ASSESSMENT OF POST-HARVEST LOSSES OF MANGO (*Mangifera indica* L.) IN MOROGORO REGION

BY

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ABSTRACT

High postharvest loss of up to 60 % due to improper postharvest handling practices during the supply chain has been reported in fresh mango fruits in Tanzania The study was conducted to determine mango fruit damages in different stages of the supply chain and develops suitable practices for reduction of postharvest losses during the wholesale market in Morogoro region. Based on farmers/traders practices, postharvest losses of mango fruits at harvesting, transportation and wholesale storage were evaluated. Moreover, an assessment was conducted to compare fruit postharvest losses when 'tenga' were loaded with or without separators in between for truck transportation and when fruit 'tenga' were stored under the sun, woven polypropylene and black net shades during the wholesale storage. Survey data were analysed using SPSS program based on cross tap method whereas data analysis to compare effect of separators between cartons on fruit losses based on Student t-test ($P < 0.05$). Data to compare effect of shades on fruit losses were subjected to analysis of variance and treatments mean separation was carried out based on Tukey test ($P < 0.05$). The total postharvest losses of mango fruits encountered in all stages along the supply chain was 43.8 % with the main damage features being caused by fruit fly maggots, microbial decay and fruit softening each accounting for 8.65, 11.85 and 20.05 % of the total losses, respectively. Conversely, fruit storage under the shades significantly ($P < 0.05$) reduced fruit postharvest losses from 31.09% under the sun to 9.31 and 11.34 % under the woven polypropylene and black screen shades, respectively. It is recommended that traders should use separators between 'tenga' during long distance mango fruit transportation and store fresh mango fruits under polypropylene shade during the wholesale storage market in order to reduce postharvest losses. Municipal or district authorities are argued to construct cold storage facilities for storing fresh fruits.

Furthermore, farmers should disinfect fruits against fruit fly eggs and decay micro organism as a strategy to reduce postharvest losses.

DECLARATION

I, Elde Saul Kimaro, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

05/08/2011

Elde Saul Kimaro

Date

The above declaration is confirmed

05/08/2011

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(Supervisor)

Date

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LIST OF ABBREVIASIONS AND SYMBOLS

ANOVA	-	Analysis of Variance
cv.	-	Cultivar
DASL	-	Department of Agriculture Sri Lanka
^0C	-	Degree Celcius
FAO	-	Food and Agriculture Organization
FAIC	-	Ficci Agribusiness Information Center
MAFS	-	Ministry of Agriculture and Food Security
NGMG	-	New Guyana Marketing Corporation
RCD	-	Randomized Completely Design
RH	-	Relative Humidity
SPSS	-	Statistical Package for Social Siences
TFC	-	Tanzania Federation and Cooperatives
TMPA	-	TelMed Pac Agriculture
UMADEP	-	Uluguru Mountain Development Programme
URT	-	United Repulblic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1. Background

Mango (*Mangifera indica* L.) is among the most important fruits in Tanzania and in export market, it ranks third after citrus and pineapple (FAO, 1999). The crop provides income to growers and traders and its production has been growing steadily in the last few years (FAO, 2000). Mango production in the country has increased from 61,680 metric tones in 1990/91 to 254 550 metric tones in 2004/2005 (URT, 2003). The export market is growing, especially in the Middle East countries, where 49 metric tons have been exported to the Middle East markets in 2003 (TFC, 2008).

Mango fruits are usually harvested from November to April, and this makes the country to have competitive advantage to access to the Middle East market. During this time there is an off season in mango supply from the Asian countries such as India and China, which dominate this market (TFC, 2008).

Mango fruits are picked when they begin to change colour or after a few fruits have dropped from a tree (Samson, 1986). Other useful maturity indices for picking mango fruits are total soluble solids of at least 12 % brix, fruit specific gravity of 1.01 and firmness of 1.75 to 2.0 kg/cm^2 (Medlicort, 2003). The same author indicates that harvesting of mango is a delicate process and is done by hand because the fruit is easily bruised. In commercial mango production, fruit pickers climb the tree with a bag and special knife consisting of bamboo pole with attached knife and open cloth bag. Chaplin (1981) advises to leave 5 mm of stalk on the fruit in order to prevent stains from exuded sap. The same author recommends picking fruits early in the day and to cool them immediately to 12-15° C. Similarly, harvested mangoes should not be left in direct sunlight, wind or rain, either in the field or during transportation (Medlicort, 2003). The rate of respiration and ripening, development of pigments, flavour compounds, polyphenolics, sugars, fruit quality, and postharvest diseases are all affected by postharvest handling procedures (Angela, 2004).

Fruits are packaged in cardboard boxes in a single layer to about 4-5 kg in weight per box. Each alternate mango in a carton should be wrapped in a tissue paper to reduce fruit to fruit rubbing (Singh, 1986; Madlicortt, 2003). Cool chain is essential during the transportation of export quality fruits for it helps in maintaining the temperature inside the box in the cold storage (FAIC, 2008). Trucks are used to transport fruits over long distances of 800 - 1000 km, connecting the producing centres to the consuming centres (Iksan, 2000). Fruit transportation during the night is preferred because of low temperature and high relative humidity (Ikisan, 2000; Pathac, 2006; FAIC, 2008; Iqbal, 2008).

Mango fruits are preferably stored at temperatures of 8-9 °C and relative humidity of 85-90 %. According to Campbell *et al.* (2000), 10 - 12 °C is the best temperature for storage of mangoes. Mangoes start to ripen at 12 °C if stored for long periods of time while when they are stored below 10 °C develop chilling injury symptoms (Medlicott, 2003 and Angela, 2004). Thus, mangoes must be ripened between 18 and 22 °C for optimum appearance and eating quality. Mangoes ripened under the correct conditions have yellow colour, are soft to firm and sweet with little acidity (Iksan, 2000; Pathac, 2006; Iqbal, 2008).

Postharvest losses of mango fruits have been estimated at 25 – 40 % in India and at 69 % in Pakistan (Iqbal, 2008 and Iksan, 2008). The main causes of postharvest losses include improper handling before, during and after harvesting (Medlicott, 2003). Field management such as pest control leads to minimal postharvest losses (Samson, 1986). Harvesting during cool part of the day, picking by using poles, removal of latex and field heat, fruit treatment by hot water, use of proper transportation trucks, transportation during the night and storage of fruits under the shade reduce postharvest losses (Iksan, 2000 and FAIC, 2008; Iqbal, 2008).

