives of the project are to

- Evaluate the postharvest handling of mango in Northern Region.
- Identify the major problems facing the postharvest handling of the fruit.
- Study the effect of postharvest handling on the marketing of mango in the Northern Region and to

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 MANGO DISTRIBUTION AND PRODUCTION

Between 1971 and 1993, the production of mango (*Mangifera indica L.),* worldwide, has increased by nearly 50% (F.A.O. 2003). Much of this new production has occurred outside the traditional centers of mango cultures, in South and Central America, Africa and Australia and a significant proportion of the new mango production is for export markets. The high esteem in which this fruit has always been held in Asia, where mango has been cultivated to be the king of fruits (Purseglove, 1969), is now apparently true for much of the world.

Mangoes are now widely available as fresh fruit and in the form of frozen and processed products, not only in the tropics and subtropics, but also year-round in North America, Japan and Europe. India has the largest mango cultivation area by far, about one million hectares (Samson, 1986). Cultivation is also widespread in Pakistan, Bangladesh and other countries of the South-East Asia. The southern sahel is well suited to mango culture and commercial cultivation of the produce are found in Israel, Florida (USA), Mexico, Queensland and Egypt. In Africa, the mango has become naturalized due to germinating discarded seeds and are produced from seedlings fruits which are strongly flavoured. Fruits are seasonal and are consumed locally with a small quantity being exported. Where high-quality improved cultivars are grown some exportation, primarily to Europe, does occur. African exporters of mangoes include Kenya, Malagasy, Mali, Senegal, Congo, Burkina Faso, Cote D'Ivoire and Southern African countries (Rice *et al*., 1987).

In Ghana the crop does well in savannah and transitional areas, high potential production areas include Central, Greater Accra, Eastern, Volta and Northern regions. The crop is cultivated by both small and large-scale holders with reasonable proportion of the crop growing in the wild. It is estimated that the cropping area for mango crop area in 1997 was about 879 hectares (See Table 1). These include exotic, local and mixed varieties. About 60 % of the total area (527 hectares) beared matured fruits in 1997 thus giving an annual total production of 5,797 mt. In Tables 1 and 2 are the production estimates for 1997 and the subsequent four years.

Table 2.0: Projected Production Estimates of Mango in Ghana (1997)

	YEAR				
	1997	1998	1999	2000	2001
Area (ha)	879	1,010	1,172	1360	1578
Area(ha) bearing	527	606	703	816	947
Production (mt)	5,797	6,680	7,730	8,970	10,417

Source: MOFA Survey Results on selected non – traditional crops in Ghana 2000

Table 2.1 Estimated 1997 Mango Crop Area by Region in Ghana

Region	Estimated Cultivated Area (In Hectares)
Brong-Ahafo	39
Ashanti	37
Central Eastern	147
Greater Accra	133
Northern	218
Upper East	78
Upper West	69
Western	62
Volta	32
Eastern	64
Total	879

Source: MOFA Survey Results on selected non – traditional crops in Ghana 2000

Table 2.2 .The Major Producers of Mango Worldwide (x 1,000 tonnes) Year

Country	1975	1980	1981	1982	1983	1984
India	8,500	8,363	8,516	8,500	8,700	8,919
Mexico 3	89	581	620	663	665	670
Brazil	615	530	560	600	600	520
Pakistan	605	550	550	552	683	683
Philippine	250	374	380	390	550	550
Indonesia		345	444	340	344	360
China	203	276	341	338	353	387
Haiti	278	362	330	355	340	340
Bangladesh	284	207	203	203	182	185
World	12,664	13,091	13,507	13508	13954	14,213

SOURCE: FAO Production Year book 1982

2.2 DISEASES AND PESTS

Anthracnose disease caused by *Colletotrichum gloeosporioides* is one of the major common diseases for pre-and postharvested fruits and is associated with high rain fall and humidity (Fitzell and Peak, 1984; Jeffries *et al.,* 1990). Alternaria rot or black spot is another postharvest fruit disease, which infects fruits during ripening. Anthracnose (Figure 1.1) Stem end rot (Figure 1.2), black mould rot, bacterial black spot are common postharvest fruit diseases which can be prevented by using certain chemicals, or proper postharvest fruit treatment.

There are a number of fungi which attack mango fruit at their mature stage during storage and transit: *Pestalotiopsis Mangifera* (Figure 1.3*), Colletotrichum gloeosporioides* Figure 1.4), *Ceratocystis fimbriata* , *Gloeosporium* species, *Dothiorella ribis*, *Penicillium*, and *Cladiosporium* are some fungi which commonly infect mango fruits. Bactrocera dorsalis, *Ceratitis capitata, Anastrepha* suspense and *Diaschamimorpha longicaudata* are common flies which can damage fruit

Figure 2.0. Tear shape pattern of anthracnose In mango (from APS digital image)

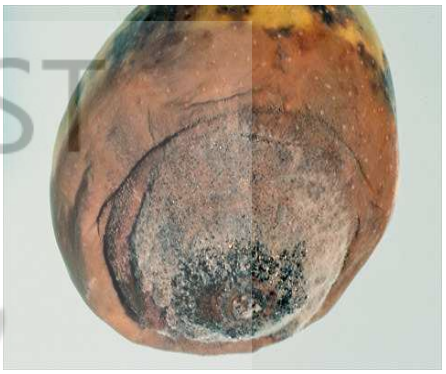

Figure 2.1: Stem end rot in mango. disease (from APS digital image collection, 2001)

Figure 2.2: Whitish gray lesion on mango mango leaf caused by *Pestalotiopsis.*

Figure 2.3 Typical anthracnose on lesion caused by *Colletotrichum gloeosporioides*

For fresh mango fruit to be accepted by market, it has to be treated to ensure that it is free of fruit flies. Disinfestations can be done by chemical fumigation, or by non- chemical treatment, which consists of heating the fruits to specific temperature and maintaining this temperature for a defined period of time which could kill fly larvae and eggs. Vapour heat treatment (VHT), forced hot air treatment (FHAT), and hot water (HW) immersion are commonly used heat treatments for mango fruit (Esguerra and Lizada, 1990)

2.3 HARVESTING

Mangoes are usually harvested green. Harvesting usually takes place after 15-16 weeks of fruit set when they are physiologically matured (Lakshminarayana *et al.*, 1970). Later harvesting may result in uneven ripening, and can lower sugar to acid ratio. There is no particular parameter for judgment of fruit maturity; it depends on mango type, variety, production conditions, and location. Physical, chemical, and physiological parameters are used to define the maturity stage for harvesting of fruits. Useful chemical parameters are acidity, soluble solid content, phenolic constituents, and carbohydrate content. Physical parameters are size, shape, surface colour, pit around the pedicel, lenticels and specific gravity (Popenoe and Long, 1957; Krishnamurthy and Subramanyam, 1970; Ketsa *et al.*, 1991). Physiological maturity shows changes in the pulp colour, breaking to yellow, hence it can be tested by slicing a fruit before harvesting. An ancient advice for mango harvesting says that, when first fruits begin to drop, the crop is ready for picking. Usually harvesting is done by hand. Sometimes a long picking pole, ladder or hydraulic lifts are used to pick the fruits from tall trees (Singh, 1960).

Picking of fruits begins from the lower side of the tree just to avoid sap oozing on the fruit below. At the time when mango is fully-grown and ready for picking, the stem will snap

easily with a slight pull. If a strong pull is necessary, then the fruit is still fairly immature and harvesting should be delayed (Ram Prakash, 1998). Some cultivars require multiple picking as not all the fruits mature at the same time. Usually fruits are picked with approximately 4-inch (10 cm) stem to avoid the spurt of milky/resinous sap; because in some cultivars it causes sap burn on skin of any fruit with which they comes into contact (Waskar *et al.,* 1997). The fruits are then placed in field crates and after desapping, which can be done by breaking off the fruit stalk; they are placed stem-end-down to cease the flowing sap.

2.4 POSTHARVEST HANDLING

Mango being a highly perishable fruit possesses a very short shelf life and reach to respiration peak of ripening process on third to fourth day after harvesting at ambient temperature (Narayanan *et al.,* 1996). The shelf life of mango varies among its varieties depending on storage conditions. This short Shelf life seriously limits the long distance commercial transport of this fruit (Gomer-Lim, 1997).

Usually after harvesting the ripening process in mature green mango takes nine to twelve days (Herianus *et al,* 2003). The ripening process in the fruit involves a series of biochemical reactions resulting from increased respiration, ethylene production, changes in structure of polysaccharides causing fruits to soften, degradation of chlorophyll, pigment developing by carotenoids biosynthesis, change in carbohydrates or starch conversion into sugars, organic acids, lipids, phenolics and volatile compounds (Herianus *et al,* 2003). Fruit sensitivity to decay , low temperature and general fruit perishability due to the rapid ripening and softening limits the storage, handling and transport potential (Hoa *et al*, 2002). Because of this when mango fruit are exported to distant markets around the

world, they are often subjected to various postharvest treatment (cold storage, modified atmosphere, controlled atmosphere, thermal quarantine, fungicidal spray, etc,.) intended to lengthen their shelf life and prevent the spread of invasive pest that cause economic and environmental harm..

Statistically, Postharvest losses have been generally estimated in developed countries, in fruits to range from 5 to 25% while in developing countries it is 20 to 50% depending upon the commodity (Kader, 1992). This continues to cause heavy losses in revenue for the grower, wholesaler, retailers and exporters of mangoes.

