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# Post-harvest losses in mandarin orange (*Citrus reticulata* blanco.) in the Gulmi District of Nepal

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***Abstract***— *A study was carried out in Gulmi District, Nepal, focused on the status of post-harvest technology and mandarin post-harvest losses. A random sampling technique was used to select the household and an interview with a semi-structured questionnaire was carried out. Collected data were analyzed by using descriptive through SPSS and Ms. Excel and results were obtained. Through the collection and analysis of data from a sample of 100 respondents, this study delved into various aspects of Mandarin's post-harvest status, including socio-demographic characteristics, post-harvest operation, and challenges faced by farmers. The findings revealed critical insights into the demographics of the surveyed farmers, their practices related to post-harvest management of Mandarin, and the issues they encounter. The study uncovered that while many farmers exhibit a lower understanding of post-harvesting technology including the use of chemicals, processing facilities, the effect of proper harvesting technique, and other post-harvest handling practices on the shelf life of fruits, there is still room for improvement, particularly in post-harvest handling techniques and access to markets. Aggregate mean post-harvest losses were found to be 8.12% at the harvesting stage, followed by 4.05% at the grading stage, 3.07% at the sorting stage, and 1.65% during storage. The end use of market-rejected poor-grade fruits was also studied. The research also highlighted the significance of farmer groups and the potential for training programs to enhance post-harvest knowledge and skills. Furthermore, the study identified critical needs among farmers, emphasizing the importance of access to essential resources, training, credit related to post-harvest management, marketing assistance, and improved infrastructure to improve Mandarin post-harvest handling in the region. These findings can inform targeted interventions and policies aimed at enhancing Mandarin farming practices, post-harvest handling practices, and improving farmers' livelihoods in the Gulmi district.*

***Keywords***— ***Mandarin post-harvest losses, technology, farmer challenges, market access, and training programs.***

## I. INTRODUCTION

In Nepal, citrus is produced in 64 districts of tropical and subtropical regions, accounting for 49,306 ha of the country's total fruit-growing area (MoALD, 2023). Lime (*Citrus aurantifolia*), Mandarin (*Citrus reticulata*), and Sweet Orange (*Citrus sinensis*) are the three main citrus species that are grown commercially in Nepal (A. Adhikari et al., 2021). Among them, mandarin (*Citrus reticulata*) is the most common citrus fruit grown in Nepal. It is a perennial shallow-rooted tree of the Rutaceae family. The origins of Mandarin may be traced to Southeast Asia's tropical and subtropical regions, mainly China, India, and the area between these three nations. In Nepal, Mandarin accounts for 63.76% of total citrus production and 14.63% of total fruit production (MoALD, 2022). Mandarin has obtained 27,982 ha, 19,481 ha, and 1,85,346 mt of total area, productive area, and production respectively (MoALD, 2023). Even though Gandaki Province has the highest area, productive area, and production of mandarin orange (7,795 ha, 3,534 ha, and 39,226 mt), Lumbini has the highest productivity (11.45 mt/ha), followed by Gandaki (11.1 mt/ha) and Karnali (10.97 mt/ha), while Bagmati Province has the lowest productivity (9.34 mt/ha) (NCRP, 2023).

In Nepal, Mandarin production has shown a significant increase in the past few years (NCRP, 2023), but the nation's domestic demand for mandarin fruits cannot be satisfied. It is the result of not implementing the improved pre- and post-handling practices. Even if losses of mandarin fruits vary depending on several parameters, including climate, topography, and variety, the shelf life of horticulture production is significantly impacted by post-harvest management strategies (Acharya et al., 2023). However, considerable attention has not been given to increasing post-harvest loss issues. Due to the non-climacteric and perishable nature of mandarin fruit, significant losses occur immediately after harvesting and continue during handling and marketing which are reported to vary between different percentages. In Nepal, the post-harvest loss of citrus fruit was estimated to be between 15% and 20% (D. Bhattarai, 2018). Post-harvest technology includes a variety of methods, procedures, and treatments for handling, processing, storing, transporting, and other aspects of fruit handling with the goals of extending their commercial life, preparing fruits for market demands, and minimizing losses throughout the entire supply chain, from harvest to the table of consumers (Zacarías et al., 2020).