1.2 Problem Statement and Justification

In Tanzania, harvested mango fruits in 30 – 40 kg containers are loaded onto a truck without using separators in between them and are transported under bumpy roads and unfavourable weather conditions. Even after the arrivals to urban markets, the containers with fruits are dumped on dirty ground, under sunny, dry and hot conditions. The postharvest loss of mango fruits in Tanzania has been estimated at 60 % (TFC, 2008). There is a diversity of mango varieties in Tanzania but Dodo is the most predominant mango variety among small-scale farmers in Morogoro region. In Tanzania, mango fruits pass through various stages along the supply chain as they move from orchards to markets. The main stages of the supply chain are harvesting, transportation and wholesale storage during marketing. The postharvest losses of mango fruits as they pass at different stages along the supply chain are presently unknown. Development of appropriate intervention strategies to reduce postharvest losses of mango requires knowledge on causes of the fruit postharvest losses at the various stages of the supply chain. The causes of high postharvest losses of mango fruits under small-scale supply chain are hardly known.

This study intends to determine postharvest losses of mango fruits at different stages of the supply chain so as to develop suitable transportation and storage conditions for reduction of postharvest losses of the fruits.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of this study was to determine mango fruit postharvest losses during different stages along the supply chain and develop suitable practices for reduction of postharvest losses during the wholesale market in Morogoro region.

1.3.2 Specific objectives

The specific objectives of this study were:

i. To assess the appropriateness of postharvest handling practices used by farmers and sellers handle mango fruits.
ii. To determine mango fruit postharvest losses during harvesting, transportation and storage under small scale farmers' and sellers' practices.
iii. To assess the effect of loading fruit containers with separators in between them on postharvest losses of mango fruits during for transportation.
iv. To assess the influence of storing mango fruits under shades in the wholesale market on postharvest damage and losses.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of Mango

2.1.1 Uses of mango fruits

In most mango growing countries, the bulk of mango produced is generally consumed as fresh fruit and mostly in the ripened form (Mtebe *et al.*, 2005). Mango is named as divine food (Tasneem, 2004) and is among the many fruits consumed for their potential health benefits, including anticancer and antiviral activities due to its abundance in antioxidants (Angela, 2004). Mango is usually called the king of tropical fruits containing high levels of vitamins, especially ascorbic acid (vitamin C), (Tasneem, 2004) (Table 1). Green mangoes are often eaten with salt, and they are cooked or used in salads in the tropics. About 25 % of mangoes are processed into juices, chutneys, sauces, or dried (Mark, 2006). The seed can be processed into flour, and the fat it contains can be extracted and substituted for cocoa butter (Medlicort, 2003 and Mark, 2006).

Table 1: Dietary value per 100 gram edible portion of fresh mango fruits

Nutrient	Quantity (mg)	Vitamins	Quantity (mg)
Proteins	360 – 600	Vitamin A	0.135 – 1.872
Fat	300– 530	Thiamine	0.020 – 0.037
Carbohydrate	16200 – 17180	Niacin	0.025 – 0.0707
Fibre	85 – 1060	Vitamin C	7.80 – 172 .00
Ash	0.34 – 0.52	Tryptophan	3.00 – 6.00
Phosphorus	5.50 – 12.80	Methionine	4.00
Iron	0.02 – 0.63	Lysine	32.00 – 37.00

Source: Angela (2004) and Mark (2006)

2.1.2 Economic importance of mango

Mango originated in the Southeast Asia, and is now produced by several countries worldwide. India is the leading world producer, providing over 60 % of the world's supply (FAO, 2000), followed by China, Mexico, Thailand, Philippines, Pakistan, Nigeria, Indonesia, Brazil and Egypt providing up to 40 % of the world market (FAO, 1999). Mango was ranked second to bananas among fruit crops and fifth in terms of world tropical and subtropical agricultural production in 1996, and is currently ranked second to pineapple in quantity and value (FAO, 2003).

2.2 Mango Production in Tanzania

In Tanzania, mango is produced under widely varied environments and management conditions. This widespread production brings with it a range of special challenges. The crop is one of the traditional fruits grown mainly in coastal zone (Dar es Salaam, Coast Region, Tanga, Pemba and Unguja) and Morogoro and Tabora regions. In North Eastern Tanzania, mango is mainly grown in Tanga and Kilimanjaro regions (TFC, 2008). In Tanzania and Africa at large, processing of mango is less developed and cultivars grown are most suitable for local markets (TFC, 2008).

The production of mango in Tanzania has increased by 300 % from 1990/91 to 2004/5 (TFC, 2008). Common upcoming mango export cultivars include Apple, Palma, Boribo, Dodo, Haden, Keitt, Kent, Van Dyke, Red Indian, Alphonso Tommy Atkins, Ngowe and Hadijar. Apple and Ngowe have high demand by the export market sub-sector, especially in Gulf States (Niyibigira *et al.*, 2004) whereas Dodo is the most cultivated mango variety among small-scale farmers for local markets in Tanzania. The demand for mango in Gulf States is higher during October to March, which is the off-season for the major mango suppliers like India and Pakistan. In 2003, Tanzania exported 49 metric tons, (less than

0.05% totals production) worth US $ 60,000 (MAFS, 2003). Mango exports were projected to reach 2000 metric tons worth US $1 million by the year 2007. Mango exports from Zanzibar have been consistently rising from 16 metric tons in 1992 to about 100 metric tons in 1995. The export in the Island was projected to reach 2000 metric tons worth US $ one million by the year 2007. Unguja is the main mango producing Islands in Zanzibar (TFC, 2008).

2.3 Mango Supply Chain Systems

There are two supply systems of mangoes in Tanzania namely, traditional and commercial systems. The traditional system is characterized by farmers who sell their produces on farm or roadside stalls. This channel handles the traditional cultivars mostly during peak season (TFC, 2008). The commercial supply chain system is driven essentially by traders who use rural middleman/brokers to connect them to farmers. This channels most of the mango fruits during the season from farm to urban markets. In the commercial supply chain system, mango fruits pass through harvesting, grading, transportation, wholesale and retail storages stages but the postharvest losses of fruits at each stage are hardly known. During the off season (June to September) mangoes are occasionally imported into the country by supermarkets such as Imalaseko and Shoprite mainly from South Africa, Kenya and Zambia (TFC, 2008).

2.4 Types of Mango

There are two principal types of mangos namely, west Indian and Indochinese cultivars (Mark, 2006). Indian types typically have monoembryonic (single embryo) seeds, highly coloured fruits and are susceptible to anthracnose disease (Saul, 2008). The author also reports that, West Indian cultivars are more rounded and plumpy, and generally have a bright red blush to the skin. Many of the so-called "Florida cultivars" are West Indian types selected or bred in Florida, such as 'Haden', 'Tommy Atkins', 'Kent', and 'Keitt' (Mark, 2006). Conversely, the Indochinese mango cultivars have polyembryonic seeds (multiple embryos), and fruits usually lack coloration, and are resistance to anthracnose (Mark 2006). 'Dodo' cultivar possibly belongs to Indochinese mango type for it has polyembroynic seeds and poor peel coloration at ripe stage.