Most of the postharvest technologies for mangoes have been developed for controlling diseases and insects and for protection against injury during packaging and transport. Mangoes have poor storage qualities and technologies for longer term storage, such as controlled or modified atmospheres which are known have not been applied successfully to mango storage (Litz, 1997). This is because mangoes are not stored at the right maturity level thereby inducing ripening processes. Storage methods for mangoes have been characterised by variable results and the occurrence of physiological disorders (Chaplin, 1989). The practices relating to the storage of mangoes should therefore be given maximum attention to increase the shelf life and maintain quality

The trade of mango has been significantly limited due to their short shelf life and highly perishable nature (Gil *et al.*, 2000). Harvest maturity and postharvest storage conditions are commonly altered to lengthen the shelf life of fruit for extended markets. Time of harvest, storage temperature and atmospheric conditions are all key factors in postharvest physiology of fruit. As climacteric fruits, mangoes are harvested at a mature, unripe (green) stage as they will naturally ripen off the tree. Harvesting mangoes prematurely, however, will prevent fruit from reaching full ripeness. Harvesting fruit at stages beyond

mature green will also reduce their shelf stability and shorten their fresh market life. Kalra *et al.* (1995) reported that mature ripe mangoes perished within 6 days under ambient conditions.

According to Rathore (2007) the quality of mangoes are highly influenced by postharvest handling techniques due to its high perishable nature and its susceptibility to postharvest disease, extremes of temperature and physical injury. Further Mangoes thus have short shelf life and reaches respiration peak of ripening process between three (3) to four (4) days after harvest at ambient temperature. This seriously limits commercialization of mango fruits in distant markets hence, mangoes have to be consumed soon after harvest or given the proper storage conditions.

On the effect of maturity on transportation and storage of mango, Mitra and Baldwin (1997) states that generally, fruits designated to local markets or shipments by air (a three-day marketing frame) are harvested after the colour break or medium-ripe and fruits intended for longer transportation distances or storage (8–10 days) are in general harvested firm and green, but physiologically mature. However, improper handling and inadequate transport and storage conditions result in poor quality of the fruits, and limit mango marketability.

The above assertion appears to reflect the study of Malik *et al.* (Eds) 2005 who reviewed that 25 - 30% of mango produce is lost due to improper postharvest operations; as a result there is considerable gap between the gross production and net availability. The authors further suggested that if proper care is taken from harvesting to final marketing, considerable losses can be minimized and better quality fruit can reach consumers, ensuring higher returns to the producers

2.5 STORAGE OF FRUIT

The basic concept of storage is to extend the shelf life of products by storing them in appropriate conditions to maintain their availability to consumers and processing industries in their usable form. They can either be stored naturally in the field, or in built storages (Pantastico *et al*., 1975; Gariépy &Raghavan, 1985 and). In natural storage the product is left in the field and harvesting is delayed, while in artificial storage favorable conditions are provided which help to maintain product freshness and nutritional quality for a longer period.

2.5.1 EFFECT OF TEMPERATURE ON STORAGE CONDITIONS OF MANGO

Lee and Kader (2000) state that, temperature management after harvest is the most important factor to maintain vitamin C of fruits and vegetables. They further stated that vitamin C losses are accelerated at higher temperatures and with longer storage durations. They report that the loss of vitamin C after harvest can be reduced by storing fruits and vegetables in reduced oxygen and or up to 10% carbon dioxide atmospheres, with higher levels of carbon dioxide accelerating vitamin C loss.

Jobling (2000) also reports that temperature management is essential for maintaining produce quality. The author further explained that the ideal temperature of fresh produce after harvest often depends on the geographic origin of the product. He stated that tropical plants have evolved in warmer climates and therefore cannot tolerate low temperatures during storage

The study conducted by both Lee , Kader (2000) and Jobling (2000) it is clear that both researchers regard temperature management as a key factor in maintaining fruit vitamins and produce quality.

Again, according to Jobling (2000) temperature has big effect on the rate of metabolism of

produce. He explains that when temperature of products rises, so too does the rate of metabolism. One of the main processes of metabolism is respiration which is the process of breaking down stored carbohydrate to produce energy. When temperature rises in products which do not have a lot of stored reserves, such as leafy vegetables and flowers, carbohydrate can become limited and more simply they run out of food and as a result the shelf life and quality is rapidly reduced by warm temperatures.

Jobling (2000) further explains that high temperatures usually result from exposure to either direct sunlight, hot air in the field or heat treatments used for the eradication of pests. Some examples include non removal the field heat from harvested products, leaving harvested product in the direct sunlight or a breakdown of refrigeration and lack of air circulation. The temperature is also increased by the heat generated by the product itself. As the product respires it produces heat and if the products are packed in a way that prevents air circulation then the heat can build up considerably. At extreme temperatures problems may arise. For example, some enzymes which keep the plant functioning slows down at temperatures above 30° C and cease operating at 40°C. This results in high temperature injury. The consequences are a general loss of pigment or colour and affected areas develop a watery appearance and appear translucent. Kader (1992) and Mitra and Baldwin 1997 both also describes the consequences of chilling injury as surface pitting, discolouration, internal breakdown and decays.

Jobling (2000) concluded that at extremes of temperatures, products get damaged. He explained that some suffer chilling injury whiles others suffer damage at very high temperatures and all products are damaged if frozen. The author further explained that that short exposures or few hours of exposures to extreme hot or cold temperatures can cause a marked decrease in shelf life and loss of quality. Hence it was suggested that correct and

careful temperature management throughout harvest and marketing chain is essential if the quality of the product is to be assured. He (Jobling, 2000), for example reported that mango should be stored at temperature above 10º C.

According to Mitra and Baldwin (1997) however besides the quality of fruit at harvest, the use of an optimum temperature during handling and storage of fresh mango is a major factor and determines the quality of a fresh fruit. Mango fruit is very sensitive to cold temperatures and prolonged storage periods at temperatures below 10º C may delay ripening and lead to chilling injury damage. Depending on the cultivar, maturity stage and season of harvest, some mango fruits can be stored between 7º and 8º C for 25 days while others require temperatures above 13º C (Mitra and Baldwin 1997) . Green fruit should be stored between 10º and 15º C, while ripe fruits can tolerate much lower temperatures. Therefore, in order to reduce the risk of chilling injury,Mitra and Baldwin 1997 recommends storage temperatures for mangoes between 12º and 13º C (Mitra and Baldwin 1997)

Nune *et al.* (2007) stated that although some studies refer to the quality changes in mango fruit during storage, no information are found regarding precise quality curves for mangoes stored at different temperatures or regarding which quality factor(s) are the most important to determine the limits of marketability. Nune *et al.(* 2007) further carried out a study to (1) obtain quality curves for mango stored at different temperatures; (2) to identify for each temperature which quality factor(s) limits mango marketability; and (3) to compare the quality curves and shelf life of mango based on quality evaluations with those predicted by respiration rates reported in literature.

As part of their study two mango varieties (cv. Tommy Atkins and palmer) were harvested medium – ripe and held for 7 to 20 days at five different temperatures and evaluated for quality attributes.

The curves obtained from quality evaluations for each temperature showed that a single quality attribute cannot be used to express loss of quality of mango over the normal physiological range of temperatures (Nune *et al.,* 2007) The study also revealed that the weight loss of mangoes increased during storage, regardless of storage temperature, and the rate of the weight loss was comparable for two mango cultivars. The study suggested that a weight loss between 7 and 9% may be the maximum acceptable loss before tommy atkins and palmer mangoes become unacceptable for sale.

The authors also reported that the colour of the fruits changed regardless of the storage temperature (Nune *et al.,* 2007). However, the changes were faster in mangoes stored at temperatures higher than 5º C. Besides, the colour of "Tommy Atkins" mango changed much faster than that of "Palmer." Overall, after 4 days at 20º C, the skin of the "To mmy Atkins" mango was almost full yellow- reddish, while it took approximately 6 days at the same temperature for the skin of the "Palmer" mango to reach the same colour stage (Nune *et al.,* 2007)

Morton (1987) reports, that in India some cultivars, especially Bangalora, Alphonso, and Neelum have much better keeping quality than others. The author reported that Alphonso kept well for 4 weeks at 11.11° C and 6 to 7 weeks at 7.22° C. it was further reported that storage at lower temperatures is detrimental inasmuch as mangos are very susceptible to chilling injury. Any temperature below 13° C is damaging to Kent. In Florida, this i s regarded as the optimum for 2 to 3 weeks storage. The best ripening temperatures are 21.11°- 23.89° C (Morton 1987)

2.6 EFFECT OF OTHER FACTORS ON STORAGE CONDITIONS OF MANGO

According to Morton (1987), Irwin, Tommy Atkins and Kent mangos, held for three (3) weeks at storage temperature of 13° C and relative humidity 98% to 100% and

atmospheric pressure of 76 or 152 mmHg, ripened thereafter with less decay at 21° C under normal atmospheric pressure.

2.6.1 COLD STORAGE

Cold storage of mango is used to prolong shelf life by slowing the metabolic rate of fruit. Chaplin *et al*. (1991) was successful in the application of Cold Storage at 15°C to 'Kensington' mango for 4 weeks, with acceptable ripening and quality indices upon ripening. However, because mango are of tropical origin, their storage conditions are limited to those with temperatures greater than their critical minimum temperature of 10°C (~10-16°C depending on the cultivar and maturity or ripeness stage) in order to prevent chilling injury . Chilling injury occurs as a result of disruption in cell wall membrane functions, changing the flow of cellular fluids in and out of the cell, causing the leakage of metabolites such as amino acids, sugars, and mineral salts (Wills *et al*., 1981).

