# Postharvest Damage and Losses of Mandarin Fruits in Bhutan

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ABSTRACT

*Postharvest damage and losses in the horticultural production chain is a major challenge in a developing country like Bhutan. Though there are significant damages and losses of mandarin fruits in Bhutan, no reliable data is available. This study through field surveys assessed the extent of damages and losses due to postharvest conditions in the field as well as natural factors. Data were randomly collected from the fields of eight districts (Samdrup Jongkhar, Pema Gatshel, Zhemgang, Sarpang, Tsirang, Dagana, Chukha and Samtse). Postharvest damages of mandarin fruits due to postharvest handling was found to be 25.57% while the complete loss of mandarin due to same factor stands at 5.63%. Partial damages from natural causes such as diseases, birds, pests and physiological disorders stands at 10.26% while, 3.82% were completely damaged in the field. This accounts to 31.20% of the total mandarin fruits harvested being damaged (including losses) due to postharvest handling operations and 14.08% of the mandarin fruits were damaged (including losses) at the time of harvesting due to natural causes making the total damage to the mandarin fruits at 45.28%. Only about 54.73% of the mandarin fruits were marketed without damages or defects. Harvesting operations contributed to about 9.37% while, physiological disorders accounted for the maximum damages with 11.63% among the natural causes. Lack of proper storage and transportation facilities were the leading factors. Mandarin growers need to be supported with proper storage and transportation facilities as well as educate players in the value chain.*

**Keywords***: Mandarin fruits, Postharvest damages, Losses*

## 1. Introduction

Agriculture is the main source of livelihood in Bhutan as about 66 % of the Bhutanese population live in rural areas and depend on agricultural resources for their livelihood (MoAF, 2014). The diverse agro-climatic conditions of Bhutan are favourable for production of wide-range of horticultural crops. Citrus is the most widely grown fruit plants in Bhutan along with numerous other horticultural crops. The most common and widely grown types of citrus in Bhutan are local mandarin (*Citrus reticulata*) (Dorjee, Bockel, Punjabi & Chhetri, 2007). Currently about 60% of the Bhutanese farmers are directly or indirectly involved in mandarin farming (Joshi & Gurung, 2009).

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The integrated and systematic production of mandarin fruits in Bhutan started in early 1960s with the establishment of the Department of Agriculture (Gyeltshen, Grifith, Lakey & Dorji, 2015). Prior to this, cultivation of mandarin fruit was limited to backyard orchard for self or family consumption (Dorji, 1999). Over the years mandarin fruit cultivation was identified as a potential source of income for famers and by 1980s Bhutan began exporting mandarin fruits to India and Bangladesh (Dorji & Yapwattanaphun, 2011). Presently, mandarin in Bhutan is the main source of foreign exchange and livelihood for farmers in the citrus growing districts besides providing employment opportunities during harvesting and marketing seasons (Joshi & Gurung, 2009).

The main production areas in Bhutan are concentrated in subtropical-southern and central districts of Zhemgang, Sarpang, Dagana, Tsirang, Samtse, Chukha, Pema Gatshel and Samdrup Jongkhar (Gyeltshen et al., 2015). Mandarin orchards are mainly found in the foothills at altitudes between 300 – 1500 masl (Tashi, 2007). Mandarin fruit production over the last few decades has seen substantial increase both in number of trees as well as production. From 29,6161 metric tons of mandarin produced in 2000, the production reached 72,071 metric tons in 2007 (Dorjee et al., 2007).

Bhutanese mandarins are not just high-income earning cash crop but also are superior and unique in taste as it comes from clean environment (Dorjee et al. 2007). In general, mandarins are low in calorie and contain no saturated fats or cholesterol but rich in dietary fibres and pectin (Ladanyia & Ladaniya, 2010). Mandarins, like other citrus fruits are an excellent source of vitamin-C and also contain a good level of vitamin-A. Apart from other B-complex vitamins, mandarin fruit also contain some amount of minerals like potassium and calcium (Liu, Heying & Tanumihardjo, 2012).