Fruit losses can be attributed to the use of improved cultural practices, the prevalence of pests and diseases, improper harvesting methods, packing, shipping, and storage techniques, as well as harvesting at an improper stage of maturity. Generally, picking fruit involves shaking trees or striking them with a stick. As a result, the fruit falls along with the leaves and peduncle. Most of the losses happen on the way from the farm yard to the collection center, and then to the wholesale market and retail stores. Reducing post-harvest loss of mandarin fruit is a very efficient method of increasing fruit availability and lowering farmer's cultivation costs, both of which contribute to higher farmer incomes. Proper post-harvest management is a complementary strategy to meet food needs (Bhattarai D. R., 2018). This study was conducted to assess post-harvest losses in mandarin orange in Gulmi and to study the orchard management practices, pest infestation, fruit handling activities, and marketing practices of mandarin, to assess the barriers to the post-harvest technology adoption, to examine the knowledge and awareness of farmers regarding post-harvest technologies, to explore the mandarin production status and price fluctuation.

Bhattarai et al., 2013 present a comprehensive study on post-harvest losses of mandarin oranges in Dhankuta District, Nepal, revealing significant challenges in fruit handling and storage. Conducted through systematic surveys from October to January 2011, the research highlights that post-harvest losses can reach as high as 46%, with specific losses during harvesting (7%), transportation (25%), grading (3%), packaging (1%), and marketing (5%). The study identifies key factors contributing to these losses, including improper handling, climatic changes, and fungal diseases, with fungal attacks being the most prevalent issue. The authors emphasize the need for improved post-harvest management strategies, such as better harvesting techniques and storage conditions, to mitigate these losses and enhance food availability. Overall, the findings underscore the critical importance of addressing post-harvest issues to improve the economic viability of orange production in Nepal.

(Acharya et al., 2023) explores the significant postharvest losses experienced by mandarin farmers in Gandaki Province, revealing that losses range from 14% to 18% across various stages of handling, including harvesting and transportation. Key findings indicate that while farmers earn an average profit of around 50,000 Nepalese rupees annually from mandarin cultivation, their knowledge of postharvest technologies is limited, with only 10% receiving relevant training. The authors argue for enhanced training and infrastructure improvements to mitigate losses and improve economic outcomes for farmers, emphasizing the need for targeted interventions by government and NGOs to support better postharvest management practices.

D.C. investigates the impact of various edible coatings on the postharvest quality of mandarin oranges, which face significant losses in Nepal due to inadequate postharvest practices. Conducted at Prithu Technical College, the study employs a Completely Randomized Design with seven treatments, including different concentrations of paraffin wax, mustard oil, Aloe vera, and turmeric paste. Results indicate that 75% paraffin wax significantly reduces physiological weight loss and maintains higher juice content and marketable fruit percentage compared to other treatments. The findings suggest that using 75% paraffin wax is an effective method for enhancing the storage quality of mandarins under ambient conditions, making it a viable option for farmers in Nepal to minimize postharvest losses and improve fruit quality.

Strano et al., 2022 provide a comprehensive overview of postharvest challenges faced by citrus fruits, which account for significant losses of 30-50% due to diseases and metabolic disorders. The authors critically review various strategies aimed at preserving fruit quality and extending shelf life, emphasizing the importance of sustainable practices to minimize synthetic fungicide usage and environmental impacts. The paper discusses innovative technologies, including modified atmosphere packaging and cold storage, while highlighting the need for improved handling techniques to mitigate physical injuries that lead to spoilage. Furthermore, it integrates recent findings on the effectiveness of heat treatments and biocontrol agents in combating

common pathogens like Penicillium spp., ultimately aiming to enhance the overall management of citrus fruit quality postharvest.