2.5 Maturity Indices Mango Fruits

According to Iksan (2000), chemical, physical, and physiological parameters are used to define the maturity stage for harvesting of mango fruits. The most useful chemical indices are acidity, soluble solid contents, phenolic constituents and carbohydrate content (Angela, 2004). Physical indices include fruit size, shape and pit around pedicels, lenticels and specific gravity (Samson, 1986). Moreover picking of fruits when their specific gravity is 1.01-1.02 is reported to give satisfactory results in respect to uniform ripening and keeping quality (Samson, 1986 and Iksan, 2000). The attainment of full maturity as indicated by sinking in water appeared to be very essential for normal ripening of fruits under all conditions. Physiological maturity shows changes in the peel and pulp colour and fruits are harvested at peel green mature stage (Iqbal, 2008). An ancient advice for mango harvesting says "when first fruits begin to drop, the crop is ready for picking" (Tasneem, 2004). Alternatively mango fruits can be harvested in 80-180 days after bloom depending on cultivar and environmental condition of the area (Mark, 2006 and Iksan, 2000).

2.6. Harvesting of Mango Fruits

Mango fruit should be harvested early in the morning or late in the evening (Pathac, 2006) and collected in plastic trays and kept under shades (Iksan, 2000). A long-poled picking bag is used by pickers to protect fruits from mechanical damage due to falling impact

(Medlicort, 2003). Mango fruits should also be kept upside down to prevent latex oozing on the fruits (FAIC, 2000).

2.7. Biology of Harvested Mango

2.7.1. Physiological changes

The ripening of mango fruits passes through pre-climacteric, climacteric, post-climacteric to senescence phases. Pre-climacteric phase lasts for three days and is characterized by slow release of carbon dioxide while, climacteric peak occurs between 6 and 10 days and is characterised by softening of the fruit. Post-climacteric phase lasts for 10-14 days with a decrease in carbon dioxide production and attainment of fruit edible ripeness stage (Iksan, 2000; Iqbal, 2008 and Whangchai *at al.*, 2001). Once fruit have fully ripened, they begin the senescence process with respiration rates reaching their lowest levels while ethylene productions drop to hardly detectible levels (Angela, 2004). Senescence is that stage in which the membrane breaks down due to degradation of lipid bilayers, leading to cell damage and necrosis (Curry, 2006).

2.7.2 Chemical changes

Unripe fruits are characterized by generally green colour firm texture, high starch content, high organic acid concentrations and subsequent low pH (Panhwar, 2009; FAIC, 2008, and Angela, 2004). Ripening is characterised by hydrolysis of starch into glucose, fructose and sucrose (Panhwar, 2009). Sucrose is the predominant sugar and contributes to 57 % of total sugar in ripe mango (cv. Keitt) while fructose and glucose are 28 and 15 %, respectively (Tasneem, 2004). During ripening there is a decrease in citric acid and succinic acid, and an increase in malic and uronic acids (Iksan, 2000). The carotenoids, pH and sugars increase during ripening but at the end stage, the total soluble solids start to decline (Panhwar, 2009).

2.8 Postharvest Handling Practices of Mango Fruits

Postharvest losses in tropical fruits vary widely from 10 to 80 %t in developed and developing countries respectively. These losses occur all along the supply chain, beginning from the time of harvesting, packing, transportation, storage, and consumption (FAO, 1989). In most developing countries, this is mainly due to the combination of poor infrastructure and logistics, poor farm practices, lack of postharvest handling knowledge and a convoluted marketing system (TMPA, 2005). Generally, the emphasis in postharvest handling technology is on reduction in fruit field heat, reduction of mechanical injury, prevention to pathogen entry and water loss, use of suitable storage and packaging facilitating for both local and export markets (Kitnoja, 2005).

2.8.1 Pre-cooling of mango fruits after harvesting

The field heat of the product holds from the sun and ambient temperature is usually high, and should be removed as quickly as possible before shipping, processing, or storage (Bachmenn and Earles, 2000). Pre-cooling is the first step in good temperature management (Iqbal, 2008). Harvested fruits should be stored under the shade for about two hours to make them cool and remove the field heat (Bachmann and Earles. 2000).

2.8.2 Fruit disinfection

Mangoes are highly perishable often due to increased susceptibility to bacterial and fungal diseases (Panhwar 2009; Swart, 1999). Insects and diseases results in loss of yield and deterioration of quality and thus adequate control are essential (Yahia, 1999). Damaged fruit parts are susceptible to microbial infection, particularly when low temperature long-term storage is used (Panhwar, 2009). Careful handling should therefore be used during harvesting and handling operations such as grading, packing, transportation and storage (Legder, 2004).

Preharvest pest control contributes very significantly to increase mango yield and quality (Yahia, 1999). Various techniques are used to reduce postharvest loss and increase shelflife of mango fruits in the world. According to Iksan (2000), field application of fungicides, followed by postharvest hot water treatment improved the shelflife of fruits. Similarly, pre- and postharvest application of benomyl for control of latent infection of anthracnose (*Colletotrichum spp)* has been recommended (Swart, 2009). Add all diseases of importance in postharvest decay. In addition, the treatment of mango fruits with hot water at 52 ^{0}C containing benomil at 500 - 1000 mg/l for five minutes reduced the incidence of postharvest diseases (Panhwar, 2009). Iqbal (2008) recommends vapour heat treatment to control infections of fruit flies in harvested fruits. Washing fruits in hot water at 52 - 55 °C for 10 minutes also kills insect eggs and sanitize the fruit from bacterial and fungus infections (Panhwar, 2009).

2.8.3 Grading and packaging of mango

Fruits should be graded in each carton according to the variety, size and maturity (Medlicort, 2003). Grading mango fruits is very important as it has been observed that bigger sized fruits take 2-4 days more time in ripening than smaller ones (FAIC, 2008). Therefore, packaging of smaller fruits with larger ones should be avoided to achieve uniform ripening. Firm green full mature and half mature fruits ripen at different rates should not be packed in the same carton. Immature, overripe, damaged and diseased fruits should be discarded (Legder et al., 2006). According to Medlicort (2003), fruits should be checked prior to packing to ensure absence of blemishes, bruises, insect and mechanical damage. When packing, the fruits should be placed leaning to the side rather than directly on the base (Iksan, 2000). Various types of package materials are used for mango depending on market requirements. According to Iksan (2000), wooden crates are good containers, especially for high value mango cultivars which are packed in mature condition. Packaging should be designed to prevent physical damage and be easy to handle (Bachmenn and Earles, 2000).

Mango fruits for local markets are often packed in baskets or wooden crates, which may be lined with straw or leaves (Iksan 2000). Net pack weight requirements are 4 to 5 kg depending on the carton and the market destination (Pathac, 2006). Cartons must not be over-filled during packing (Mark, 2006; Medlicort, 2003). Packs weighing more than 25 kg are difficult to handle carefully and can cause damage to fruits (Wilson, 2008). Wooden boxes are commonly used for packaging and transportation of mango fruits (Medina and Garcia, 2002). The ideal field container is a durable plastic crate that is well ventilated and has a smooth inside (NGMC, 2009).

