PRE- AND POST HARVEST LOSS OF ORANGE IN KARMALING GEWOG, DAGANA DISTRICT, BHUTAN

By

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Abbreviations

FAO: Food and Agriculture Organization

WFLO: World Food Logistic Organization

UN: United Nation

1: Abstract

Pre harvest factors and postharvest practices play an important role in avoiding fruits losses. Orange is an important cash crop of Bhutan that has highest export value. However, the extent of loss due to pre harvest and postharvest is rarely reported despite huge decline of production. This research was carried out to assess the extent of losses incurred by pre and postharvest conditions of oranges and factors leading to loss during the peak harvesting season in the year 2018 in Karmaling gewog under Dagana District. Pre harvest loss was determined based on field examination and observation and personal interviews with related people. And similarly, postharvest losses were graded based on the type of damage (mechanical damage, button holes and shape, size and colour) at the collection centre.

The pre harvest loss in the fields was found to be 0.88kg/tree, 0.71kg/tree and 0.25kg/tree maximum in Labrang, Homa and Deorali respectively. The postharvest loss due to shape, size and colour was 79.36% maximum followed by buttonholes 12.28 % and mechanical injury 8.36 % minimum. The loss of oranges from every truck trip was 78.78pons maximum and 47.48 pons minimum.

2: Introduction

Although Bhutan is a mountainous country, various fruits can be grown, and it is the main source of income for most of the farmers in the country. The Government of Bhutan aims to convert the whole agricultural area to Organic Agriculture to provoke a substantial increase of productivity and farmers income while preserving the environment. Due to geographical locations Bhutanese people practices mixed farming which includes crop production, fruit production, livestock production, and forest production. Orange is one of the largest grown fruits in southern part of Bhutan. Most of the farmers depends on orange production for their livelihood, whereby pre harvest and post harvest of orange affected them adversely. Minimizing the pre and post harvest losses of orange is a very effective way of encouraging farmers to work hard.

Dagana district is located in southern part of the country that covers an area of 1389 Sq. Km, with an elevation ranging from 600 to 3800 meters above the sea level. Previously Karmaling gewog is known as Deorali gewog. Most of the farmers in this gewog rely on agriculture farming where orange and cardamon is the main income source. Due to favorable climatic zones farmers also grows a variety of crops such as paddy, maize, millet, banana, passion fruit, pear, avocado, and vegetables such as broccoli, cauliflower, cabbage, potato, chilies, and tomatoes (*Annual Dzongkhag Statistics*, 2010). However, Orange remain great priority for generating income for the farmers in most part of the country. Although pre harvest and post-harvest losses was the major challenges faced by the farmers, proper pre and postharvest practices would help the production and reduces the loss.

3: Literature review

Citrus have a prominent place among popular and exclusively grown tropical and subtropical fruits. Worldwide they are the worlds' largest exporting fruit. Nevertheless, according to United Nations Conference on Trade and Development, mandarins are the most common among citrus fruits with nearly 70% of the total world citrus production (as cited in Mathers, 2008). According to FAO (2014), Brazil ranks first in citrus production followed by United States, China, India and Mexico, and in 2013 Bhutan ranked 70th in terms of oranges production with 67069MT that provide world share of 0.2%. However, Pre and post-harvest losses in tropical fruits vary widely from 10 to 80 percent in both developed and developing countries (FAO, 2006). Kitinoja(2005), Ray(2011) and WFLO(2017) observed that 40 to 50 of horticulture crops which includes fruits and vegetable are lost before they reach consumer mainly due to poor handling after harvest.

Citrus is one of the most important cash crops in Bhutan, home to some 670,000 people on the eastern end of the Himalayas (Gyles, 2017), where the cultivation of citrus is mainly dominated by orange although there are existence of some varieties of lime, lemons, pomelos and citrons. Mandarin (*Citrus reticulata* Blanco) is the only type of commercial citrus (Dorjee et al., 2018) distributed in 17 out of 20 districts (Dorji and Yapwattanaphun, 2011). Its cultivation dates to a very long time. Major citrus growing places are located in the subtropical southern regions of the country at altitudes between 3001650 masl (Dorji and Yapwattanaphun 2016). The six largest orange growing *Dzongkhags* in terms of production are Tsirang, Sarpang, Pemagatshel, Samdrup Jongkhar, Dagana and Chhukha (Connellan, et al., 2017).