### 1.1 Citrus in Nepal

Nepal's mid-hills, which range in elevation from 800 to 1500 meters, have ideal agroclimatic conditions for the production of high-quality citrus fruits. Many citrus species are grown in Nepal, but only a few selected varieties like mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*), acid lime (*Citrus aurantifolia*), and hill lemon (*Citrus pseudolimon*) are produced on a commercial basis. Citrus is one of Nepal's most significant fruit crops in terms of production, area covered, and export potential. In the year 2021/2022, the total area of production, total production, and productivity of citrus were found to be 49,306 ha, 3,06,149 mt, and 9.47 mt/ha respectively (MoALD, 2023)

### 1.2 Mandarin in Nepal

Mandarin is one of the most significant citrus fruit crops farmed worldwide, including in the Gulmi district of Nepal. Mandarin fruit is in high demand because of its excellent flavor and rich nutritious content, and it's becoming a more appealing option for making money in the upper hills as well. Citrus fruits are especially valued for their beneficial effects on health since they are a significant source of flavonoids, vitamin C, hydroxycinnamic acids, and bioactive substances with strong antioxidant activity. Nepalese farmers grow several popular types of mandarin including Syangja local, Khoku, Morcot, Kinno, and Ansu. In the fiscal year 2021/22, the total production area, total production, and yield of mandarin were found to be 865ha, 7,164mt, and 12mt/ha respectively, in the Gulmi district.

### 1.3 Mandarin Statistics: Trend Analysis

*Table 1. Comparative analysis of area, productive area, production, and yield of mandarin in Nepal*

| **Mandarin in Nepal** | | | | |
|---|---|---|---|---|
| **Fiscal year** | **Area (ha)** | **Productive area (ha)** | **Production (mt)** | **Yield (mt/ha)** |
| 2016/17 | 28760 | 17457 | 164593 | 9 |
| 2018/19 | 27951 | 17220 | 177381 | 10.3 |
| 2019/20 | 6591.18 | 4550.32 | 156179.68 | 10.73 |
| 2020/21 | 27002 | 18369 | 198406 | 10.8 |
| 2021/22 | 27982 | 19481 | 185346 | 9.51 |

*Source: Statistical Information on Nepalese Agriculture (2022/2023)*

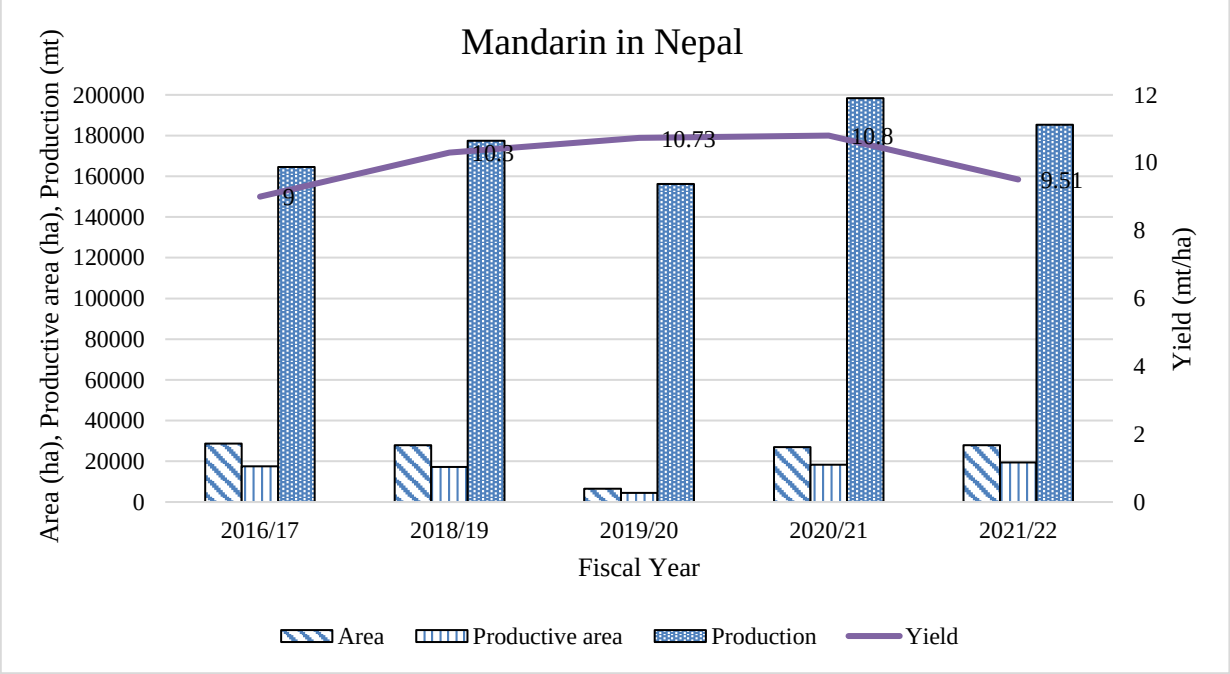


*Fig.1: Area, Productive Area, Production, and Yield of Mandarin in Nepal*

*Table 2: Comparative analysis of the area, productive area, and yield of mandarin in Gulmi*