The goal of postharvest storage regimes for fresh fruit distribution is to create a set of conditions conducive to extending shelf life while reducing or eliminating conditions deleterious to consumer appeal. The use of postharvest techniques may biochemically alter fruit tissue, as respiration rates increase or decrease, affecting the natural ripening process. These biochemical changes in ripening may be responsible for potential alterations in radical scavenging compounds due to an elicited biological response to stress when stored above or below optimum temperatures. As a result, postharvest treatments may have a new role as a food additive process, improving potential health benefits of mango.

2.6.2 TREATMENT WITH CHEMICALS BEFORE STORAGE

Treatment efficiency varies with infection level and storage regime. The length of shelf life depends on cultivar, injury, maturity at harvest, calcium spray, and exposure to ethylene (Anonymous, 1988, Coates *et al*, 1995). A dip in 4-6 % calcium chloride can

increase the shelf life of some cultivars (Singh *et al*., 1993). Ethylene is used to reduce time for ripening initiation and it can also enhance skin colour of the fruit (Burg and Burg, 1962). In South Africa, a benomyl dip for 5 min at 55 ℃ is recommended just after picking of fruits, which can control soft brown rot (Sepiah, 1986). Prochloraz also provides good protection from anthracnose and Alternaria rot in mango (Johnson and Coates, 1993). Prior to harvest Gibberellic acid (GA3) spray can retard mango ripening at ambient temperature for up to six days of storage (Khader, 1991). Calcium chloride treatment resulted in low ethylene production, low respiration, and helped to reduce the occurrence of storage decay (Eeden, 1992).

2.7 USE OF HEAT-TREATMENT

Different heat-treatments have been used to alleviate the incidence of chilling injury symptoms in mango fruits. Heat Treatment of mango fruits showed increased level of putrescine and its accumulation helped the reduction of Chilling injury (CI) (Esguera and Lizada, 1990). As stated by González *et al*. (2000) peppers treated with HW at 53 ℃ for 4 min, had a reduced incidence of chilling injury after 14 and 28 days storage at 8 ℃.

Ethylene-treated fruits, irrespective of the method of application, cause severe mesocarp discoloration in avocado fruits. Loss of green colour has been observed in plant tissues while they are treated with Ethylene. The treatment also decreases fruit firmness, and chilling injury during prolonged storage (Watada, 1986). The mechanism by which ethylene regulates these attributes is not yet known. High temperature treatment inhibited ethylene production, which affected fruit ripening process.

Effects of postharvest heat-treatment on fruits are varied, since in some fruits it affects fruit firmness, colour development and ethylene production. Chaplin *et al*., (1982),

reported that pre-treatment of avocado fruits at 38 ºC for 12 hrs before storage at 0 ºC showed reduced symptoms of flesh injury. There are several possible explanation supports the concept that heat-treatments provide protection against CI (Chaplin *et al*.,1982),

i) Heat-treatments induce heat shock protein, which provide protection against heat injury, chemical stress as well as from chilling injury.

ii) It is suggested that exposure of plant tissue to one stress (heat-treatment) provides protection of the plant from another stress.

iii) Increase in ethylene synthesis means increased level of chilling injury and heat- treatments decrease the synthesis of ethylene.

In 1999, Fallik *et al,*. Established a hot water-brushing treatment in which fruits, moving along with brush roller, received Hot Water treatment. This treatment was used for disinfestation of fruits and vegetables but it was noted that it induces tolerance to low temperatures in grapefruit cultivar. Star Ruby.

Modified atmosphere horticultural crop packaging leading to high Carbondioxide level and low Oxygen level protected many chilling sensitive crops against CI (Forney and Lipton, 1990). Further, hot water treatment with controlled atmosphere storage also alleviated CI in Fuyu' persimmons

2.7.1 PHYSIOLOGICAL RESPONSES TO HEAT-TREATMENT

Immature mangoes have lower heat tolerance compared to mature ones. When immature mangoes get treated with Heat treatment at 46 ºC for 10 min internal breakdown has been noted by Esguerra and Lizada (1990) in the form of spongy white starch tissue in fruit mesocarp; however, no external damaging was noted.

2.8 PHYSIOLOGICAL AND PHYSICAL DISORDERS

During ripening, mango fruits are susceptible to several physical and physiological postharvest disorders, which affect fruit quality. Some disorders are inherent while some are induced. The inherent physiological disorders include spongy stem-end disorder, soft nose, and spongy or soft tissue.

2.8.1 SAPBURN

The stem of picked mango exudes large quantities of latex or sap which has low pH and high oil content and also has tendency to burn the fruit skin. According to Joel (1978, 1980) the latex repels fruit flies. The authors indicated that Terpinolene is the main ingredient responsible for the skin burn while high nitrogen levels in the fruit cause more severe sap-burn.

2.8.2 SPONGY TISSUE

In the pulp of ripened fruit, a desiccated sponge-like tissue is found which is called a spongy tissue (Amin, 1967). The fruit pulp remains unripe and due to physiological and biochemical disturbances a deposition of non-hydrolyzed starch occurs. Mechanical injury can also be responsible for spongy tissue like symptom in fruits. The affected fruit has no external symptoms either at the time of picking or while ripening. The affected portion gets prominent when the fruit gets cut. The exact cause of spongy tissues is still unknown. It has been noted that the affected fruit pulp has higher acidity, low pH, low ß-carotene content, sugar and ascorbic acid.

2.8.3 BLACK-TIPS

In black-tip disorder, the distal end of the fruit becomes yellow, and mesocarp and seed are unaffected in early stage, while later on the entire tip of the fruit turns brownish black in

color (Ram, 1989). The affected portion gets hard and its growth is retarded. The fruit becomes unattractive and loses its quality. Sprays of sodium carbonate, sodium hydroxide and borax can prevent the incidence of black tip in mango. (Ram, 1989).

2.8.4 SOFT-NOSE

Young (1957) described soft-nose as breakdown of fruit flesh at the fruit apex. The mesocarp shows premature softening at distal end. This disorder may be related to calcium deficiency. Cultivars Kent and Ameeri from Canary Island were found more susceptible to this disease (Galan Sauco *et al*., 1984). The fruit, which has low calcium content, is the most affected by this disease.

2.9 QUALITY EVALUATIONS

Product quality can be evaluated by using different methods. According to Salunkhe *et al.,* (1991) quality characteristics of the product can be divided into three types; sensory, hidden and quantitative. Sensory category includes color, size, shape, defects, gloss, taste and odor (Salunkhe *et al.,* 1991)

2.9 .1 MANGO QUALITY ATTRIBUTES

According to Zind (1989) cited in Nune *et al.(* 2007) appearance, colour, texture and aroma are probably the most important criteria used by a consumer to evaluate the immediate quality of a fruit and thus, persuade him or her to buy it.

Zuniga – Arias *et al.* (2007) also suggests that the different attributes included in the concept of quality depend on the relevant actor who is acquiring the product. Major actors participating in the valuation of food quality for the export market are producers, processors, exporters, importers, wholesalers, retailers and consumers, while external

agents like voluntary agencies and the government may influence these perceptions wholesalers and retailers emphasize visual attributes such as size, form, colour and shelf life, taking into consideration consumer preferences (Zuniga – Arias *et al.* 2007)

Government officials are involved in regulations concerning health and safety aspects. Producers and processors commonly give preference to profit attributes, like higher yields, suitability for mechanical harvesting and industrial preparation, and resistance against plagues and diseases. However, consumers are interested in many more aspects related to food quality such as taste, freshness, appearance, nutritional value and food safety.

According to Kader (1999) quality, that is, the degree of excellence or superiority of fresh fruits and their products is a combination of attributes, properties, or characteristics that give each commodity value in terms of human food. The author further stated that the relative importance of each quality component depends upon the commodity and its intended use (example, fresh or processed) and varies among producers, handlers and consumers. Romano *et al.* (2006) also stated that quality has different meanings for different stakeholders (producers, distributors, consumers, etc) but consumer acceptance seems to be the most important factor to consider.

Kader (1999) stated that to producers a given commodity must have high yield and good appearance, it must be easy to harvest, and must withstand long distance shipping to markets. He further explains that appearance quality, firmness, and shelf – life are important from the point of view of wholesale and retail marketers whiles consumers judge quality of fresh fruits on the basis of appearance (including freshness) and firmness at the time of initial purchase (Kader 1999).

Consumers are also concerned about the nutritional quality of fresh fruits, which are not only colourful and flavourful components of our diet, but also a good source of energy, vitamins, minerals, dietary fibres and many bioactive compounds that enhance human

health (Kader 1999).

Kader (2008) stated that although consumers may buy fruits on the basis of their appearance and firmness, subsequent purchases depend on their satisfaction with how these fruits taste.Further mango flavour quality is influenced by the cultivar, maturity stage at harvest, post harvest handling procedures and environmental conditions (avoiding mechanical damage and chilling injury), and ripeness stage at the time of eating the mango. (Kader 1999). Kader (2002) reported that the quality performance of mango fruit is based upon the external and internal quality attribute. The external attributes include the weight of the mango fruit, the presence of black spots, latex and damages. The internal quality attributes include the presence of mango fly, flesh maturity (based on flesh colour), internal damages, pH and Brix % of fruit juice.

Kader (2008) asserts that mango quality indices include uniformity of shape and size, freedom from decay and defects, skin colour that is characteristics of the cultivar, flesh colour, flesh firmness (juiciness, fibre content), and flavour (sweetness, acidity, aroma intensity). There are large differences in flavour quality and fiber content of mango cultivars, which can be grouped on the basis of fibre content into none to slight (less than 1%), moderate (1-2%), and high (more than 2%).