Nonetheless, this high value cash crop production and marketing in Bhutan is hindered by number of constraints. Some of these include high cost of production, low yield, weak input delivery system, lack of accessibility and high cost of transportation, and weak market information system (Dorjee et al., 2007). Moreover, there is a significant postharvest loss of mandarin fruits due to lack of proper postharvest knowledge among the growers, exporters and retailers. It is estimated that about 30 % of the mandarin fruits are lost due to poor postharvest activities though the figure needs to be assessed with proper research on post-harvest loss of mandarin fruits in Bhutan (Dorjee et al., 2007).

Since accurate data on postharvest damages and losses of mandarin fruits in Bhutan is not available, this preliminary study is aimed to assess postharvest damages and losses of mandarin fruits from harvest till export to the international markets, besides the damages and losses from natural factors. With clear information on damages and losses of mandarin fruits at different stages of postharvest handling operations and natural causes; interventions can be developed and designed to minimize such damage and losses that will ultimately generate more income to the mandarin growers.

## 2. Materials and Methods

### 2.1 Study area

The survey was conducted to collect the data on postharvest damage and losses of mandarin fruits due to postharvest handling activities in the field viz. preparation for market and transportation to the market. The survey data was collected through random sampling from eight mandarin fruit growing districts of Bhutan (Samdrup Jongkhar, Pema Gatshel, Zhemgang, Sarpang, Tsirang, Dagana, Chukha and Samtse). The livelihood of most farmers in these districts depends on small scale growing and marketing of mandarin fruits.

### 2.2 Data Collection

The National Post Harvest Center (NPHC) technical staff collected the data from mandarin orchards, collection centres/depots and the major international marketing exit points (Samdrup Jongkhar, Gelephu and Phuntsholing).

### 2.3 Primary data

Primary data were collected through field surveys in the prescribed standard format. Two random samples were collected from each data collection area with three replications. Four independent factors viz. harvesting-handling operations, field to depot transportation, sorting/grading/packaging and depot to market transportation were used for data collection from each of these postharvest activities. Further, damages and losses of mandarin fruits due to natural factors were also assessed by collecting information on bird and insect damages, diseases and physiological disorders on mandarin fruits.

### 2.4 Data analysis

Data were analyzed using Web Agri Stat Package (WASP 2.0) and Microsoft (MS) Excel Spreadsheet.

## 3. Results and Discussion

Survey findings on damages and losses due to each of these factors are presented in the following sections.

### 3.1 Damages and losses due to postharvest handling operations

The percent gross damage of mandarin fruits at different stages of postharvest handling operations are shown in Figure1. In almost all the orchards, mandarin fruits were harvested by seasonal labourers hired by the contractors. As shown in the Figure 2, it was observed that 7.89% of the mandarin fruits were damaged due to harvesting operations but marketable, whereas 1.48% were damaged beyond marketability during harvesting and thus without any economic value. Mandarins were harvested manually and thus factors such as dropping of fruits, injury by the harvesters' hands, bruises from branches and storage bags/baskets and abrasions contributed to the damages and losses. Thus gross damages of mandarin due to harvesting operations stands at 9.37%.

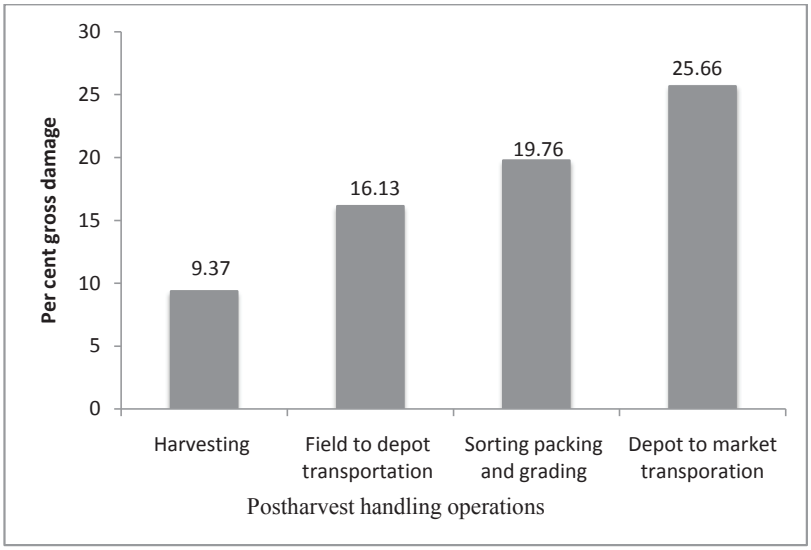


Figure 1.Per cent damages of mandarin fruits at different postharvest handling operations.