According to National Statistics Bureau (2011), there are about 3.12 million orange trees being grown in the country, of which 1.72 million are bearing fruits and producing about 70,000 MT of orange. In Dagana district, number of fruit bearing tree were 332710 trees in 2016 and is dropped to 232614 trees in 2018. Similarly, production was 17,455MT in 2016 and 6497MT in 2018 (Annual *Dzongkha*g Statistics, 2010). Within two years there was 62.8 % decline of orange in terms of production and similar trends was also observed in other regions as well. Tomiyasu et al., (2002) reported infection of destructive disease called citrus HuanglongBing. This infection caused lots of fruit trees being wiped out and as a result production of orange declined (as cited in Penjor et al., 2011). Further, Tshetrim and Chhetri (2018) recently reported

that 35 % of the orange orchards in Dewathang gewog have been affected by greening disease. In india (Nanda et al..,2012) who collects wide range of data on pre harvest and post harvest factors influencing food losses for multiple crops in each state of India observed that 40 percent of orange are being lost before they reach consumer. The main reason for huge loss was due to poor infrastructure and logistic in remote areas. However, country like Bangladesh it is observed that the orange losses was only 23.6% lower than other fruits (Kamul Hassan et al., 2015).

Although many studies have reflected preharvest factors that regulate the production, but they haven't reported what quantity of loss incurred by those factors. Moreover, despite farmers faced several consequences as a result of diseases and pest, dying of the orange trees and substantial loss in their economy there was no proper evaluation of the orange loss as a result of pre and postharvest practices in the country. Dagana District being one of the six largest mandarin producers in the country no studies were done in pre and postharvest losses particularly in the Karmaling *gewog*. The losses due to the postharvest diseases and the condition of oranges at field, transportation, storage, grading and the marketing level significant damages occur. Usually the postharvest loses are high in the developing countries (Bhattarai, Rijal et al. 2013). Similarly, In Nepal, post harvest loss of orange is 25% to 35% (Khaini, 2017). Post harvest losses during handling, transport, storage and distribution are the major problem for the loss of orange. According to Kabas (2010), this causes losses on farmers and on country's economy (as cited in Bhattarai, Rijal et al. 2013).

4: Research aims

This study aims to bring the challenges of the citrus growers into the notice of concern authority for the improvement in the future and the other alternatives that the farmers of southern Bhutan have adapted to sustain their livelihood. Similarly, losses due to disease and pests are also not yet explored extensively. The present study thus to estimate the pre and post harvest loss of oranges and the factors leading to loss particularly in Karmaling goeg, Dagana Dzongkhag due to transportation, storage and grading.

5: METHODOLOGY

The survey was conducted to assess the extent of loss due to post and preharvest conditions of oranges and factors leading to these losses during the peak harvesting season. It was carried out in Karmaling gewog particularly in three *chiwogs* (spots) that includes Labrang, Deorali and Homa under Dagana District.

It was based on literature review, field examination, observations and personal interviews with related people, which consisting parameters such as, weighing dropped oranges from sampled trees in the orchard using digital weighing balance and observation of orchard maintenance particularly in the case of creepers and parasitic plants to determine preharvest loss. Simultaneously, some informal personal interviews were carried out on the field with related people. And similarly, a scientific grading based on the type of damage (mechanical damage, buttonholes and shape, size and colour) was done at the collection centre randomly with several truckloads of oranges to determine postharvest loss.

5.1: Statistical analysis

Data analyses were done using SPSS Ver. 21 and Microsoft Word excel.