Iqbal (2008) recommends that boxes should not be over packed within a truck because the fruits in lower boxes may suffer damage from the weight of boxes above. Packing mango fruits in containers tightly reduces fruit movement within containers, and this is important when both road and trucks are in bad conditions (Vijay, 2003). Under-packing fruits results in excessive movement of the fruit within the boxes, leading to bruising or abrasion damage (Iqbal, 2008; Iksan, 2000). Usually, mango fruits are placed in layers one above the other, with a straw padding in between (Iqbal, 2007). The same author reports that mango fruits for export purposes should be cushioned by paper material scraps and newspapers to prevent them from getting bruised and spoiled during storage and transportation. Polythene lining has also been found beneficial for maintaining humidity, and reducing shrinkage during storage. Wrapping of fruits individually with newspaper or tissue paper and packing in honeycomb nets helps in getting optimum ripening with reduced spoilage (Iqbal, 2008).

2.8.4 Transportation

The pick-up, enclosed truck, open truck or refrigerated vehicles have been adopted as the most convenient mode of transport due to their easy approach from the orchards to the market (FAO, 2002). However, trucks were found unsuitable for transporting live material as they exert lot of pressure on the fruits and may not contain temperature control devices (Iksan, 2000).

Proper arrangement of boxes in the truck to allow good air circulation is recommended (Pathac, 2006). The author advises that fruits should be carefully loaded onto trucks, transported during the cooler part of the day and trucks should be covered well leaving proper ventilation (Pathac, 2006). Traders in Tanzania do not use separators in between fruit cartons when loading them onto a truck and overload cartons to maximise profit. Although the effect of loading mango fruits with separators has been reported elsewhere, in Tanzania with bumpy roads and hotter weather, the effect of separators between cartons is hardly known. Refrigerated vans are recommended as vehicles good for transport of mango fruits (Iqbal, 2008). Temperature management is also important as postharvest diseases are favoured by temperatures above 25°C during ripening in transportation (ledger, 2004). In addition, fruits should be arranged in containers by putting pallet in between them to reduce loses due to compaction during transportation.

2.8.5 Storage practices

Harvested mango fruits continue to undergo the biological activity of respiration and transpiration during storage (Bachmann and Earles, 2000). Mangoes are tropical fruits, and are therefore sensitive to chilling when stored below a critical minimum temperature (Tasneem, 2004). Prolonged low temperatures during storage also retard ripening. Recommended storage temperatures for mangoes are in the range of 10 - 15 °C which leads to storage shelflife of 2 - 3 weeks. The best ripening temperature ranges from 19 to

24 °C while high temperature of 32 °C retards ripening process (Eileen and Joselito, 2001). In Tanzania, the majority small-scale traders store mango fruits under the sun during marketing where temperatures are as high 30 - 32 °C. Cold storage facilities are unavailable but storing mango fruits under shades using locally available materials could reduce postharvest losses.

It is recommended to store mango fruits at relative humidity of 98 - 100 % but this humidity accelerates development of fungi diseases (Campbell, *et al;* 2000, Pathac, 2006; and Wilson, 2008). On the other hand, water loss increases in the fruits with decreasing relative humidity (NGMC, 2009). Temperature and relative humidity are managed by storing fruits under the shades after harvesting (DASL, 2008).

The effect of ethylene as ripening stimulant can be inhibited by carbon dioxide concentration in the fruits and reduction of oxygen (Ryall, 1974). This condition prevails in controlled atmosphere storages and is practiced by elevating carbon dioxide and lowering oxygen levels surrounding the product. High carbon dioxide and low oxygen levels lead to decrease in respiration and ethylene production rates (Tasneem, 2004). In a closed storage, the respiration will simultaneously lead to build-up of carbon dioxide and depletion of oxygen. Controlled environment can provide an effective storage environment for different fruits, including mango fruits (Tasneem 2004 and Ryall, 1974).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Survey and Experiments

This study had two parts namely, field survey and experiments. The field survey aimed at finding farmers and trader's knowledge and skills on postharvest handling practices of mango fruits.

3.1.1 Description of survey study area

The survey was conducted in four villages (Mfumbwe, Kibwaya, Kiholole and Mkuyuni) in Mkuyuni ward, and Kiroka village in Kiroka ward in Morogoro region. The topography of the area was hilly with altitude ranging from 180 to 300 m asl. The climatical conditions were humid tropical at lower and sub tropical at high altitude. Total annual rainfall ranged from 1300 to 2900 mm with short dry seasons (less than two months). This climate favours growth of mango fruits and various fruits including citrus, jackfruit, breadfruit and banana, various spices (black pepper, vanilla, turmeric) and field crops (maize, paddy and beans) (UMADEP, 2001). Mango cv. 'Dodo' is the most popular commercial fruit crop cultivated in this area. The survey was also conducted in Mawenzi and Central market in Morogoro Municipal Council.

3.1.2 Survey design

Ten mango farmers each from the five villages at Mkuyuni and Kiroka wards were purposively selected for the study (Table 2). Five traders each from the central and Mawenzi markets were selected. Mango growers and traders were purposively selected based on their involvement in mango business. Farmers with at least 10 mango trees and traders annually involved in mango marketing were considered as good informants.

Table 2: Number of respondents interviewed and their respective villages/markets

Ward	Village/market	Number of respondents
	Mfumbwe	9
Mkuyuni	Kibwaya	8
	Kiholole	13
	Mkuyuni	10
Kiroka	Kiroka	7
Morogoro Town	Central markets	5
Chamwino	Mawenzi market	5
Total		**57**

3.1.3 Data collection

Data from the interview were collected using structured questionnaires with open and closed ended questions (Appendix 1). These data included fruit maturity indices, harvesting time and methods, types of packing materials, type of cushioning materials, transportation means, and storage conditions in the markets, fruit shelf life and postharvest losses.

3.2 Experiments

Two experiments namely experiment 1 and experiment 2 were conducted. Experiment 1 was conducted to determine mango fruit postharvest losses at different stages of the supply chain namely harvesting, transportation and wholesale storage markets.

3.2.1. Description of the experimental material

Mango cv. 'Dodo' fruits were harvested from farmers' orchards at Kibwaya village (500 fruits) and Kiholole village (4500 fruits) on 9 – 10th February 2009. Fruits were harvested according to farmer's practices. How did you determine harvesting stage? Fruits were harvested using poles with sleeve and ring at the top to pick fruit (Figure 1).

A picker had ability of carrying up to five fruits and putting them in a collection container ('tenga') on a tree from where 'tenga' were delivered down using a rope (Fig. 2). The slight rigid 'tenga' were made of bamboo plants with perforations to allow air circulation (Yahia, 1999). 'Tenga' were cushioned by dry banana leaves and each tenga was packaged with 125 to 130 fruits.

Figure 1: Harvesting mango fruits using a pole with ringed sleeve

Figure 2: Harvested mango fruits delivered down from a tree using a rope.