| Mandarin in Gulmi | | | | |
|---|---|---|---|---|
| **Fiscal year** | **Area (ha)** | **Productive area (ha)** | **Production (mt)** | **Yield (mt/ha)** |
| 2017/18 | 534 | 345 | 3137 | 9.1 |
| 2018/19 | 1297 | 660 | 8250 | 12.50 |
| 2019/20 | 853 | 484 | 5879 | 12.15 |
| 2020/21 | 858 | 591 | 6597 | 11.16 |
| 2021/22 | 865 | 597 | 7164 | 12 |

*Source: Statistical Information on Nepalese Agriculture (2022/2023)*

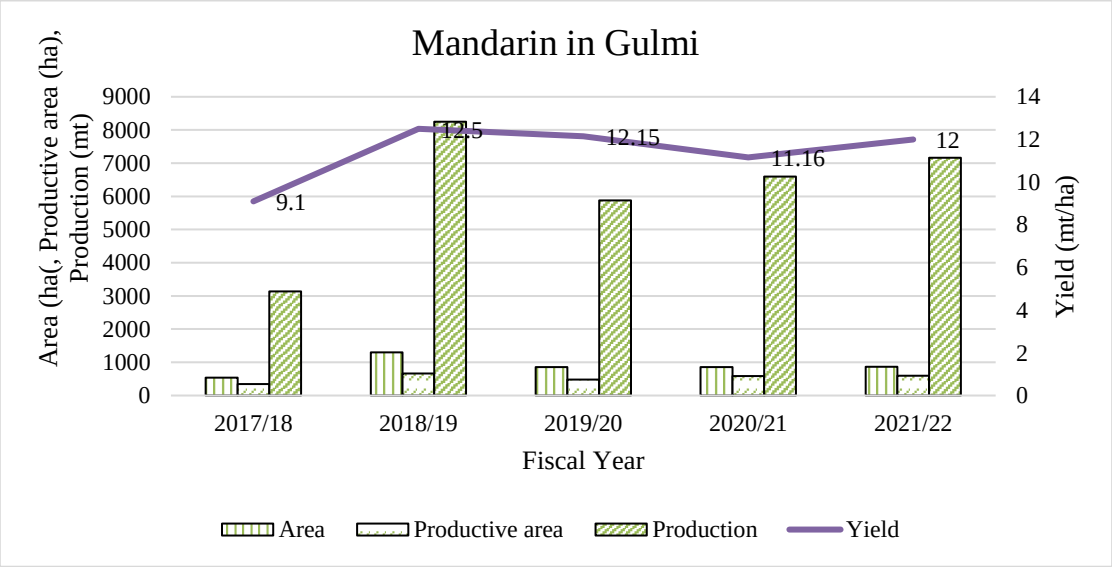


*Fig.2: Area, Production, Productivity, and Yield of Mandarin in Gulmi*

### 1.4 Post-harvest loss and its significance

Post-harvest loss is the term used to describe quantifiable loss, both qualitative and quantitative, that occurs between the harvest and consumption points (Kiaya, 2014). Since fruits are living things, they can still respire after being harvested (B. Adhikari & G.c, 2021). Post-harvest loss challenges the food security at both local and global levels. Post-harvest management of fruits and vegetables encompasses pre- and post-harvest practices as well as the harvesting, handling, packaging, storage, distribution, and marketing of the produce (Goyal & Singh, 2017).

Citrus fruits being a horticultural crop can contribute to food security, enhance nutritional status, create jobs, raise income, and boost the nation's GDP overall. Citrus fruit is a high-value crop in the mid-hill region of Nepal. Among them, mandarin orange is the most common and preferred one. Increasing awareness of the health benefits of mandarin orange among local people makes it high in demand in the nation. But mandarin being perishable, suffers from post-harvest losses. In Nepal, the post-harvest loss of citrus fruit was estimated at 15%-20% (D. Bhattarai, 2018).