5.2: Study area map

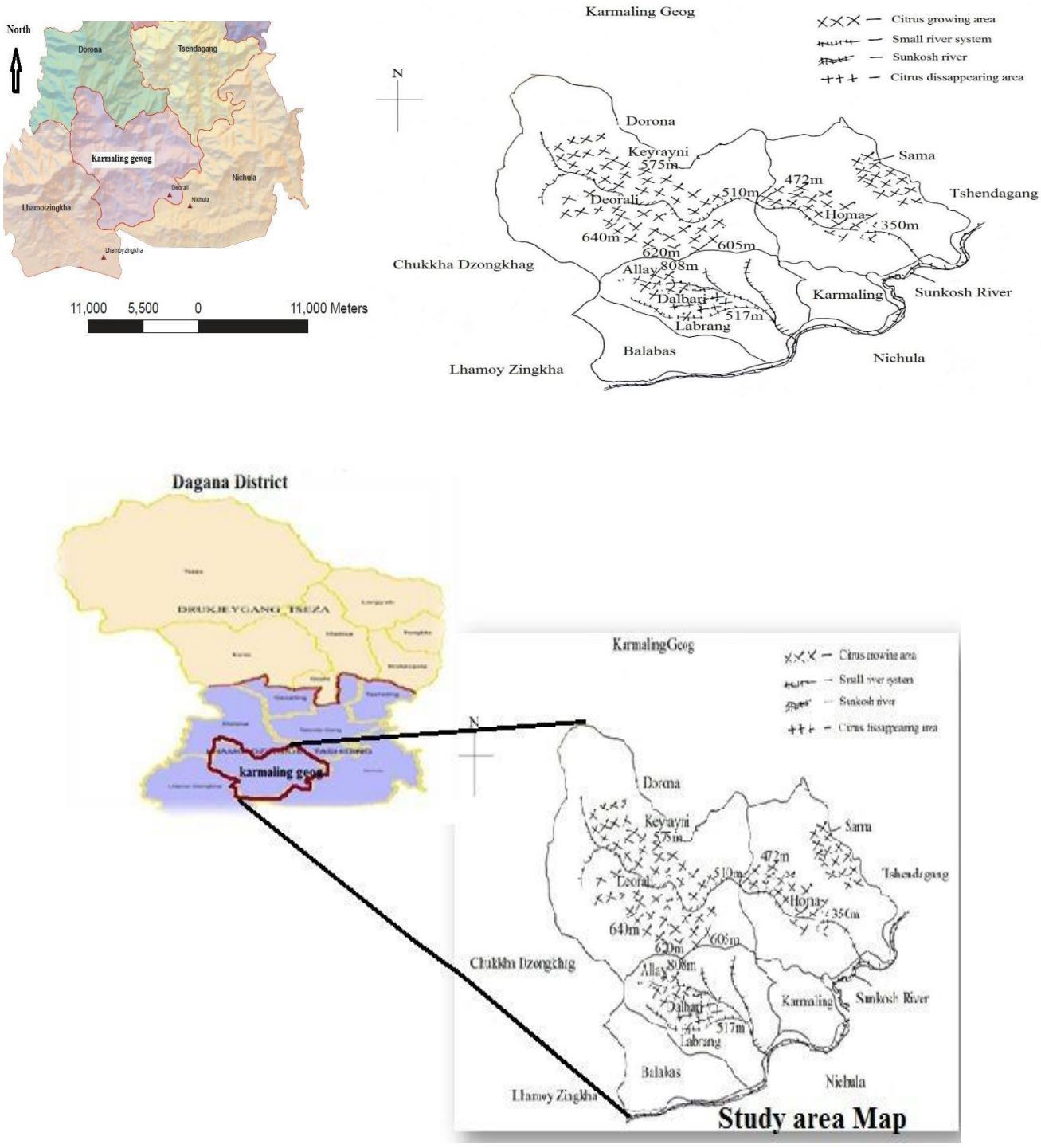


Figure 1: Showing Study map: Karmaling gewog

6: RESULTS AND DISCUSSION

The extent of orange loss due to pre and postharvest conditions was determined in Karmaling gewog under Dagana District. Three *chiwogs* **Sama, Homa** and **Labrang** were assessed for preharvest loss located at different altitude while one additional *chiwog* **Deorali** was assessed for postharvest losses of orange at Depot based in Lhamoizingkha, Kalikhola.

i. Pre harvest loss

The pre harvest loss which may be due to the pest and diseases, agroclimatic factors, edaphic factors, fruit drop or destructions incurred by wild animals and birds was evaluated during the peak harvesting season. The losses as per the result shown in the Table 1, 2 and 3 and Graph 1, 2 and 3, there is not much losses due to the preharvest factors and loss does not correlate with the altitude range of the orchards. It varies and exhibit disproportionate loss within the same altitude of different area or different altitude of the same area.