Zuniga – Arias *et al.* (2007) reported that the choices of attributes are based on the following; weight as producers are paid on the basis of the kilograms of mango fruit and the presence of black spots which could be result of a disease such as a fungus, or the damages due to latex.. Damage could also be for example due to harvest, tight fruit packing, transport or general rough fruit handling (Zuniga – Arias *et al.* 2007)

The presence of mango fruit fly is a negative quality attribute (Prinsley and Tucker 1987). The fly itself burrows into seed of the fruit and the fly and its larvae eat and damage the seed and the fruit flesh, which results in an un-eatable fruit for the consumer. Export

markets such as the United Stated have strict laws regarding the presence of pest and disease in and on fruit (Prinsley and Tucker 1987). The result of this is, that fruits are given a heat treatment in the sorting and packing plant to kill the fruit fly, when being exported to the United States.

Zuniga – Arias *et al*. (2007) reported that quality variability is lower in the export side of the chain and the variability in quality increases the closer you get to the consumer. This might be because the closer to the consumer bigger the niches and outlets and consumer wishes the product must meet, then the retailers must have any type of mango to cope with that wide range of options. Producers delivering to the export market face the international regulations, forcing them to have a certain type of produce to meet the strict requirement for the export market (Zuniga – Arias *et al*. 2007) .

2.9 .2 FACTORS AFFECTING FRUIT QUALITY

Kader (2008) reported that there are several factors which affect fruit quality including maturity at harvest as an important factor in determining eating quality of ripe mangoes. According to Mitcham and McDonald (1992), Six stages of maturity and ripeness of 'Keitt' and 'Tommy Atkins' mangoes are as follows: (1) Immature- green (underdeveloped shoulders); (2) Mature-green (well-rounded shoulders); (3) Firm (yields slightly under pressure); (4) Fairly-firm (yields significantly under pressure); (5) Soft-ripe (soft fruit); and (6) Over-ripe (extremely soft, mushy). Earlier however, Mitra and Baldwin (1997) had reported that many maturity indices have been tested however, due to differences among cultivars, production conditions and locations, there is no consensus on maturity indices. Kader (1999) further asserts that the eating quality of mangoes when ripe depends upon maturity at harvest, avoiding physical damage and chilling injury during postharvest handling, and minimizing anthracnose incidence.

Another factor affecting quality of fruits which Kader (2008) reported on was genotype (cultivar or variety). He also mentioned it as a very important factor for determining mango quality. Cultural practices such as water and nutrients (especially nitrogen and calcium) supply, integrated pest management procedures, and crop load on the tree also influence mango maturity rate, quality at harvest, and postharvest-life potential (related to incidence and severity of physiological disorder and decay). (Kader, 2008)

He also reported on others factors affecting quality of fruits as postharvest handling practices such as preparation of fruits for market (washing, heat treatment, waxing, fungicide treatment, packaging, cooling); management of temperature and relative humidity (to avoid chilling injury and minimize water loss). According to Kader (1999) stated that, the optimal temperature for mature-green mangoes ranges from 12º to 14ºC and 8º to 12ºC for partially-ripe and ripe mangoes with an optimal relative humidity range of 85 to 95% for all mangoes.

He also reported that delaying ripening by modified or controlled atmospheres and/or treatment with 1-methylcyclopropene (1-MCP; Smartfresh) cannot substitute for keeping mangoes at the optimal range of temperature and relative humidity, but can be useful supplemental treatments under conditions when a longer postharvest-life is needed for successful marketing (Kader, 2008).

2.10 MANGO FRUITS PROCESSING

With a global production exceeding 26 million tons in 2004 FAO, (2005), the mangoes are among the most important tropical fruits. Beside the fresh fruit, processed mango products such as juices, nectars, jelly powders, fruit bars, flakes, dried fruits and jams have become increasingly popular in Europe Mahayothee, (2005). The export of mango pulp as raw material for these products was estimated to be about 62% of total exports

of fruits and vegetables in India, the world's largest mango producer (Sreenath *et al.*, 1995). The edible pulp makes up 33-85% of the fresh fruit, while peel and kernel amount to 7-24% and 9-40%, respectively (Wu *et al.* , 1993).

CHAPTER THREE

3.0 METHODOLOGY

3.1 RESEARCH DESIGN

This chapter discusses the methods used in carrying out the research from sampling of the study communities through to the collection, presentation of data and findings.

3.2 OVERVIEW OF RESEARCH DESIGN

The research employed desk study in gathering relevant literature and secondary data. During the field study the research employed a survey and a case study in gathering data and information from actors and stakeholders in the mango producing areas in Northern Region of Ghana.

3.3 DATA COLLECTION

Data collection was based on a survey of individual mango producers, out growers, sellers and stakeholders in the mango sector, using a set of questionnaires. The research therefore had a quantitative and qualitative approach on empirical basis and literature review. Mango farmers and sellers were selected based on their scale of production within the Northern Region to evaluate postharvest handling of mango fruits from the farm gate to the market.

3.4 STUDY AREA

The Northern Region is much drier than southern areas of Ghana, due to its proximity to the Sahel, and the Sahara. The vegetation consists predominantly of grassland, especially savanna with clusters of drought-resistant trees such as baobabs or acacias. Between May and October is the wet season, with an average annual rainfall of 750 to 1050 mm (30 to 40 inches). The dry season is between about November and April. The highest temperatures are reached at the end of the dry season, the lowest in December and January. However, the hot Harmattan winds from the Sahara blows frequently between December and the beginning of February. The temperatures can vary between 14°C (59°F) at night and 40°C (104°F) during the day.

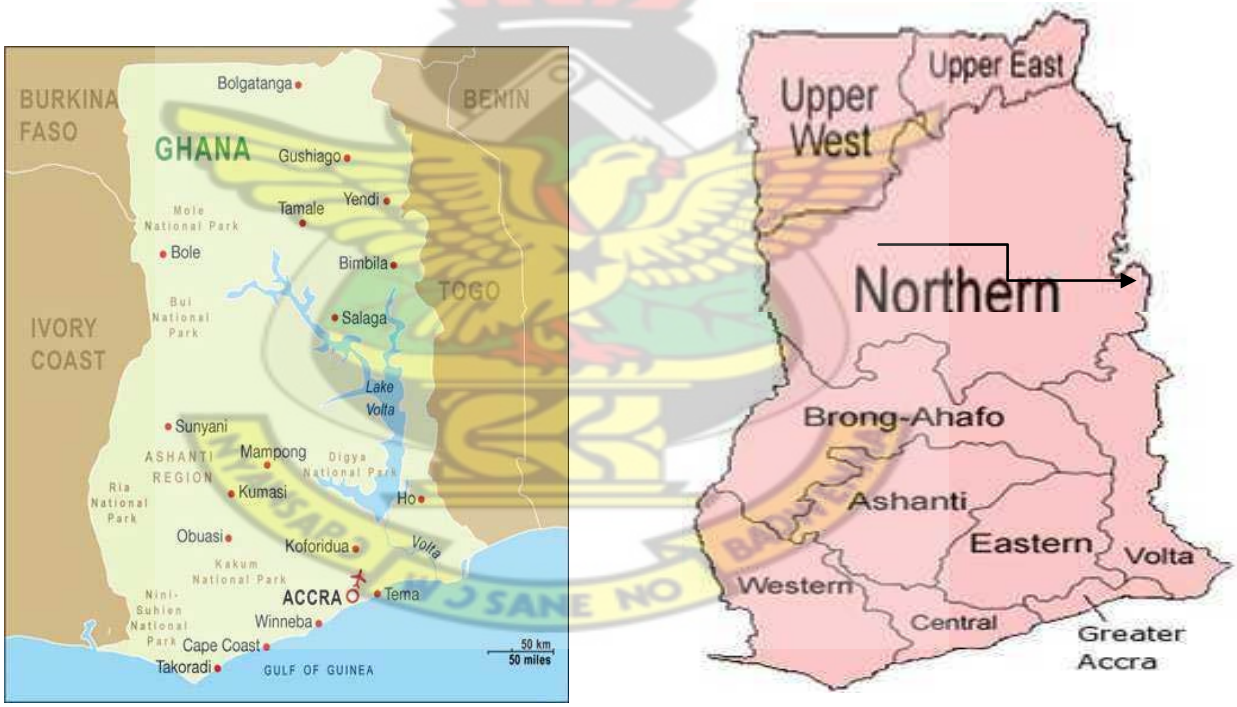

Figure 3.1: Map of Ghana showing Northern Region (Source: Internet)

3.5 SURVEY

Data from the field study was collected through a survey employing set of questionnaires. The survey research strategy was used to gain an overall picture of the current postharvest handling of mango fruits in the Northern region of Ghana. The survey was carried out on producers of mangoes and sellers in the Northern Region of Ghana. One hundred and forty nine (149) producers and twenty one sellers (21) were selected through a selective sampling from the total number of mango producers and sellers in the region.

3.6 SAMPLE SIZE AND SAMPLING PROCEDURE

The study employed both probability and non- probability sampling techniques in selecting the respondents for the study. Simple random sampling, a probability sampling method and purposive sampling, a non –probability sampling method was employed in the sample size of one hundred and forty nine (149) respondents of mango farmers and twenty one (21) mango sellers for the study.