3.2.2. Experimental layout and design

'Tengas' with mango fruits were packed in an open body truck the way traders and farmers do. Fruits were transported from Mkuyuni ward to Morogoro Town (about 40 km) starting from 8.00 am to 10 am. After the arrival to the urban market the fruit cartons were kept on the ground under the sun for three and five days to simulate wholesaler marketing during peak and low seasons. Long distance fruit transportation was carried out from Mkuyuni to Dar es Salaam (about 250 km) during the night at 21.00 pm to 1.00 am.

3.2.3 Data collected

Data collected during harvesting, transportation and wholesale storage market stages included the number of marketable and unmarketable fruits (postharvest losses). Unmarketable fruits were characterised by defect caused by insect, microbial decay, and bruises during handling and over softening as shown in (Fig. 3, 4, 5, 6, 7 and 8).

Figure 3: Marketable mango fruits of 'Dodo' cultivar

Figure 4: Fruit damage by falling during harvesting

Figure 5: Fruits damaged by maggot of fruit flies in wholesale storage market (Iqbal, 2008)

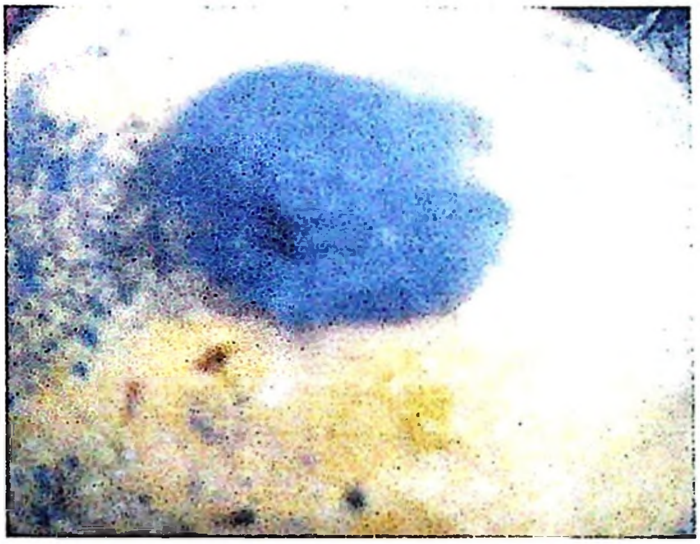

Figure 6: Fruit damage features by microbial decay in wholesale storage market (Ledger, 2004).

Figure 7: Fruit damage features of microbial decay on wholesale storage market (Ledger, 2004).

Figure 8: Fruit damage by microbial decay on mango fruits observed in wholesale storage market (Ledger, 2004).

Figure 9: Damage features of overripe and softened fruits in wholesale storage market.

3.3 Experiment 2

This experiment had two parts namely, part 1 and part 2. These experiments were meant to determine the postharvest occurred during transportation and in wholesale storage markets.

3.3.1 Description of part 1 of experiment 2

Mango cv. 'Dodo' fruits were harvested as per Experiment 1 above. The experiment was conducted on a truck running 40 km from Mkuyuni ward to Morogoro urban markets.

3.3.2 Experiment design

The experiment setup was randomized completely design with one treatment and one control. A treatment consisted of fruit 'tengas' arranged in the truck by one row separated by putting poles in between 'tengas'. In a control, 'tengas were loaded into a truck without separators/poles in between. The treatment and a control were replicated four times each with nine 'tenga' each containing 125 fruits.

3.3.3 Data collection

Data collected at the end of transportation and fruit damage features were the same as those collected during harvesting stage.

3.4 Description of part 2 of experiment 2

The experiment was conducted at Horticulture unit of Sokoine of Agriculture to simulate wholesale storage conditions. Mango cv. 'Dodo fruits harvested from Mkuyuni were used in this experiment. Two shade structures were constructed each with dimensions of 300 cm width, 300 cm length and 400 cm height. The first shade structure was roofed with woven polypropylene sheet (Twiga Cement Ltd) and second one with black net (Balton Tanzania Company). Polypropylene sheet were obtain from used cement bags (Fig. 10) and is sued as shade material by fruit retail traders. The black net has shading capacity of 40% and is specifically used as a shade material (Fig. 12.) The sides of shade structures were left uncovered; the detailed description of these shades is given below (Table 3).

Table 3: Description of treatments assessed in part two of experiment

Type of shade	Temperature (C^o)	Relative humidity (%)
No shade (under sun)	31.7	44.2
Polypropylene sheet	28.7	47.0
Black net screen Shade*	29.7	46.0

*Black perforated sheet with light reduction by 40%

Figure 10: Polypropylene sheet obtained from twiga cement used as shade of Mango fruits.

Figure 11: Fruit 'tengas' stored under full sunlight

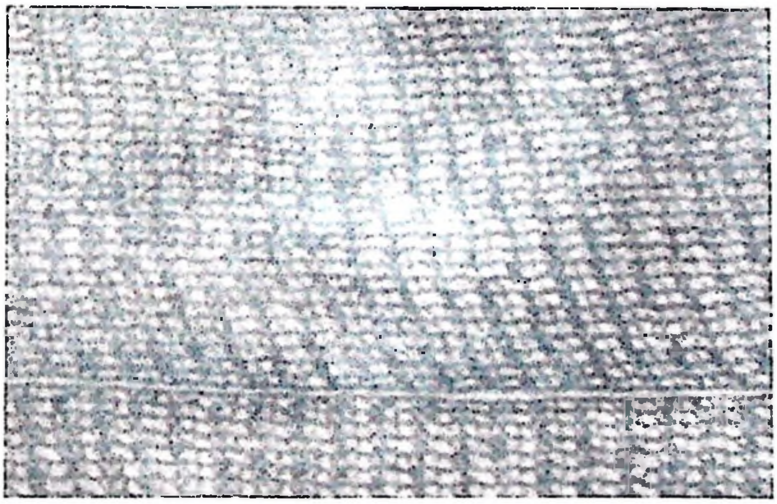

Figure 12: Black net shade used for storing mango fruits

3.4.1 Experimental design

The experimental setup was a randomized completely design (RCD) with three replications. These treatments were woven polypropylene shade, black net screen shade and full sunlight as control. A replicate contained six 'tengas' each with 125 fruits.

3.4.2 Data collection

Fruit 'tenga' were opened on the third day of the wholesale storage. Data collected during this stage were the same as those collected in experiment 2.