Mandarin is an important cash crop for many farmers in Nepal, particularly in the hilly regions where the climate is suitable for cultivation. Mandarin is also a significant part of the local diet in many parts of Nepal. Production and marketing of mandarin fruit is an important source of income not just for mandarin farmers and traders, but also provides seasonal employment for many agriculture laborers (Acharya et al., 2023). Post-harvest losses can lead to reduced incomes for farmers due to lower yields of marketable produce. Post-harvest losses also take away the opportunity for higher profit which farmers may have gotten by selling fruits during the off-season. Post-harvest losses contribute to food insecurity by reducing the availability of fresh, nutritious produce for consumption, especially during

the off-season. Post-harvest losses can affect the quality of mandarins, making them less competitive in domestic and international markets which in turn may fetch lower prices. Nepal is susceptible to the consequences of climate change, which may intensify losses incurred after harvest due to variations in temperature, patterns of precipitation, and the frequency of extreme weather occurrences. For Nepal's mandarin industry, post-harvest losses must be addressed to increase food security, foster economic growth, and increase climate change resistance.

### 1.5 Factors contributing to post-harvest losses

The first stage of post-harvest operations is regarded as the harvesting criteria. The various parameters such as time, method, and stage of harvesting hurt the postharvest quality and shelf life of mandarin. Mandarin's quality after harvest may be impacted by midday higher temperatures and by subsequent handling practices. After harvesting, sorting practice helps avoid mixing fresh and healthy fruits with diseased and damaged fruits. It is not advised to leave the sorted fruits in the orchard because this encourages the spread of disease infection and provides an environment that is conducive to the growth of pests. The types of packaging materials used have a major impact on the extent of damage during subsequent handling, storage, and transportation. Depending on the packaging materials, means of transportation, road conditions, and temperature, a significant amount of loss occurs during Mandarin transportation.

The degree of decay losses during handling and storage is mostly determined by harvesting techniques, fruit damage during harvesting, and weather conditions during harvest (Milind S Ladaniya, 2015). After harvest, mandarin fruit typically suffers significant losses from the farm gate to the market and loses market acceptance from consumers. Improper harvesting, handling, packaging, and shipping can have a significant impact on loss (Dabargainya et al., 2022). Besides disregarding scientific methods for harvesting, handling, transporting, storing, and treating with antibiotics; inadequate plant protection techniques and a rise in pathogen inoculation in orchards also result in significant fruit losses after harvest (Sonkar et al., 2009). The low level of knowledge and skills in post-harvest operations also results in significant physiological and physical losses.

### 1.6 Causes of postharvest losses

#### 1.6.1 Mechanical injury

Mechanical damage during harvesting and associated handling operations can result in defects in the produce (Wills R., 1998). According to Choudhary, 2004, fresh fruits and vegetables are extremely vulnerable to mechanical injury due to their tender texture and high water content. Improper handling, inappropriate packaging, and poor packing during transit are the causes of bruising, cutting, breaking, impact wounding, and other forms of damage in fresh fruits and vegetables.

#### 1.6.2 Postharvest pathogens

The incursion of fruits and vegetables by fungi, bacteria, insects, and other organisms, is a major cause of postharvest losses in fruits and vegetables. Microorganisms readily attack fresh produce and spread rapidly, owing to the lack of natural protection mechanisms in the tissues of fresh produce, and the large quantity of nutrients and moisture which supports their growth. Managing postharvest rot is ever more becoming a complicated task, since the number of pesticides available is rapidly declining as end-user concern for food safety is greater than ever (Choudhary, 2004).

#### 1.6.3 Physiological deterioration

Fruits tissues still respire after harvest, and continue their physiological activity. It occurs due to a lack of minerals or unattractive ecological conditions such as low or high-temperature injury and humidity. Physiological deterioration can also occur unexpectedly owing to enzymatic activity, leading to over-ripeness and senescence (Choudhary, 2004).