3.6.1 SOURCES OF DATA

The data gathered for the study included both primary and secondary. The primary source of data comprised basically the out growers, processors and agencies. The secondary sources of data included, reports, company brochures, journals, newsletters, bullets, books, internet and other relevant existing empirical literature of scholars in the area of postharvest on mango fruit.

3.6.2 DATA COLLECTION TECHNIQUES

Questionnaire and interview schedule were used as techniques for gathering data in the study. A detailed interview guide to elicit factual and in-depth data postharvest on

handling and marketing mango fruits was used. Questionnaires were administered to out growers, processors and other agencies.

3.7 PRE-TEST

The interview schedule and questionnaire was pre-tested on out growers, sellers and stakeholders to the study, to ascertain the validity and reliability of the questionnaire based on the understanding of the respondents. The final questionnaire was then revised based on the outcome of the pre-test.

3.8 METHODS OF DATA PROCESSING AND ANALYSIS

The data collected from the field was examined from the completed questionnaires through quality control measures such as sorting, editing, and coding to identify and eliminate errors, omissions, incompleteness and general gaps in the collected data. The refined data were analyzed using Statistical Package for Social Sciences (SPSS) and excel, to facilitate data description and analysis.

Descriptive statistics such as cross tabulation and frequencies were employed to summarize and present the quantitative aspect of the data in the form of tables, to facilitate interpretation and analysis using frequencies, percentages, bar and pie chats

The qualitative aspect of the data was summarized in the form of text, quotes and extracts for easy description and analysis.

CHAPTER FOUR

4.0 RESULTS

This chapter deals with the analysis and interpretation of the data collected. Descriptive statistics was used in analyzing the data; percentages were employed to explain certain points where and when necessary.

4.1 BIO DATA OF RESPONDENTS

Table 4.0 shows the bio data of the respondents which made up of one hundred and forty nine (149) mango farmers and twenty one (21) mango sellers in the Northern Region

Table 4.0 Gender of Respondents

Gender	Mango Farmers		Mango sellers	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**
Male	128	85.9	4	19.05
Female	21	14.1	17	80.95
Total	**149**	**100.00**	**21**	**100.00**

From Table 4.0 out of the total number of respondents 85.90% were males and 4.1% were female. On the other hand sellers consisted of 80.95% females and 19.05% males.

4.2 EDUCATIONAL LEVEL OF RESPONDENTS

Educational level of respondents is represented in figure 4.0**,** .Majority of the respondents (47.65%) of framers had no formal educational background and few of them had either basic (27.52 %) or secondary (19.46%) education.

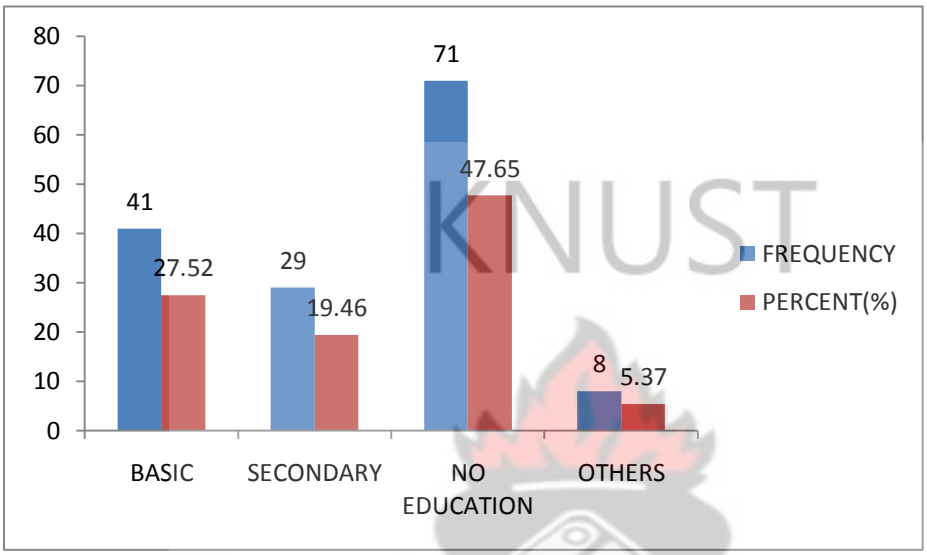

Figure 4.0 Level of Education of respondents

4.3 METHOD OF LAND ACQUISITION FOR MANGO CUTLTIVATION

From the survey, (97.99%)of the respondents acquired land for mango cultivation from their family land and (0.6%) acquired then either by hiring or outright purchase.

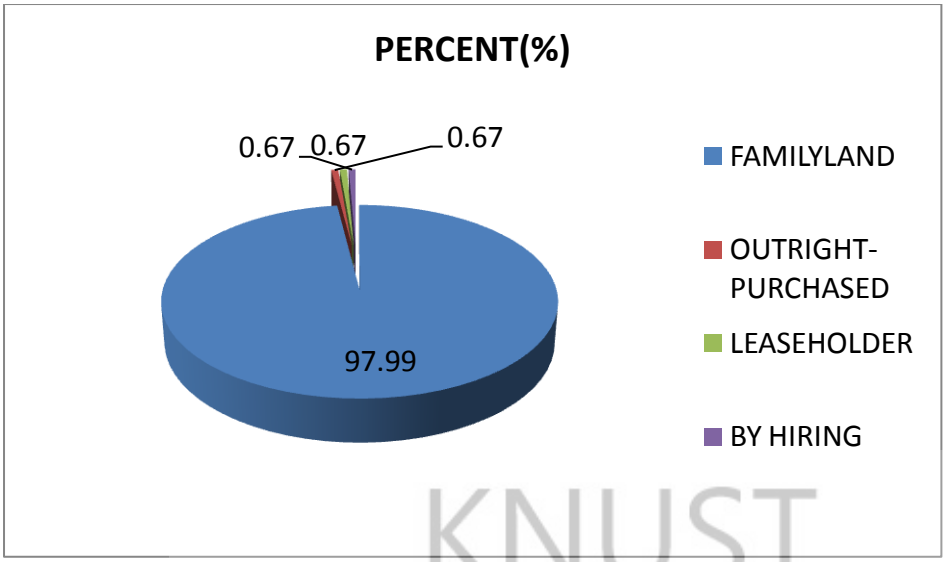

Figure 4.1 Method of Land Acquisition

4.4 TYPE OF MANGO VARIETIES CULTIVATED BY FARMERS

The results obtained (table 4.1) shows that most 32.89% of the mango farmers cultivate the Kent , while 29.55% grow Amelie. Also 28.19% of grown keitt. On the other hand 2.68% of the respondents cultivate the local variety.

Table 4.1 Type of Variety Cultivated By Farmers

Response	Frequency	Percent (%)
Keitt	42	28.19
Amelie	44	29.53
Kent	49	32.89
Zill	10	6.71
Others	4	2.68
Total	149	100.00

4.5 STAGE OF HARVESTING OF MANGO FRUITS AND MARKETING

The survey revealed 65.10% of the farmers harvest their mango fruits at full ripe stage. Thirty two percent harvest at half ripe stage (table 4.2); while 80.95% of the sellers purchase their mango fruits at full ripe and 14.29%at half ripe stage. Only 4.76% of farmers harvest fruits at physiologically matured stage.

Table 4.2 Stages of mango fruit before harvesting and marketing

Response	**mango farmers**		**Mango seller**	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**
Half ripe	48	32.22	3	14.29
Full-ripe	97	65.10	17	80.95
Physiological matured(green)	4	2.68	1	4.76
Total	149	100.00	21	

4.6 MONTHS FOR HARVESTING VARIETIES

The table 4.3 shows the months at which certain varieties are harvested in the Northern Region. Thirty- five point five -seven percent of farmers harvest Kent within May-June, while 30.87% of the framers harvest Keitt variety at the month of June-July. Furthermore 19.46% of Amelie variety was harvested within March –April and Zill variety (14.09%) was harvested in April- May.

Table 4.3 Month of harvest against varieties

Month	Variety	Frequency	Percent (%)
March-April	Amelie	29	19.46
April-may	Zill	21	14.09
May-June	Kent	53	35.57
June-July	Keitt	46	30.87
Total		149	100.00

4.7 METHOD OF HARVEST

The survey conducted showed that 59.75% of the respondents use knives for harvesting 20.13% of the famers handpick their fruits; whilst 16.78% shake the tree .Only 3.36% of the respondents could not give a definite method of harvesting

Table 4.4 Method use in harvesting mango in Northern Ghana

Response	Frequency	Percent (%)
Knives	89	59.73
Shaking	25	16.78
Handpicking	30	20.13
Others	5	3.36
Total	149	100 .00

4.8 NUMBER OF TIMES MANGO FRUITS HARVESTED WITHIN YEAR

The table 4.5 shows 90.30% of the respondents harvest fruits once a year and only 4.70% harvest their mango fruits twice a year.

Table 4.5 Number of time harvested in Year

Response	Frequency	Percent (%)
Once year	142	90.30
Twice year	7	4.70
Total	149	100.00

4.9 GRADING METHODS USED BY FARMERS AND SELLERS

From the results 36.24% of the farmers grade their mango fruits by looking at uniformity in size and shape. Nineteen point four six percent grade based on mechanical damage. Also 18.79% of the respondents grade based on variety. Only 12.08% of the farmers considered flesh firmness as their grading method. On the other hand ,42.86% of the sellers grade their mango fruits using uniformity in size and shape. Twenty- eighty point seven –five percent used skin colour and 14.29% for free from mechanical damage. Only 4.76% of the sellers considered variety of mango.