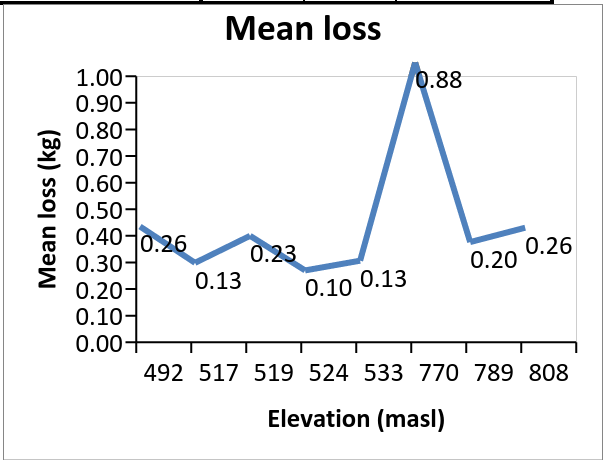
Table 1. Loss from each orchard *

Elevation of the orchard

Loss from each orchard (kg) Labrang

Elevation of the orchard (masl)	Mean	N	Std. Deviation
492	0.26	20	0.16
517	0.13	20	0.14
519	0.23	20	0.15
524	0.10	20	0.07
533	0.13	20	0.10
770	0.88	20	0.67

789	0.20	20	0.14
808	0.26	20	0.14
Total	0.27	160	0.35



Since preharvest loss was determined from various ranges of an altitude in three different *chiwogs* viz., Labrang, Homa and Deorali. In Labrang *chiwog* the altitude of study area ranges from 492m to 808masl, and the preharvest loss was highest from 770m accounted to 0.88 kg/tree and the minimum loss was 0.10kg/tree from an altitude of 524m. The significant high loss in 770masl may be due to the variance of fruits size among the orchards. The information is depicted in table 1, graph 1.

Table 2. Loss from each orchard (kg) * Elevation of the orchard (masl) Loss from each orchard (kg) Homa

Elevation of the orchard (masl)	Mean	N	Std.Deviation
350	0.71	20	0.48
375	0.13	20	0.18
419	0.15	20	0.13
430	0.24	20	0.22
472	0.39	20	0.28
Total	0.30	120	0.34

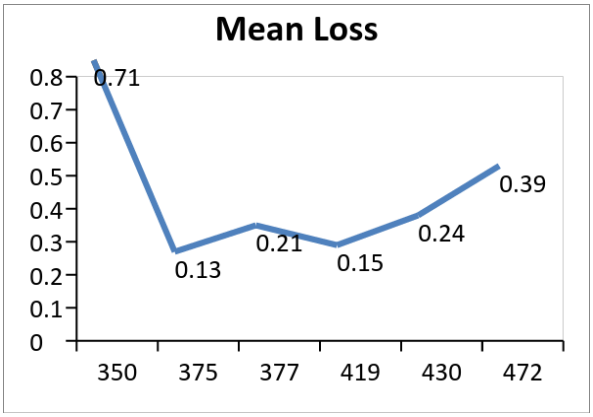
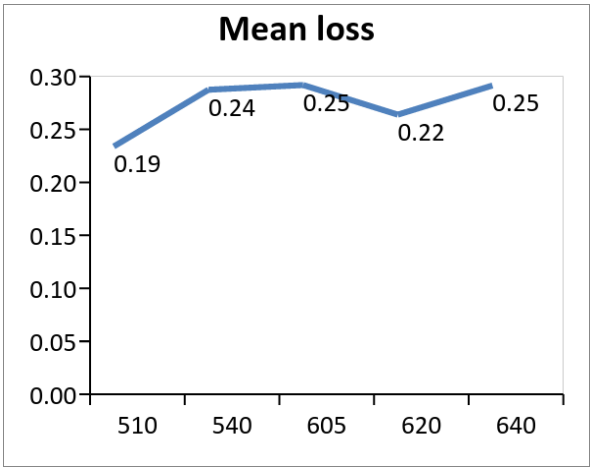


**Table 3. Loss from each orchard *

Elevation of the orchard **Deorali Loss from each orchard**			
Elevation of the orchard (masl)	Mean	N	Std. Deviation
510	0.19	20	0.25
540	0.24	20	0.28
605	0.25	20	0.48
620	0.22	20	0.20
640	0.25	20	0.20
Total	0.23	100	0.29