3.4.3 Data analysis

Data were analyzed according to type with different statistical ware and methods as presented below (Table 4)

Table 4 : Statistical methods used to analyse the different data set

Statistical soft ware used	Statistical method used for data analysis	Type of data analysed
SPSS 12	Crosstabs	Survey data
COSTAT	ANOVA based on F-test ($P < 0.05$)	Fruit damage at different stages of the supply chain
		Performance of fruits in wholesale market in different type of shades.
	Mean separation based on Turkey test ($P < 0.05$)	Fruit postharvest losses at different stages of the supply chain.
		Fruit postharvest losses in wholesale market in diffeıent type of shades
	Student t- test ($P < 0.5$)	Fruit postharvest losses in short and long distance transportation
		Fruit postharvest losses in 'tenga' with and without separators

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1. Mango Fruit Harvest and Postharvest Practices Used by Farmers and Sellers

4.1.1 Mango fruit harvesting practices

About 49.1 % of the farmers harvested mango based on fruit falling under the tree 22.8 14 and 5.3. % of the farmers harvested the fruits based on numbers of days from first flowering, change of fruit colour and fruit shoulder enlargement (Table 5). The majority of respondents (68.4 %) harvested mango fruits irrespective of time from morning to evening (whole day) while 26.6 % of them harvested the fruits in the morning only.

Table 5: Maturity indices, harvesting time and methods of mango fruits according to farmers' practices in Mkuyuni and Kiroka wards in Morogoro Region

Variables	Frequencies (n=57)	Percentage (%)
Fruit maturity indices		
Fruit falling under the tree	28	49.1
Number of days after flowering	13	22.8
Fruit colour change	8	14.0
Fruits shoulder enlargement	3	5.3
All indices above	5	8.8
Total	**57**	**100.0**
Harvesting time		
Whole day	39	68.00
Morning only	18	26.00
Any time of a day	3	6.00
Total	**57**	**100.0**
Harvesting methods		
Using pole with open bag & knife	57	100.0
Hand picking		0.00
Tree shaking		0.00
Total	57	**100.0**

The majority of farmers harvested mango fruits based on fruit falling under the tree. This fruit maturity index is in agreement with Samson (1986) who also recommended harvesting mango fruits when a few start falling under the tree. Farmers in these study areas harvested mango fruits in the morning when it was still cool and this is in agreement with standard recommendations on harvesting time (Iksan, 2000; Angela, 2004 and Tasneem 2004). All farmers harvested mango fruits using a long pole attached with sharp knife and an open cloth bag. This is a recommended harvesting method and agrees with Chaplin (1981) who recommended the use of proper harvest tools such as use of pole with a sharp-edged cutting blade and sleeve attached at the end. This harvesting method greatly improves fruit quality, reduces post-harvest losses and extends the shelf-life Abu-Goukh and Havisa (2006).

4.1.2 Packaging and transportation of fruits

All farmers in this study experienced low fruit postharvest losses during harvesting ranging from 2 to 4 % (Table 6). The low postharvest loss was probably due to the fact that farmers used proper harvesting tools which reduced fruit bruising and breakage due to falling impacts. Moreover, farmers immediately put the harvested fruits upside down in order to prevent fruit burning due to latex oozing on the surface. Respondents cushioned tenga with dry banana and grass leaves prior packing mango fruits in it (45.8 %) while 31.6 and 22.8 % of all respondents cushioned the tenga with dry grasses only and dry banana leaves only, respectively (Table 6).

About 96.5 % of the respondents in this study transported mango fruits using open body trucks, while 3.5 % carried their fruits by head to nearby markets and only 3.5 % of respondents used other types of vehicles (buses and pickups) depending on the amount of fruits and travelling distance (Table 6). About 66.6 % of the respondents transported their fruits during the night while 31.4 and 3.4 % respectively did so during mornings and afternoon only. About 80.2 of respondents in this study reported high fruit postharvest losses of 21 – 25 % while 19.8 % reported losses of 16 – 20 % during transportation.

Table 6: Packaging and transportation practices of mango fruits according to farmers and sellers in Mkuyuni and Kiroka in Morogoro Region

Fruit handling practices	Frequencies (n=57)	Percentage (%)
Cushioning material		
Dry grasses and banana leaves	26	45.6
Dry grasses only	18	31.6
Banana leaves only	13	22.8
Total	**57**	**100.0**
Fruit transportation means		
By trucks	55	96.5
By carrying	2	3.5
Total	57	**100.0**
Type of trucks		
Open body trucks	55	96.5
Closed body trucks	2	3.5
Any other type of vehicles	0	0.0
Total	**57**	**100.0**
Fruit transportation time		
At night only	38	66.7
Afternoon only	17	30.0
Morning only	2	3.3
Total	57	**100.0**
Fruit losses during transportation (%)		
16- 20	11	19.2
20- 25	46	80.8
Total	57	**100.0**

Farmers drained out the latex by putting harvested fruits upside down. The practice of putting harvested fruit upside down was also recommended by Medlifort (2003). In agreement to farmers' practices, several studies have recommended packaging mango fruits by placing them in layers with a straw padding in between (Iksan, 2000; Pathac, 2006; Wilson, 2008).

Farmers transported mango fruits during the night when it is cool but also to avoid road inconveniences such as traffic jam and police traffic interrogations. Fruit transportation during the night is most recommended because of low temperature and high relative humidity which reduce fruit postharvest losses (Ikisan, 2000; Pathac, 2006; FAIC, 2008 and Iqbal, 2008). The majority of farmers and traders reported high fruit postharvest losses of mango fruits possibly due to several factors such overloading of fruit cartons onto a truck and transporting them in bumpy roads. Yahia (1999) recommends using separators in between containers to reduce fruit damage due to compression.

4.1.3 Storage of mango fruits in the wholesale market by traders

The interview in this study revealed that 54.7, 27.9 and 17.4% of the traders stored mango fruits under the sun, polypropylene sheet shade and iron roofed building shade, respectively (Table 7). About 52.6, 35, 8.7 and 3.5 % of the respondents reported storage losses of mango fruits of 41 – 50, 31 - 40, above 50 % and 20 – 30 %, respectively. All traders revealed that the shelflife of mango fruits ranged from 7 to 12 days in the market when stored under sulphate sheet shade.

Table 7: Storage and postharvest losses of mango in the wholesale market according to traders and farmers in Morogoro Urban

Variables	Frequencies (n=57)	Percentage
Mango market storage place		
Under the sun	32.8	54.7
Sulphate sheet shade	16.7	27.9
Iron roofed building shade	2.9	17.4
Total	**57.0**	**100.0**
Mango postharvest losses (%)		
Above 50	5.0	8.7
41 – 50	30.0	52.6
31 - 40	20.0	35.0
20 – 30	2.0	3.7
Total	**57.0**	**100.0**

The higher fruit losses in this study were probably caused by poor storage conditions in the wholesale market, especially fruit heaping under the sun. Yahia (1999) warned against storage of mango fruits under the sun for this can lead to 100 % fruit losses. The mango fruit shelflife of 7 – 12 days reported by traders in this study nearly agrees with Angela (2004) who also reported shelf life of mango fruits of 10 to 15 days when kept at room temperature.

4.2 Experiments

The effects of mango fruit postharvest losses during harvesting, transportation and storage under small scale farmers' and sellers' practices and the influence of storing mango fruits under shades in the wholesale market.