Table 4.6 Grading criteria used by farmers and sellers

Response	Mango farmers		Mango seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Variety	28	18.79	1	4.76
Flesh firmness	18	12.08	2	9.52
Uniformity in size and shape	54	36.24	9	42.86
Skin colour	20	13.54	6	28.57
Free from mechanical damage	29	19.46	3	14.29
Total	149	100.00	21	100.**00**

4.10 SUPPLY CHAIN OF MANGO FRUITS

The results of the survey conducted showed that 22.15% of the farmers sell their harvested mango fruits through the retail outlet, 21.47% of then sell to the processors and 20.18% sell at the farm gate. Also 15.44% of farmers sell to wholesalers and 2.62% to middlemen. On the other hand 71.43% of the sellers purchase their mango fruits at the farm gate and 28.37% from middlemen.

Table 4.7 Mango fruits supply chain in the Northern Region

Response	Mango Farmers		Mango seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Wholesalers	23	15.44		
Retailers	33	22.15		
Middlemen	4	2.62	6	28.57
Export market	26	17.45		
Farm gate	32	20.81	15	71 .43
Processors	31	21.47		
Total	149	100.00	21	

4.11 TRANSPORTATION SYSTEM

The analysis of the transportation system being practice by both farmers and sellers revealed that 66.44% of the farmers use open truck to convey their harvested mango fruits. 28.19% use motor king and only 5.37% use the booth of vehicle. (Table 4.8). Regarding the sellers, 61.90% use motor king, 19.05% the booth of vehicle and only 14.29 % use open truck to transport fruits from the farm gate to the market.

Table 4.8 Transportation practice by farmers and sellers

Response	Mango farmers		Mango seller	
	Frequency	percent (%)	Frequency	percent (%)
Open trucks	99	66.44	3	14.29
Vehicle booth	8	5.37	4	19.05
Motor king	42	28.19	13	61.90
Total	149	100.00	21	100.00

4.12 NATURE OF POSTHARVEST LOSSES DURING TRANSPORTATION

Table 4.9 shows that 59.73% and 40.27% of the famers attributed their losses to compression and vibration respectively. On the other hand 76.17% of the sellers attributed their losses during transport to compression and 23.81% to vibration

Table 4.9 Nature of postharvest losses during transportation

Response	Mango Farmers		Mango Seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Compression	89	59.73	16	76.19
Vibration	60	40.27	5	23.81
Total	149	100.00	21	100.00

4.13 PACKAGING PRACTICES

The study revealed that 67.13 % of the farmers use sacks as packaging material, 22.82% of use baskets and only 12% use plastic cartons. On the other hand 71.43% of the sellers use sacks as packaging and 28.57% use baskets.

Table 4.10 Packaging techniques used by farmers and sellers

response	Mango farmers		Mango seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Sack	103	67.13	15	71.43
Basket	34	22.82	6	28.57
Plastic Cartons	12	8.05		
Total	149	100.00	21	100.00

4.14 STORAGE METHOD

The table 4.11 shows that 38.95% of the mango farmers store their harvested mango fruits by heaping them on the ground at the farm, 27.52% spread on the floor and 15.43% put them in baskets. Also 16.78% of the farmers use refrigerator to store their mango fruits and 1.34% store in boxes. In the same way, 61.90% of the sellers store their mango fruits by spreading them on the floor and 28.57% in baskets. Only 9.52% use boxes to store mango fruits.

Table 4.11 Storage methods by farmers and sellers

Response	Mango Farmers		Mango Seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Basket	23	15.43	6	28.57
Box	2	1.34	2	9.52
Spread on floor	41	27.52	13	61.90
Refrigerator	25	16.78		
Heap on ground	58	38.93		
Total	149	100	21	100

4.15 ANTHRACNOSE DISEASES

It can be observed from table 4.12 that 87.25% of keitt is most susceptible to anthracnose and 6.71 % for the Kent variety. Also 3.36% affect the Zill and only 2.68% affect Amelie

.

Table 4.12 Diseases that affect fruits at matured stage.-Anthracnose

Variety	Frequency	Percent (%)
Kent	10	6.71
Keitt	130	87.25
Amelie	4	2.68
Zill	5	3.36
Total	149	100.00

4.16 FACTORS AFFECTING POSTHARVEST LOSSES OF MANGO FRUITS

From table 4.13 that 46.30% of the respondents indicated that method of harvesting and field handling were the factors affecting postharvest handling of mango fruits. Also 16.78% of the respondents indicated that stage of fruit at harvest has been one of the factors affecting postharvest losses. Fourteen point seven-seven percent attributed the factors to transport system and 12.08 % said marketing handling. Fewer farmers (10.07%) considered as factor which affect postharvest losses.

Table 4.13 Factors affecting postharvest losses of mango fruits

Responses	Frequency	Percent (%)
Method of Harvesting and field handling	69	46.30
Packaging	15	10.07
Transportation	22	14.77
Marketing handling	18	12.08
Stage fruits at harvest	25	16.78
Total	149	100.00

4.17 CAUSES OF THE LOSSES

As shown in table 4.14, 32.89% of the mango farmers attributed postharvest losses are attributed to softening of fruits due to over ripening; 16.79% of the respondents had their losses caused by both cuts and bruises and poor road network; 16.78% of the respondents indicated that improper loading of the fruits was the cause and 8.78 % for poor packaging was the main factor.. Only 8.05% of the farmers said losses are due to exposing the fruits to the sun.

Regarding the sellers 28.57% attributed losses to fruit softening arising from over ripening and 19.05% to both cut and bruise and exposure to sun .The lowest to consider for the mango sellers as causes of losses are the poor packing presenting 9.52% and overloading (9.52%).

Table 4.14 Causes of the losses

Response	Mango farmers		Mango seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Cuts and bruises	25	16.78	4	19.05
Exposure to sun	12	8.05	4	19.05
Poor road network	25	16.78	3	14.29
Poor packaging	13	8.72	2	9.52
Over loading	25	16.78	2	9.52
Softening due to over ripening	49	32.89	6	28.57
Total	149	100.00	21	100.00

4.18 CONSTRAINTS OF MARKETING MANGO FRUITS

The survey revealed that 29.53% of the farmers indicated perishability of mango fruits as the major marketing constraint confronting them and 28.19% lack of storage facility .Also showed that lack of market and transport were considered and 16.79% and 13.42% of farmers respectively. Only few of the respondents indicated low price of mango fruits (6.71%) and low patronage (5.37%) as constraints.

Regarding the mango sellers, 42.86% of the respondents indicated perishability of mango fruits as their constraint whilst 28.57% revealed that lack of storage facility is constraint. On the other hand 4.76% of the respondents indicated lack of market, low price of the fruits and low patronage as their constraints.

Table 4.15 Mango marketing constraints

Response	Mango Farmers		Mango Seller	
	Frequency	Percent (%)	Frequency	Percent (%)
Lack of market	25	16.78	1	4.76
Low price of product	10	6.71	1	4.76
Lack of storage facilities and conditions	42	28.19	6	28.57
Lack of transport	20	13.42	3	14.29
Perishability of produce	44	29.53	9	42.86
Low patronage	8	5.37	1	4.76
Total	149.00	100.00	21	100 .00

CHAPTER FIVE

5.0 DISCUSSION

5.1 EVALUATION OF THE POSTHARVEST HANDLING OF MANGO IN NORTHERN REGION.

It was revealed from the study that four varieties were cultivated by farmers in the Northern Region of Ghana. These varieties were, Kent, Keitt, Zill, and Amelie. The farmers cultivate these varieties based on several reasons and purposes. Some were of the assertion that, certain varieties have longer shelf life, well patronized by farmers, resist handling pressure and resistance to diseases and pest.

According to Pandey (1986) over 1,000 different mango cultivars throughout the world have been identified and only 800 mango cultivars have been named. Further Galan Sauco *et al*., 1984 that each mango growing country possesses different climate, geological feature, harvest time, and marketing season, each country generally has its own major cultivars for commercial use. Since many cultivars have their own characteristics, each mango is cultivated according to the regional and climatic conditions of the respective countries. The shelf life of mango varies among its varieties depending on storage conditions and ranges from four (4) to eight (8) days at room temperature and two to three weeks in cold storage at 13°C (Carillo *et al*, 2000).

From the findings, it was revealed that mango farmers and sellers harvest their mango fruits for sale based on certain indicators. It was realized 65.10% of the mango farmers and 80.95% of the mango sellers either harvest or buy mangoes when they are full-ripe.

On the Contrary, 2.28% of the farmers harvest when it is physiological matured and 4.76% of the sellers also buy mangoes when they are physiological matured.

Lakshminarayana *et al*., (1970) reported that, mangoes are usually harvested green. Harvesting usually takes place after 15-16 weeks of fruit set when they are physiologically matured. Late harvesting may result in uneven ripening, and can lower sugar to acid ratio.

Contrarily to the research, mangoes are harvested at a mature, unripe (green) stage as they will naturally ripen off the tree. Harvesting mangoes prematurely, however, will prevent fruit from reaching full ripeness. Harvesting fruit at stages beyond mature green will also reduce their shelf stability and shorten their fresh market life. It is therefore obvious that a lot more mango fruits are lost since harvesting is done at the full ripe stage by both farmers and sellers. Kalra *et al.* (1995) reported that mature ripe mangoes perish within 6 days under ambient conditions for which the temperature in the northern region of Ghana is not exception.