### 1.7 Technological and management interventions to reduce post-harvest loss

Although many factors affect mandarin fruit losses, including cultural practices, topography, climate, and varieties, the shelf life of horticulture production is greatly influenced by post-harvest management strategies. To reduce post-harvest losses, the development of appropriate post-harvest technologies and their wider adoption among all mandarin growers is important. Numerous studies have been conducted, and effective technologies have also been developed to lessen post-harvest damage and extend the post-harvest life of oranges. In previous decades, a variety of practical technologies have been employed to extend the shelf life of harvested fruits including the use of fungicides, cold storage, controlled atmosphere storage, anti-transparent, wax coating, growth retardants, irradiation, and various types of packing materials (Yadav et al., 2010). Mandarin fruits are harvested by different methods such as direct pulling, twisting, and pulling, hitting by sticks, and clipping. According to the experimental findings, fruits harvested by clippers with intact small pedicel had the lowest PLW (3.15%), the higher fruit firmness (3.30 kg/cm$^2$), the higher juice recovery % (49.69%), the lowest TA (0.85%), and the highest vitamin C concentration (25.50 mg/100 ml) when stored in a cellar (Rokaya et al., 2020).

Standardization of mandarin maturity indices is crucial to minimize post-harvest losses during handling procedures and preserve the quality of the produce. Various

studies have been conducted to examine several physio-chemical changes that occur during the fruit's maturation stages to find the ideal stage of harvest maturity of mandarin and to identify appropriate post-harvest treatments for extending the mandarin's shelf life (Deka et al., 2006). Wooden boxes, and bamboo containers 'doko' are used for collecting mandarins (Milind S Ladaniya, 2015). Post-harvest losses can be minimized by extending the shelf life by monitoring the rate of transpiration, respiration, microbial infection, and membrane disintegration. Modified atmosphere packaging is used which increases the shelf life of Mandarin by up to 3 weeks (Milind S Ladaniya, 2015). Fruits coated with edible materials (oil, wax, chemical) can result in the creation of a modified atmosphere because the fruit's pores are not effectively blocked, which lowers respiration and enhances post-harvest quality (Kader, 2005).

Because of the perishable nature of horticultural crops, processing of these crops is regarded as one of the most important operations addressing postharvest loss issues. It also helps to add monetary value to the product.

Nepal has imported 1529472kg of citrus fruit (fresh or dried) in the last fiscal year of 2021/22 while exporting 50980kg in the same year (MoALD, 2023). This data clearly shows that the country lacks enough quantity of the citrus to be exported, rather it has to import a huge quantity of the fruit. This huge gap exists due to the ignorance of the government and researchers in the field of post-harvest loss in the mandarin industry in Nepal. Reducing post-harvest losses can bring more food without requiring more area for production, and post-harvest horticulturists must work together with those involved in production to develop marketing strategies (Acharya et al., 2023). Minimizing post-harvest loss is very important to increase the availability of fruit and ensure food security, so this factor needs to be addressed by the government and the researchers.

## II. CONCEPTUAL FRAMEWORK


*Fig3. A conceptual framework for understanding the factors involved in post-harvest technology*

## III. METHODOLOGY

### 3.1 Site Selection

The study will be conducted in the Gulmi district, which is declared a zone of Mandarin. The site exhibits climatic potentialities suited for citrus production. Due to the large production of citrus, the Government of Nepal has declared Gulmi as a zone under PMAMP.

The research will be conducted at the Mandarin orchards of Resunga Municipality and Dhurkot Rural Municipality. These areas are purposely selected as they are accessible for the researcher and thus more affordable as far as traveling expenses are concerned.