Harvesting time and natural conditions are also crucial in minimizing the post-harvest damages and losses. Mandarins harvested at the right time of season with the use of proper equipment will reduce damages substantially (Sudheer & Indira, 2007). Moreover, mandarin contractors and seasonal harvesters can be trained on good harvest handling practices.

The harvested mandarin fruits are then transported to collection points or depots for sorting, grading and packaging. Mandarin fruits were again assessed for damages and losses after reaching the depots from orchards. It was observed that another 6.93% of mandarin fruits were damaged during transportation to depot making the total per cent of damaged mandarin fruits at 16.13% (Figure 1). During this operation, 1.19% of mandarin fruits were completely damaged beyond marketing conditions and thus assessed as the total loss. Damages and losses of mandarin fruits during the transportation can be attributed to poor mode of transportation such as in open-air trucks, poor road conditions, long distance transportation and rough handling of fruits by the transporters. Since the major nature of transportation damages and losses were due to bruising, peeling and shrinkage of fruits; the transporters could be advised to use locally available cushioning materials in the trucks and avoid transporting mandarin in open trucks exposing the fruits to sun and rain.

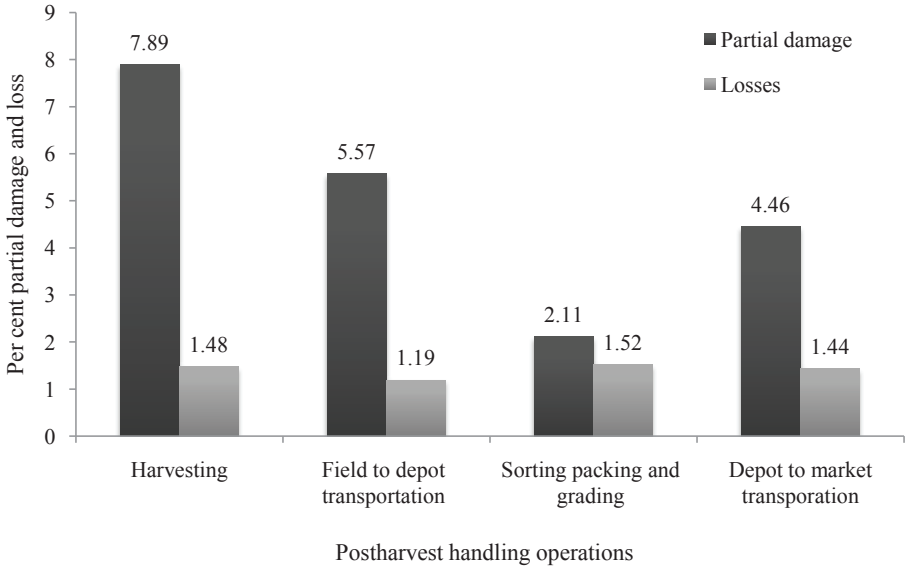


Figure 2.Percent partial damage and complete loss of mandarin due to post harvest handling operations

In the collection depots, mandarin fruits were then sorted, graded and packed for both domestic and international markets. Most of the packers and graders were Indian labourers from across the border. Damages during sorting, grading and packing were mainly due to improper handling of fruits. The percent damage of fruits during this operation stands at 19.76% indicating that additional 3.63% of the mandarin fruits were damaged during sorting, grading and packing as shown in Figure 1 out of which 1.52% fruits were completely damaged (i.e. without economic value). It was observed that the graders did not follow proper grading of fruits, but sorted the fruits based only on shape, size and colour. Rough handling of fruits while sorting, grading and packaging and use of inappropriate containers and poor storage conditions lead to these damages (Singh & Reddy, 2006). Facilitation with automatic grading machines along with appropriate containers and professional training of the graders could minimize the damages of fruits during these operations.

Fruits after grading and packing were transported to bigger markets, mainly in India and Bangladesh. The damage to mandarin fruits during this operation was also assessed. About 4.46% of the mandarin fruits were partially damaged while 1.44% of them were totally damaged during the transportation. When mandarin fruits reach the final market or export entries, 25.66% of them were either partially or completely damaged (Figure 1).