The present study also revealed that farmers and sellers convey their mango to the market in open truck, booth of vehicle and motor king. It was realized that due to poor road network and bad handling practices large quantities of mango fruits are lost due to compression and vibration. Fresh produce is primarily transported by road, from farmer to consumer. A marketing concern is that fresh produce should be of the highest quality and should be kept in the best condition during transportation. Subrahmanyam, (1986) reported that, postharvest losses not only reduce the availability of mango, but also result in increase in per unit cost of transport and marketing. Minimizing losses during transportation, necessitates that special attention be given to vehicles, equipment, infrastructure and handling

5.2 IDENTIFICATION OF MAJOR PROBLEMS ASSOCIATED WITH POSTHARVEST HANDLING OF MANGO FRUITS.

Statistically, postharvest losses have been generally estimated in developed countries in fruits to range from 5 to 25% while in developing countries it is 20 to 50% depending upon the commodity (Kader, 1992). This continues to cause heavy losses in revenue for the grower, wholesaler, retailers and exporters of mangoes.

The research revealed that there are various actors who play vital role in the supply chain of mangoes in the Northern region of Ghana. Harvested mango fruits can be purchased or sold by the farmers through the following ways in the northern region; Farm gate, wholesalers, retailer, exporters, processors and middlemen who buy and sell. This was also reported by Roduner (2007) ,who states that "value chain actors are those who directly deal with the products, that is produces, process, trade and own them whiles value chain supporters are those who never directly deal with the product , but whose services add value to the product" .

Zuniga-Arias *et al,(*2007), also suggested that " the different attributes included in the concept of quality depend on the relevant actors who are acquiring the product" whiles wholesaler, middleman and retailers emphasize on visual attributes such as size, shape, colour and shelf life, taking into consideration consumers preferences, farmers rather emphasize on or give preference to profit attributes, such as yield, input requirements, suitability for market and resistance against pest and diseases.

Malik *et al*. (Eds) (2005) in their reported that 25 - 30% of mango produce is lost due to improper postharvest operations; as a result there is considerable gap between the gross production and net availability due to improper handling by the actors involved.

This study revealed that there are differences in the way mango farmers and sellers store

their harvested fruits in the Northern region. It was observed that 38.93% of the farmers heaped their harvested mango fruits on the ground, whilst 27.52% spread them on the floor. Only 16.78% of farmers use refrigeration systems to store their fruits at the pack house. Similar observation was made for mango sellers, where 61.90% of them also spread their mango fruits on the floor after the daily sales. The method being practiced by majority of the farmers that is heaping of the harvested are above the ambient temperature. This varies with the report of Mitra and Baldwin (1997) who recommends storage temperatures for mangoes between 12º and 13º C which falls in line with Jobling (2000) who recommends that mango should be stored at temperature of above 10°C.

Raghavan and Gariépy, (1985) and Pantastico *et al*. (1975) state that , basic concept of storage is to extend the shelf life of products by storing them in appropriate conditions to maintain their availability to consumers and processing industries in their usable form . They further explained that, in the natural storage the product is left in the field and harvesting is delayed, while in artificial storage favourable conditions are provided which help to maintain product freshness and nutritional quality for a longer period.

The storage methods used by both farmers and sellers in study area is likely negative impact in the postharvest handling of mangoes.

From the findings of the study it is established that causes of postharvest handling was due to the following; cut and bruises, exposure to sun, poor road network , wrong packaging, overloading of fruits and softening due to over ripening .

Jobling (2000) explains that high temperatures usually result from exposure to either direct sunlight, hot air in the field or heat treatments used for the eradication of pests. Some examples include not removing the field heat from harvested products, leaving harvested product in the direct sunlight or a breakdown of refrigeration and lack of air circulation. The temperature is also increased by the heat generated by the product itself. As the

product respires it produces heat and if the products are packed in a way that prevents air circulation then the heat can build up considerable.

Further findings of this study were that the varieties cultivated had different susceptibility to diseases that affect matured mango fruits, especially, anthracnose. For instance the late variety, Keitt was much affected by anthracnose diseases as compared to the other varieties being cultivated by the farmers. According to Fitzell and Peak, (1984); and Jeffries *et al.*, (1990), anthracnose disease caused by *Colletotrichum gloeosporioides* is one of the major common diseases for pre-and postharvested fruits and is associated with high rain fall and humidity . the harvesting of Keitt takes place June –July which is the peak of the rain season in the Northern Region.

5.3 POSTHARVEST EFFECT ON THE MARKETING OF MANGO FRUITS

It can be inferred from the study that the major marketing constraints of mango fruits in the Northern Region are lack of storage facilities and the perishability of the fruits. According to Narayanan *et al., (*1996) mango being a high perishability fruit possesses a very short shelf life and reach to respiration peak of ripening process on third to fourth day after harvesting at ambient temperature. Also Gil *et al.,* 2000 states that, trade in mango has been significantly limited due to their short shelf life and highly perishable.

Lack of storage facilities and perishability of the mango fruits are serious postharvest constraints to farmers and sellers in the Northern Region of Ghana. Farmers and sellers are compelled to dispose off their harvested fruits mangoes at very cheaper prices to consumers.

According to Lizada, (1993); Mitra and Baldwin, (1997) world trade in fresh mango fruit is restricted by the highly perishable nature of this climacteric, fruit that displays characteristic peak of respiratory activity during ripening (Tucker, 1993).

CHAPTER SIX

6.0 SUMMARY, RECOMMENDATION AND CONCLUSION

6.1 SUMMARY

- The anthracnose disease causes lots of losses of the fruit at the mature stage, especially the Keitt variety and has negatively affected most of the farmers in the Region. For thus reason some farmers have started cutting down Keitt and replacing them with Kent and Amelie which are able to withstand the diseases
- Market women purchase their fruits at full ripe stage which deteriorate faster and the demand compels most of the farmers to harvest at this stage.
- The study revealed that, there is no proper storage facility for the market women and the farmers to store their produce after harvesting. This has created serious economic loses to all the actors in the supply chain of the fruits.
- The nature of loading of the fruits from the farm gates to the market causes losses to the produce.

6.2 RECOMMENDATIONS

- More research should be carried out to find out the best method for the prevention of anthracnose disease
- Market women and farmers should be educated on optimum maturity stage to harvest fruits .
- More processing plants should be established to process fruits.
- To reduce postharvest losses in mango and maintain product quality Export marketing and Quality Awareness project (EMQAP) under the Ministry of Food

and Agricultural should support both mango farmers and sellers with adequate pack house and cooling storage facilities.

6.3 CONCLUSION

Further research study in the area of diseases especially on the Anthracnose diseases in the study area will go a long very to help mango farmers in the Region.

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APPENDICES

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

HORTICULTURAL DEPARTMENT

APPENDIX A: QUESTIONNAIRE FOR FARMERS/ OUT GROWERS

INTRODUCTION

This is a study being undertaken by an **MSc Post Harvest Technology** student of the Institute of Distance Learning, Kwame Nkrumanh University of Science and Technology "the Evaluation of losses in the Postharvest Handling of Mango fruit (*Mangifera indica*) from the farm get to the Marketing in Ghana. A case study in the Northern Region". The purpose of the study is to assess the Postharvest handling of mango the Northern Region. This interview guide is basically for academic purpose and respondents are assured of privacy and confidentiality.

Thank you.

Please tick (√) the appropriate box and fill in the blank spaces where appropriate

SECTION A

I. Background characteristics of respondents

1. Sex Male [ ] Female [ ]

2. Educational qualification

a) Basic school [ ]

b) Secondary school [ ]

c) No formal education [ ]

d) others (specify)……

SECTION C

II. LAND ACQUISITION AND PREPARATION

3. How d id you acquire the land for your mango farm?

A. [ ] by inheritance B. [ ] Outright purchase C. [ ] Leasehold

D. [ ] by hiring E. [ ] Family land

4. What is the average size of your mango farm? A. [ ] 1 – 10 acres

   B. [ ] 11 – 20 acre C. [ ] 21 – 50 acres D. [ ] 51 – 100 acres

   E. [ ] Above 100 areas.

5. What was the main problem encountered in the acquisition of the land? Provide answers

   i……

   ii……

   iii…… ……..

6. Are you able to manage the farms well as expected? A. [ ] Yes B [ ].No.

III. SELECTION OF VARIETIES FOR CULTIVATION

7. How long have you been in to Mango fruit production?

   A. [ ] 1-5yrs B. [ ] 6-10yrs C. [ ] 11-15yrs D. [ ] 16yrs and above

8. 10.. What type of cultivars/varieties do you grow? A. [ ] Keitt B [ ] Zill

   C .[ ] Amelie D. [ ] Kent E. [ ] others (specify ……

9. What reason(s) did you consider for your choice? A [ ] fast growth rate B [ ] bigger fruit size C. [ ] longer shelf –life D .[ ] well-patronized by farmers E [ ] Resist handling pressure F. [ ] resistance to diseases and pest

   H. [ ] others (specify ……

10. What is the source of the planting materials?

    A. [ ] Reputable Farmer B. [ ] Agric Research Stations

    C. [ ] Certified Nursery Growers D. [ ] Personal Nursery

    e. [ ] market

11. If from the market how much**……...**

SECTION D

IV. CULTURAL PRACTICES ON MANGO FARM

12. Do you experience pests attack on your farm? A. [ ] Yes B[ ] No.

13. If yes, what common pest(s) do you encounter on your farm? A [ ] Mealy bugs

    B [ ]. scale insects C. [ ] fruit files d. D[ ] stone weevils

    E. [ ] Mango trips.

14. Which of them cause the greatest damage……..

15. What method(s) do you use to control the pests?

    A. [ ] Use of chemicals B. [ ] Cultural methods-pruning, scouting

    C [ ]. Biological Methods D. [ ] Physical methods-steam of water, E [ ] handpicking, F [ ] regular inspection

16. What are the common disease(s) on your farm? A[ ] Anthracnose

    B [ ]. Bacterial black spot C[ ]. Powdery mildew D [ ]. Any other……...