4.2.1 Postharvest losses of mango fruits along the supply chain

Fruit postharvest damage was significantly ($P < 0.05$) higher during the wholesale storage in the market with damaged fruits in the 5^{th} day of 30.60 % compared to 10.5 % during the truck transportation and 2.5 % during the harvesting stage (Table 8). The total mango fruit postharvest loss encountered from harvesting to the wholesale market storage was 43.8 %.

Table 8: Proportion of mature, ripe and damaged mango cv. 'Dodo' fruits at various stages of the supply chain in Morogoro region

Supply chain stage	Marketable fruits (%)	Postharvest losses (%)
Harvesting	97.4^{a}	2.6^{c}
Transportation	89.4^{b}	10.6^{b}
Wholesale at 3rd day	84.9^{c}	15.1^{b}
Wholesale at 5th day	69.4^{d}	30.6^{a}

Mean bearing the same superscript letter within the column are not significant different ($P < 0.05$) according to Tukey test.

The postharvest loss encountered in this study is comparable to mango fruit loss of 60 % reported in Tanzania (TFC, 2008), 75.4 % reported in mango cv. 'Chausa' and 68.6 % reported in cv. 'Sindri' (Malic and Mazhar, 2007). The wholesale storage was the most critical stage with the highest postharvest losses the increase of postharvest losses from 15.1 to 30.6 % from the third to the fifth day provides evidence that the crucial factors that contribute to high postharvest losses are found at the wholesale storage stage. The high fruit losses during the wholesale market were probably due to fruit storage under the sun which increases temperatures and fruit biochemical reactions/processes such as respiration and ethylene biosynthesis (Panhwar, 2009).

4.2.2 Effect of transportation distance on fruit postharvest losses

The fruit postharvest losses were 21.8 % under the long distance truck transportation compared with 10.7% under the short distance truck transportation (Table 9).

Table 9: Postharvest losses of fresh mango cv. 'Dodo' under short and long distance transportation

Distance	Marketable fruits (%)	Postharvest losses (%)
Long distance (250 km)	78.2[b]	21.8[a]
Short distance (40 km)	89.3[a]	10.7[b]

Mean bearing the same superscript letter within column are not significant ($P < 0.05$) different according to Student t-test.

The high fruit postharvest losses in the long distance truck transportation could be associated with high temperature and poor road conditions the stresses of which accumulate with distance. The use refrigerated vans for long distance transport and export purposes reduces the postharvest losses (FAIC, 2008).

4.2.3 Major damage features on mango fruits

The total postharvest losses of mango fruits during the harvesting stage were 2.6 % of which mechanical injury and microbial decay contributed to 2.0 % and 0.6 %, respectively (Table 10). The fruit damage features during the transportation were softening (1.60 %), microbial decay (4.9 %), mechanical injury (1.8 %) and fruit fly maggots (0.3 %). The postharvest losses during the whole storage market were 30.35 % with softening, fruit fly maggots and microbial injury contributing to 15.2, 8.7 and 5.2 %, respectively.

Fruit bruising was substantial during harvesting stage and was caused by mechanical damage while softening was high during the wholesale stage. The major causes of fruit softening are overripening and mechanical injury (Swart, 1999).

Table 10: Major damage features observed on mango fruits in each stage of the supply chain (%)

Type of damage	Harvest stage (n = 5000)	Transport (n = 1320)	Third day of wholesale storage (n = 2000)	Fifth day of wholesale storage (n = 2000)	Total
Fruit fly infestation	0	0.3	3	5.2	8.65
Microbial decay	0.6	4.9	7.5	8.7	21.7
Softening	0	1.6	3.25	15.3	20.05
Mechanical injuries	2.0	1.8	0.5	0.2	4.5

Fruit fly larvae and microbial decay can be reduced by dipping fruits in hot water 52 - 55 °C for 10 minutes to kills insect eggs and sanitize the fruit from bacterial and fungal infections (Benitez *et al.*, 2006). Similarly, dipping fruits in hot water at 50 – 55 °C for 2 - 5 minutes with 500 ppm thiabendazole or imazalil fungicide reduces anthracnose disease and fruit rot by 80 % (Panhwar, 2009).

4.3 The effect of loading fruit containers with separators in between them on postharvest losses of mango fruits during transportation

4.3.1 Effect of loading fruit cartons with separators on postharvest losses

The use of separators between 'tengas' significantly ($P < 0.05$) reduced fruit damage (10.00 %) by the third day at the wholesale storage market compared to 13.44 % fruit damage in un separated 'tengas' (Table 11).

The higher fruits damage in cartons without separators 'tengas' could probably be due to compression. Maximum fruit loss occurred at transportation from orchard to wholesaler (Kader 2008). According to Yahia (1999) packing of fruits in containers without separators causes high postharvest losses during transportation.

Table 11: Fruit postharvest losses at the end of truck transportation with and without separators between 'tengas'

Variables	First day		Third day	
	Load with separators between tenga	Load without separators between tenga	Load with separators between tenga	Load without separators between tenga
Marketable fruits (%)	90.5^a	89.4^a	90.0^a	86.5^a
Postharvest losses (%)	9.5^a	10.6^a	10.0^b	13.5^a

Means bearing the same superscript letter within the row are not significant ($p<0.05$) different according to Student t - test

4.3.2 Influence of shade on mango cv. 'Dodo' fruit postharvest losses

The results showed significant difference ($P > 0.05$) in postharvest losses of fruits stored under different shades. The fruit postharvest losses were 15.5% under the sun on the 3rd day compared with 7.1 and 9.3% under the polypropylene and black net shades, respectively. Likewise, the fruit postharvest losses on the 5th day were 31.1 % under the sun compared to 15.1 and 11.3 % under the polypropylene and net screen shade, respectively (Table 12).

Table 12: Fruit postharvest losses on the 3rd and 5th day during the wholesale market under different types of shades

Storage environment	Marketable fruits%	Unmarketable fruits%
Full sunshine	84.9^b	15.1^a
Polypropylene shade	92.9^a	7.1^b
Black net shade	90.7^a	9.3^b

Mean bearing the same superscripts letter within the row are not significant ($p < 0.05$) different according to Tukey test

The high fruit postharvest losses under the sun were probably due to high temperature. The high postharvest losses of mango fruits under the sun in agreement with Yahia (1999) who reported that an exposure of mango fruits in the sun for two hours can lead to 100 % losses. High temperature is reported to increase respiration and ethylene production in climacteric fruits like mango (Tasneem, 2004).

CHAPTER FIVE

5.0 CONLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Survey findings indicate that the majority of farmers used appropriate fruit postharvest handling practices during harvesting stage which resulted in lower fruit postharvest loss of 3.0 %. Conversely, most of traders over-packed fruits in 'tenga' and loaded them without using separators between 'tenga' during transportation. As consequence of these improper practices, the majority of traders suffered postharvest losses of 25 %. Similarly, over 50 % of the wholesale traders stored fruits under the sun, leading to high postharvest losses of 45 – 50 %. The survey data were comparable to experimental data in which low postharvest losses of 2.9 % was encountered during the harvesting stage and higher postharvest losses of 10.6 and 30.6 % during the transportation and wholesale storage market on fifth day, respectively..