3.2 Damages and losses due to natural causes

Fruits were assessed for damages and losses due to natural causes such as birds, insect pests, diseases and physiological disorders at the time of harvest. As shown in Table 1, 10.26% of the fruits were partially damaged and another 3.82% were completely damaged due to natural causes. Among the natural causes, physiological disorders contributed to highest damage with 11.63% followed by diseases at 1.42% and birds and insects damages at 1.03% (Figure 4).

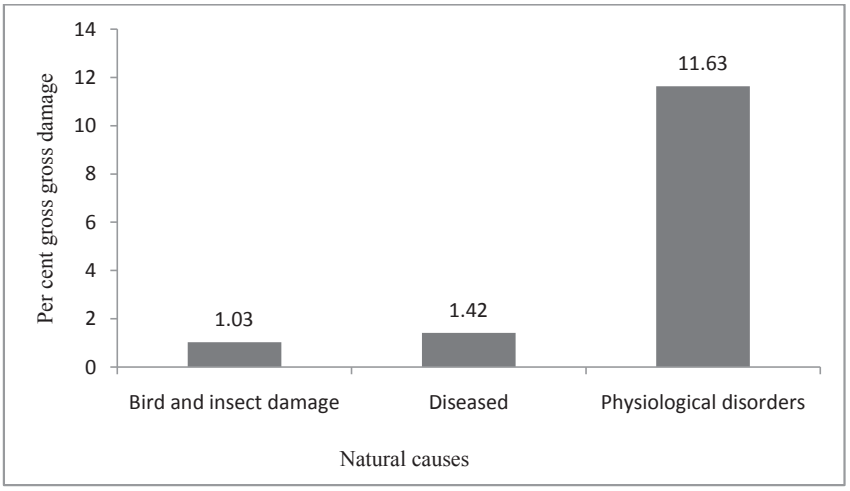


Figure 3.Percent gross damages of mandarin fruits due to natural causes at the time of harvesting

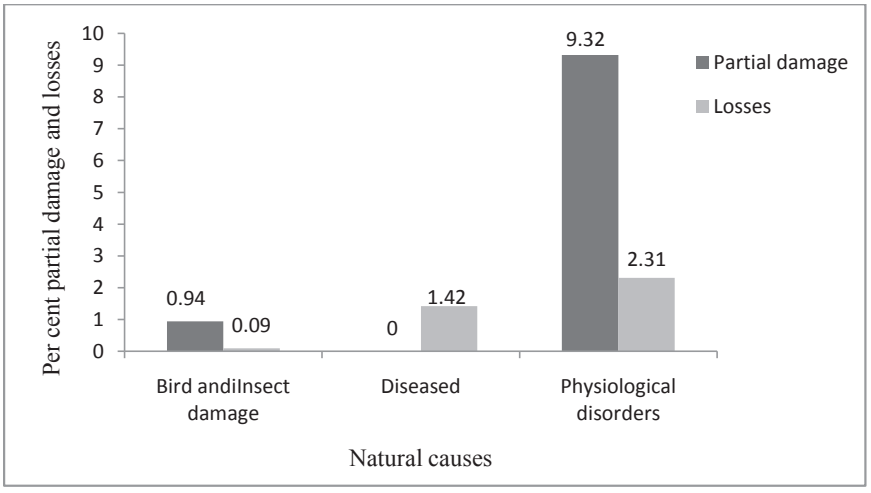


Figure 4.Partial damage and complete loss of mandarin fruits at the time of harvest due to natural causes

Adoption of good pre and post-harvest management technology can minimize damages and losses of mandarin due to natural causes. Proper orchard management practices will keep insect/pests away and use of certain fungicides needs to be considered to minimise fungal diseases in the orchards (Eckert & Eaks, 1989; Ladanyia & Ladaniya, 2010).