Similarly, from Homa *chiwog* the maximum preharvest loss was 0.71kg/tree and minimum were 0.13kg/tree from an altitude of 350m and 375m respectively. The highest loss was observed at lowest altitude at 350m. The data is shown in table 2 and graph 2. In Deorali *chiwog*

there was no significant variation of mean yield losses. The yield loss from all the ranges of altitude was alike as shown in table 3 and graph 3.

ii. Postharvest loss

In Bhutan the mode of transportation of oranges from field to terminal market are divisible to two parts. They are: 1). Transportation from orchard fields to road point: 2). Road point to depot (terminal marketing area). In the former case men and horses are main transporters of oranges while the latter case is transported in minitruck especially DCM and Mahindra cars. Despite long distance transportation almost 3050km(s) away from the terminal market area, as per the key informant's loss incurred by the transition is very less or no loss at all. Moreover, they are confident enough with their existing mode of transportation. On the other hand, Eckert, 1978; Naqvi and Dass, 1994; Singh and Jain, 2004 stated that the unscientific postharvest management, poor harvesting technique, lack of storage facilities and poor handling of fruits during grading, sorting or packaging result in substantial losses during transit and in distant marketing (as cited in Gangwar, Singh et al., 2007). Hence specific loss due to transportation was not determined rather mechanical injury which might be due to transportation, harvesting techniques and improper storage houses, and grading was determined at depot. In every truck load 400500pons of oranges are transported from the fields to depot and several truck load of orange are rejected due to mechanical injuries, improper shape, size and colour and buttonholes while grading, sorting and packaging. On examining these losses from rejected citrus that had been separated from the main marketable mandarin, loss due to mechanical injury is less as compared to loss due to shape, size and colour. In all the *chiwogs*, the maximum loss of citrus was mainly due to the improper shape, size and colour. From every tray containing mean citrus weight of 29.95kg and 4.95pons, 19.62 kg and 3.53pons of citrus loss is incurred due to improper shape, size and colour. This signifies that preharvest factors such as climatic factors, tree conditions, edaphic factors and management practices might be helping in determining the quality, size and shape of the citrus fruits. Similarly averages of 6.18kg or 0.84pons are wasted due to button holes and 4.15kg or 0.58pons due to mechanical injury. The detail average loss in *chiwog* wise is shown in table 4. The loss incurred by button holes is mainly due to either improper harvesting technique or careless harvesting technique.

Table 4. Showing Loss due to Mechanical injury, Shape, Size, and Colour and Button Hole (In Kg and Pons respectively)

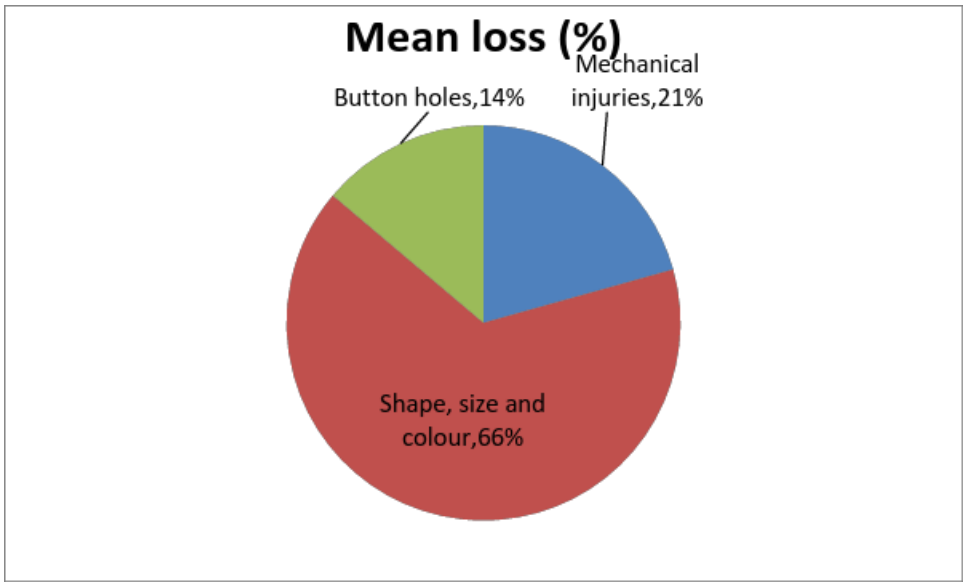
Name of the village		Loss due to Mechanical injury (kg)	Loss due to Mechanical injury (Pons)	Loss due to shape, size and colour (kg)	Loss due to shape, size and Colour (Pons)	Loss due to button hole (kg)	Loss due to button hole (Pons)
Sama	Mean	**6.17**	**0.83**	**17.17**	**3.42**	**6.67**	**0.83**
	N	3	3	3	3	3 .76	3
	Std. Deviation	0.76	0.12	2.75	0.30		0.09
Labrang	Mean	**4.50**	**0.65**	**23.83**	**5.41**	**2.50**	**0.35**
	N	3	3	3	3	3 .87	3
	Std. Deviation	2.00	0.31	3.79	0.98		0.15
Homa	Mean	**1.52**	**0.21**	**9.00**	**1.24**	**13.55**	**1.87**
	N	3	3	3	3	3	3
	Std. Deviation	0.64	0.09	11.17	1.54	10.66	1.46
Deorali	Mean	**4.4**	**0.63**	**28.47**	**4.03**	**2.00**	**0.33**
	N	3	3	3	3	3	3
	Std. Deviation	0.53	0.07	1.75	0.32	0.46	0.16