The total postharvest losses were 43.8 % with the principal causes of losses being fruit fly maggots, microbial decay and fruit softening each contributing to 8.65, 25.7 and 20.05 % of the total losses, in that order. Heat stress caused by high temperature was critical factor that increases the deteriorations of fresh fruits stored under the sun at the wholesale storage stage. The reduction of temperatures by 9.1 and 6.3 % through storing of fresh fruits under polypropylene and black net shade structures for three days at the wholesale storage stage reduced the postharvest losses by 53.9 and 39.6 % respectively. As traders have stronger selling power than farmers, they set low prices to ensure that the postharvest losses are paid by small-scale farmers.

5.2 Recommendations

In the short term, wholesale traders are advised to store fresh mango fruits under the woven polypropylene shades while in the long term, district councils are argued to construct cold storage facilities in urban markets for improvement of quality and shelflife of fresh fruits. To minimize postharvest losses, farmers are advised to treat mango fruits with hot water and fungicide in order to sanitise them against fruit fly eggs and microbial decay. Trader should use proper disposal facilities of infested fruits in order to minimise the pest population.

In addition, further studies are required to optimise the control of fruit fly maggots and microbial decay for reduction of fruit postharvest losses under small scale mango production in Tanzania.

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APPENDICES

Appendix 1: Questionnaires for determination of appropriateness of postharvest handling practices used farmers and sellers to handle mango fruits

Section A: household characteristic

1. Village name.....................District ....Region...............
2.Name of house hold head......................................Sex.............Age.........
3. Marital status (1) married (2) not married (3riwidowed (4) divorced

4. Education

1= No formal education

2 = Primary (standard 1 – VII) level

3 = Secondary level

4 = Higher education level.....

5. House hold information

Household size ....

Name	Age	Relation with head	Education	Occupation	Remarks

6. Main occupation

i. Farmer

ii. Traders

iii. Both

Section B: Mango production and marketing

7. How did you obtain your land?

1. Inherited
2. Purchased
3. Village government
4. Borrowed
5. Number I and 2 above

8. Total farm / land owned (cultivated + uncultivated)............

9. How many fruit trees do you have?

i. Oranges

ii. Mango

iii. Coconut

iv. other s

10. Among fruits how many mango trees do you have?

i. 5 – 10

ii. 11 - 20

iii. 21- 30

iv. Above 30

11. How many trees of mango did you plant?

i. 5- 10 trees

ii. 11- 20 trees

iii. 21-30 trees

iv. All trees

12. How old are the mango trees?

i. 5- 10 years

ii. 11- 20 years

iii. 21 - 30 years

iv. Above 30 years

v. Number I & iv above

13. If not you, who planted those trees?

i. Father

ii. Purchased

iii. Grand father

iv. Any other mention

14. How many fruits do you harvest per season per tree?

i. 200-500

ii. 500-800

iii. 800 - 1000

iv. Above 1000

15. What method do you use to harvest your fruits?
    i. By hand picking
    ii. Shaking
    iii. Collecting after falling
    iv. Any other explain
16. What are maturity indices that make you to harvest your mango fruits?
    i. Colour change
    ii. When the fruit has stated to fall under the tree
    iii. Shoulder observation
    iv. Number of days after flowering
    v. Any other method explain
17. Which time of the day do you harvest your fruits?
    i. In the morning
    ii. After noon
    iii. Midday
    iv. Whole day
18. How do you take care of your fruits after harvesting?
    i. Removing latex
    ii. Grading, packing and storage
    iii. Smoking
    iv. I and ii above
19. How many fruits do you sell per season per tree?
    i. 200- 500
    ii. 600 - 1000
    v. Above 1`000
20. Where do you sell your fruit?
    i. At the farm
    ii. In the local market
    iii. To traders
    iv. To the distance market
    v. All the above
21. What are the prices in Tshs. of fruits?
    i. 20.00- 50.00
    ii. 51.00- 99.00

iii. Above 100.00

22. Which season you earn more income?

i. On season

ii. Off season

23. How do you transport your mango fruits?

i. By trucks

ii. By bicycles

iii. Ox-carts

iv. Carrying by head

24. How many fruit losses occurs during harvesting

i. 2 – 3%

ii. 4-5%

iii. Above 5%

24. If number (i) above what type of truck?

i. Closed

ii. Open

iii. Any other type of vehicle

25 What type cautioning material do you use?

i. Banana leaves

ii. Dry grass

iii. Number i and ii above

26. What package materials do you use?

i. Bamboo baskets

ii. Wooden boxes

iii. Palm baskets

iv. No packaging

v. Any other……

Section C. fruit sellers

27. What package materials do you use?

i. Bamboo baskets

ii. Wooden boxes

iii. Palm baskets

iv. No packaging

v. Any other……

27. When do you transport the fruits?

    i. In the morning/
    ii. In the afternoon?
    iii. In the evening?
    iv. At night?

27. Why do you transport at that time?

    i. Easy to get trucks
    ii. To reduce losses
    iii. Any other reasons

28. How do you take care of the Mango fruit during transportation?

    i. Packing in container
    ii. Cushioning
    iii. Any other mention

29. What losses do you get during fruit transportation?

    i. 10- 15%
    ii. 16- 20%
    iii. Above 20%

30. What strategies do you use to minimize post harvest losses of fruits in transportation?

    i. Packing in a containers and cautioning
    ii. Packing in the truck floor
    iii. Any other method mention?

31. How do you store the fruits in the market before to retail traders?

    i. In a cold room
    ii. Building shade
    iii. Local made shade
    iv. Under the sun
    v. Number iii and iv above

32. What are the losses occurring during of fruits storage in the markets?

    i. 20-30%
    ii. 31-40%
    iii. 41-50%
    iv. Above 50%

33. What are the causes of the storage losses?

    i. Insects
    ii. Diseases
    iii. Compression during transportation
    iv. Temperature
    v. Number i – iv above

35. What is the shelf life of the mango fruit in the markets?

    i. 5-10 days
    ii. 11- 15 days
    iii. 16-20 days
    iv. Above 21days

36. What are the quality criteria of mango fruits?

    i. Colour
    ii. Firmness
    iii. Size
    iv. Shape
    v. All the above

37. At what stage do mangoes lose their market value (throw away mango fruits)?

    i. When overripe
    ii. When lose firmness
    iii. Colour change
    iv. All the above

40. What are the incomes of selling mango?

    i. 100,000.00 -200,000.00
    ii. 250,000.00 – 500,000.00
    iii. 600,000.00 – 1,000,000.00
    iv. Above 1,000,000.00

41. What are your suggestions on storage method of mango fruits?

    i. Building shade houses
    ii. Building cold rooms
    iii. Provide fruit shelter in the market