Table 1.Final results of post-harvest losses from handling and natural causes

| Sl. No | Factors | Partial damage (%) | Loss (%) | Damage total (%) |
|---|---|---|---|---|
| 1. | Handling operations | 25.57 | 5.63 | 31.20 |
| 2. | Natural causes (diseases, birds and insects and physiological disorder) | 10.26 | 3.82 | 14.08 |
| 3. | Total | 35.83 | 9.45 | 45.28 |

## 4. Economic impact of post-harvest damage and losses of mandarin fruits

Like any cash crop, both quantitative and qualitative losses of mandarin fruits will not only have economic impact on the mandarin farmers and the players in the supply chain but also impact the food security of the nation (Murthy et al., 2009). Though it is difficult to exactly calculate the monetary impact of damage and losses of mandarin fruits in Bhutan due to complexity of the mandarin supply chain; efforts have been made to estimate the economic losses from the recent market data and the total postharvest losses available for the mandarin fruits in this study.

Table 2.Mandarin fruit production and export statistics (Bhutan, 2016-17)

| Sl. No | Mandarin production (MT) | Quantity exported (MT) | Value (Million Nu) |
|---|---|---|---|
| 1. | 28,017.00 | 16,141.61 | 471.51 |

*Source:* (DRC, 2017; MoAF, 2017)

Table 3.Estimate of economic losses due to postharvest losses of mandarin fruits (Bhutan, 2016-17)

| Sl. No | Mandarin production (MT) | Postharvest partial damage (MT) | Economic losses (Million Nu.) | Postharvest losses (MT) | Economic losses (Million Nu.) |
|---|---|---|---|---|---|
| 1. | 28,017.00 | 10,038.49 | NA | 2,647.60 | 77.33 |

*Source*: (DRC, 2017; MoAF, 2017)

Bhutanese mandarin growers produced 28,017.00 MT of mandarin fruits in 2017, out of which 16.141.61 MT of mandarin fruits were exported to Bangladesh and India thus earning Nu. 471.51 million in revenue (DRC, 2017; MoAF, 2017). The earning from the export of mandarin fruits could be much more if not for the revenue loss of Nu 77.33 million from 9.45% (2,647.60 MT) of mandarin fruits lost due to postharvest handling operations as shown in Table 1. Bhutanese mandarin fruits were exported at an average price of Nu. 29.20 per Kg (DRC, 2017).Thus, income generation for mandarin growers, retailers and exporters could be enhanced if appropriate interventions are designed and put in place to reduce postharvest losses of mandarin fruits.

Though there could be considerable financial losses incurred from the partially damaged fruits, it is beyond the scope of this study to track and obtain data for the assumed depreciated price fetched by 35.83% or 10,038.49 MT of partially damaged mandarin fruits in the local and export markets. Thus, economic losses from the partially damaged fruits could not be determined.

## 5. Conclusion and Recommendations

Numerous factors lead to damage and loss of mandarin fruits in Bhutan. These causes include birds, insect/pests, diseases and physiological disorders besides poor postharvest handling practices. Poor production practices, improper temporary storage facilities and lack of appropriate physical infrastructures (transport, storage facilities and access to roads) also contributed to the damage and postharvest losses. Minimizing postharvest damages and losses of mandarin fruits can generate better economic returns for farmers and others who are engaged in the market value chain (Wills et al*.,* 1999).

The total postharvest damage of mandarin fruits in Bhutan during 2017-18 was very high at 45.27% of the total production. Postharvest damages from handling activities such as harvesting, transportation from the field to depot, sorting, grading and packaging and transportation to markets accounted for 9.37%, 6.76%, 3.63% and 5.90% respectively. On the other hand, damages from natural causes such as birds and insects, diseases and physiological disorders accounted for 1.03%, 1.42% and 11.63% respectively. Only about 54.73% of the mandarin fruits were undamaged and reached the final markets. About 14.08% of the total productionwas completely damaged. Reduction of this total loss will not only help to reduce the cost of production, trade and distributions but will also lower the price for consumers and increase the income to famers through larger sales volume (Bhattarai et al., 2013).

Postharvest damages and losses of mandarin fruits were found to be the major problem faced by Bhutanese mandarin growers, retailers, contractors and exporters. It was observed that certain specific interventions could be made in the production systems/orchard management as well as postharvest management practices. In light of this study finding, physical facilities such as proper storage facilities and improved fruit transport systems need be explored for mandarin growers and contractors. The National Post Harvest Center could scale up mass training of farmers, support and facilitate in providing proper handling and harvesting equipment and

continue providing technical support to relevant stakeholders involved in mandarin production and marketing system to minimize postharvest losses.

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