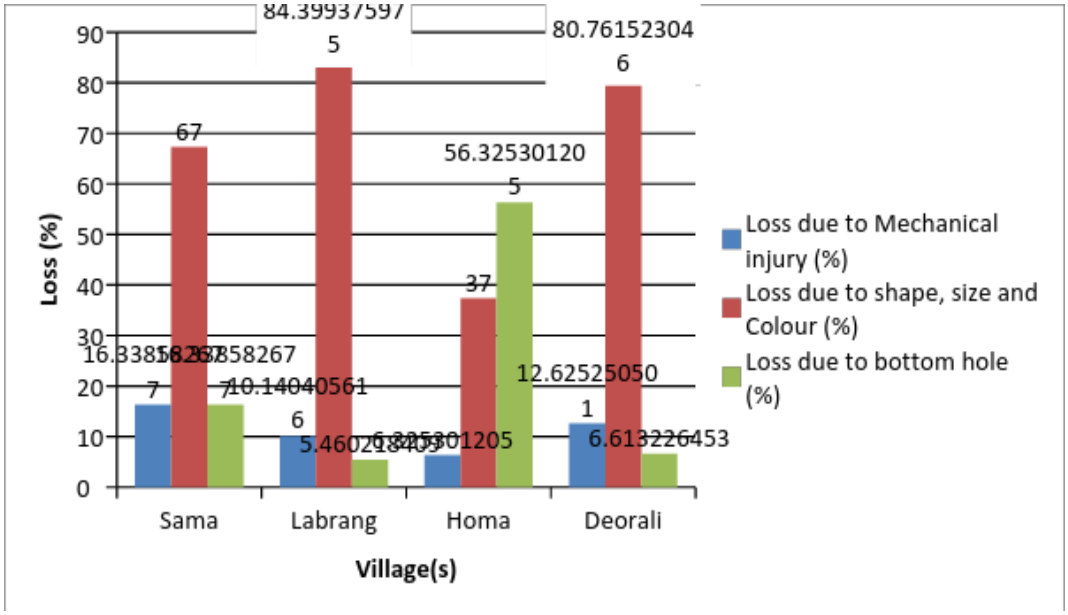
Total	Mean	**4.15**	**0.58**	**19.62**	**3.53**	**6.18**	**0.84**
	N	12	12	12	12	12	12
	Std. Deviation	2.00	0.28	9.26	1.76	6.66	0.91