17. Which of them causes the greatest harm to the fruits?

    i……
    ii……

    iii……

18. Which of these methods(s) are effectively used to control the disease(s)?

    A[ ]. Cultural methods-pruning, burning of diseased plants

    B [ ]. Chemical methods-fungicides, nematicides, bactericides etc.

    C [ ]. Integrated control methods – scouting, destruction of diseased plants.

19. What are the sources of infections? A [ ]. Rainfall and winds (the weather)

    B. [ ] Related crops – citrus, guava, papaya etc.

    C[ ]. Transport and harvesting, storage equipment

20. Do you have any plan to increase the size of the mango plantation?

A[ ] Yes B [ ] No

21. Give reasons for your answer

……

22. Which of the following are the mango fruit production constraints? (Tick as many responses as applicable)

I. Pest [ ]

II. Diseases [ ]

III. Drought [ ]

IV. Flood [ ]

V. Seedling shortage [ ]

VI. Fertilizer shortage [ ]

VII. . Lack of pesticide [

V. HARVESTING AND STORAGE OF MANGOES

22. Have you had any training in harvesting techniques? A [ ] Yes B [ ] No

23. If yes, state some of the measures you put in place before harvesting

i. …….

ii. ……..

iii. ……

24. . What stage do you start harvesting? ……

25. . At what stage do you buy your mango fruits? A [ ] full-ripe, B [ ] half -ripe ,C [ ] physiological matured(green)

26. What method(s) do you use to harvest mangoes?A[ ] handpicking

B [ ] use of knives C [ ] shaking other

27. How many times do you harvest per season? A[ ] once a yr B [ ] twice a yr C [ ] three time a yr

28. If twice a year specify the months in a season? A [ ] March -April B [ ] April- Mayber C [ ] May-June D [ ] June-July E [ ]

others (specify……..

29. What quantity do you harvest per season? A [ ] 0-1ton

B [ ] 2-3ton C [ ] 3-4ton D [ ] others (specify) ……

30. What postharvest treatment do you give during harvesting? A [ ] sorting B [ ] pre cooling C [ ] others (specify)

31. What are the criteria for grading your harvested fruits? ……

32. Is storage of mangos a problem for you? A[ ] Yes B [ ] No

33 . If yes, how much of the mango fruits is damage in the field and after harvest

Mango fruit	% of loss before harvest	% of loss after harvest

State any problems you encounter during the harvesting of fruits?

i……
ii……

iii……

34.Which of these practice(s) do you undertake after harvesting?

A [ ] Washing and cleaning of fruits B[ ]. Sorting and grading

C[ ].pre-cooling of fruits

35. What materials do you use to protect the fruits from bruises and injuries?

i……

Ii……

Iii……

36. Do you have packhouses where harvested fruits are kept?A [ ]. Yes B [ ] No.

If No, where do you keep the harvested fruits?.....

37. Do you have trained personnel who harvest the fruits? A [ ]. Yes B [ ] No

38 If yes, how regular do you give training to the personnel? A [ ].Annually

B [ ]. Occasionally C [ ]. When necessary D [ ]. Harvesting time

39. How do you protect your harvested produce from diseases and pets?

A. [ ] by washing B [ ]. Use of chemicals

C [ ] . Use of containers and equipment With clean water.

40. Do you grade your produce before sale or export? A[ ]. Yes B [ ]. No

41. If Yes, which of the following criteria do you use for grading A[ ]. Variety

B[ ]. Flesh firmness C. [ ] uniformity of size and shape D[ ]. Skin colour

E[ ]. free from mechanical damage.

42 . Which of the following do you use to reject some of the fruits? A[ ].bruises and cuts

B[ ]. Over-ripened ones C[ ]. Unusual colour D[ ]. Size and shape

43. What materials do you use for packaging?

i……

ii……

iii……

44. State some of the problems you encounter during the packaging of the fruits.

i……

ii……

iii……

45. How are the produce moved from the farm to the point of sale?

A [ ]. Use of Refrigerated vans B[ ]. Open truck C [ ] motor King

D [ ]. Vehicle boot

46. How would classify the road network from your farm to the market?

A[ ]. poor B. [ ] fairly good C[ ] good D[ ] very good

E[ ]. Excellent

47. How long does it take you to move your produce from the farm to the point of sale/export? A[ ]. 1 – 2 days B[ ]. 3 – 7 days C[ ]. More than 7 days

D[ ].one month or more

48. If fruits are not transported immediately to the market how do you keep them?

A [ ] under shade B[ ] refrigerated C[ ]. Heap on farm grounds

D [ ] . spread on the floor

49.What do you do with excess produce? A [ ]. for processing B[ ] . sell cheaply

c. store for some time D[ ]. dried for future use E[ ]. Discard them.

50. Are there enough processing factories to process excess fruits?

A[ ] . Yes B[ ] . No C[ ] . Not available D[ ] . Few

51. Do you have processing equipment?

A[ ] . Yes B [ ]. No C[ ] Cannot afford

D[ ]. intends to by one I future.

52. Are the facilities resources – financial support, equipment, sales / marketing enough to encourage you to produce more? A[ ] . Yes B[ ] . No

53. State some ways by which mango production could be improved in your area.

i……

ii…….

iii……

SECTION E

MARKETING AND PROCESSING

54 . Where do you sell your Harvested Mango Fruits? A [ ] wholesaler B. [ ] Retailers

C[ ]farm gate D[ ] Export E[ ] processors

F [ ] others (specify) …….

55. Does your mango have preferred qualities by buyer?A [ ] Yes B [ ] No

56. If yes state the preferred qualities they lookout for……

57. If No, what intervention are needed to improve quantity and quality of Mangos fruits production to attract better prices……..

58. Do you find buyers for all mangos harvested, [ ] Yes B[ ] No

59. If no, what do you do ……

60 . Which of the following are the mango marketing constraints? (Tick as many responses as Applicable)

I. Lack of marketing [ ]

II. Low price of product [ ]

III. Lack of storage [ ]

IV. Lack of transport [ ]

V. Lack of market information [ ]

VI. Perishability of product [ ]

VII. Low patronage by consumer [ ]

VIII. Middlemen interference [

61. How is the trend of price per unit of sales of mango fruit production during the last 5years (tick)

crop type	Increase	Decreasing	Same
Mango			

62.1 If the price increase, what are the reasons……

……

63. If the price decrease, what are the reasons…….

……

64. Would like to expand mango trading? , A[ ] Yes B [ ] No

65. What opportunities exist to expand mango production trading?.....

……

66. Which of the following are the factors affecting postharvest handling of mango fruits? (Tick as many responses as Applicable)

I. Harvesting and field handling [ ]

II. Packaging [ ]

III. Transportation [ ]

IV. Marketing [ ]

V. Perishability of product [ ]

RECOMMEDATION

What should be done at the following levels to improve the potential mango fruit production?

67. Crop production level

……

……

……

68 The district level

……

……

……

69. The regional level……

……

……

……

69. National level

……..

……

……

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

HORTICULTURAL DEPARTMENT

APPENDIX B: QUESTIONNAIRE FOR FRUIT SELLERS

I. INTRODUCTION

This is a study being undertaken by an MSc Post Harvest Technology student of the Institute of Distance Learning, Kwame Nkrumanh University of Science and Technology "the Evaluation of losses in the Postharvest Handling of Mango fruit (*Mangifera indica*) from the farm get to the Marketing in Ghana. A case study in the Northern Region". The purpose of the study is to assess the Postharvest handling of mango the Northern Region. This interview guide is basically for academic purpose and respondents are assured of privacy and confidentiality.

Thank you.

Please tick (√) the appropriate box and fill in the blank spaces where appropriate

1. Who are the main suppliers of the mango fruits? A [ ] Farm gate
   B [ ] wholesalers C [ ] Middlemen/Traders D [ ] Retailers
2. How are the fruits sent to you/obtain the fruits? A [ ]. In baskets
   B [ ]. Sacks C [ ] Refrigerated Van D [ ]. Open Trucks E [ ] motor King
3. Do you incur some losses after delivery of the fruits?
   A. [ ] Yes B[ ]No.
   a. If Yes, how much?A[ ]. 1 – 10% B[ ]. 11 – 20% C[ ] 21 – 40%
   b. D[ ] 41 – 50% E[ ] Above 50%.
4. What are the causes of the losses? Rank them as 1, 2, 3, 4, 5, 6 etc in the order by
5. which they affect the fruits .A[ ].cuts and bruises B[ ] exposes to long period of heat C[ ]. poor road network D[ ] wrong packing of fruits E[ ].over loading F[ ].softening due to over-ripening
6. . At what stage do you buy your mango fruits? A [ ] full-ripe, B [ ] half -ripe , C [ ] physiological matured(green)

7. Which of the following method(s) do you use to ensure longer life span of fruits?
    a. A [ ].Sorting and grading B [ ]. Removal of diseased and rotten fruits
    b. C [ ]. Keeping them in cool environment [ ] D. Refrigeration
8. Can you mention some problems you encounter in storing the fruits?
    a. i……
    b. ii……
    c. iii……
9. Mention some of the problems you encounter in getting fruits for sale.
    a. i……
    b. ii……
    c. iii……