Key notes: N means number of replication, 1 Pon = 80 pieces of oranges

iii: Loss of orange in terms of Percentage

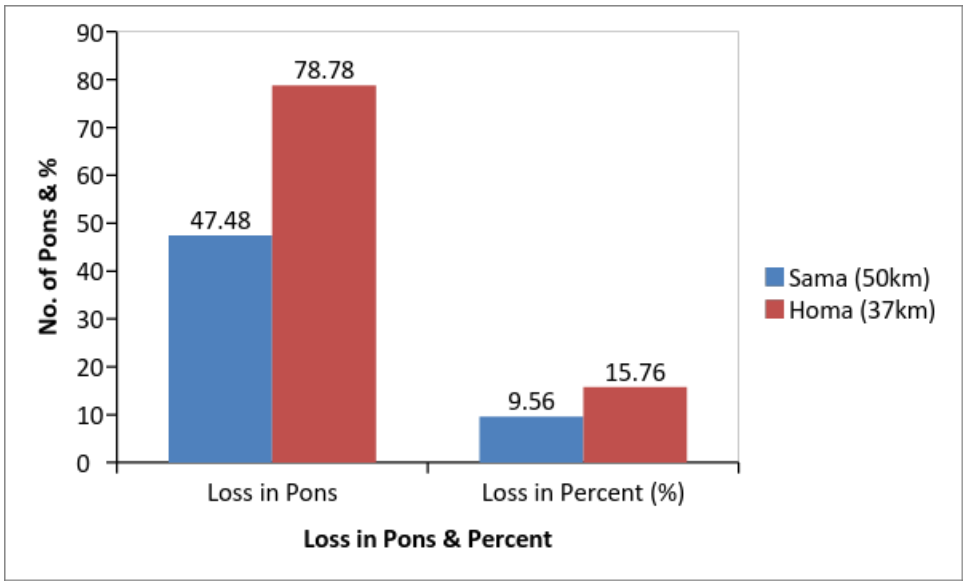
The average loss in terms of percentage showed that 65.50% is lost due to shape, size, and colour while 20.63 incurred by button holes and the lowest loss is incurred by mechanical injury with 13.38% from each tray that contain average orange weight of 29.95kg or 4.95pons. It is shown in graph 4. The detail loss in terms of percentage, *chiwog* wise is shown in table 5. Maximum loss due to shape, size and colour was found in Labrang village followed by Deorali, Sama and Homa chiwogs. Whereas mechanical loss was highest in Sama followed by Deorali, Labrang and least was observed in Homa *chiwog.* Homa *chiwog* however has highest button holes loss which is even greater than loss due to shape, size and colour.





Total citrus fruit loss from each trip (truck load of oranges)

This loss includes all the factors, such as preharvest factors of orchards, harvesting techniques, transportation methods, distances, storage facilities, etc., which will ultimately incurred the loss of citrus fruits. From every trip of mandarin transported from field to depot, while grading, sorting and packaging maximum of 78.78pons to minimum of 47.48 pons are rejected either due to mechanical injury, or under size, shape and colour or due to button holes. In term of percentage, every trip loss mean maximum of 15.76% and minimum mean loss of 9.56% as shown in graph 5, where on transition, an average of 500pons per trip is delivered to the depot.


90
80
70
60
50
40
30
20
10
0
No. of Pons & %
78.78
47.48
15.76
9.56
Loss in Pons
Loss in Percent (%)
Loss in Pons & Percent
Sama (50km)
Homa (37km)

7: CONCLUSION AND RECOMMENDATIONS

Orange is the main source of income for many Bhutanese farmers. It has highest export value due to its large in size and unique taste. Various factors such as greening disease, powdery mildew, insect and pest have affected the production of citrus and there was noticeably high decline of citrus production in Bhutan. Preharvest factors such as agroclimatic conditions, tree age, and management practices will determine the quality, size and shape of the fruits and poor preharvest management practices will reduce the yield by creating unfavorable conditions for themselves but suitable conditions for other unwanted plants.

Proper pre and postharvest practices in citrus is an important step helping farmers to reduce the losses and increase the yield. In many cases preharvest losses was maximum where fruits are usually undersize, improper shape, and colour. Also harvesting techniques and other minor factors including the transportation affects the quality of the fruits. Button holes during the harvest will not only affect the fruit themselves but it will also create conducive environment for other organism's growth. Therefore, careful harvesting without button holes will reduce the losses. From this study it also revealed that location of the orchards from the sun also affect the actual yield. In most cases orchards in moderate climatic conditions, cool, and moist facing the East direction has maximum production, while orchards facing south west with dry conditions has obviously less production.

By understanding and using these developments, the postharvest handling system can be improved, which will help to improve the profitability of industry. While, many challenges in the area of postharvest are still to be tackled, our current state of postharvest losses can be minimized by application of the principles of postharvest management.

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