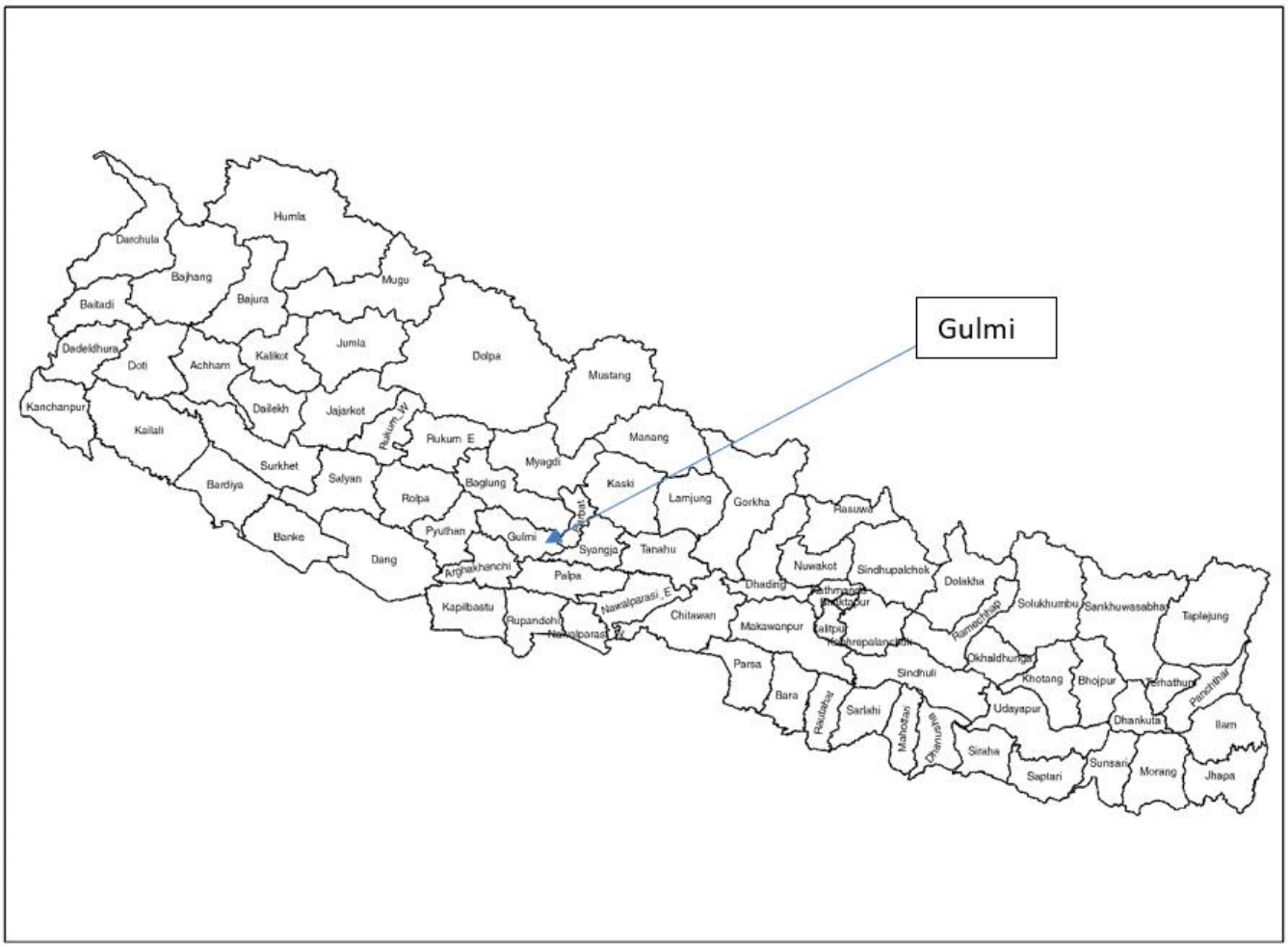


*Fig.4. Map of Nepal showing Gulmi district*

### 3.2 Preliminary Survey

The preliminary survey will be conducted to gather information on different survey components, including the site's sociocultural and demographic makeup. This will involve interviews with Mandarin farmers, and extension workers. The information thus gathered will be utilized in preparing questionnaires and creating a sampling framework.

### 3.3 Sample Size and Population

There are a total of 5773 farmers growing mandarin in Resunga Municipality and Dhurkot Rural Municipality. Simple random sampling will be carried out. The sample size for the study will be determined using Yamane's formula. Assuming a confidence level of 90%, and a margin of error of 10%, the sample size will be calculated as:

$n = N/ [1+N(e)^2]$

Where:

n = Sample size

N = Population of the study

e = Acceptable sampling error

Using the above formula, the sample size required for the study is estimated to be 98, at margin error (e) = 0.1. After rounding up the sample size, the survey will be carried out

in 100 households. The survey will be carried out in Resunga Municipality and Dhurkot Rural Municipality.

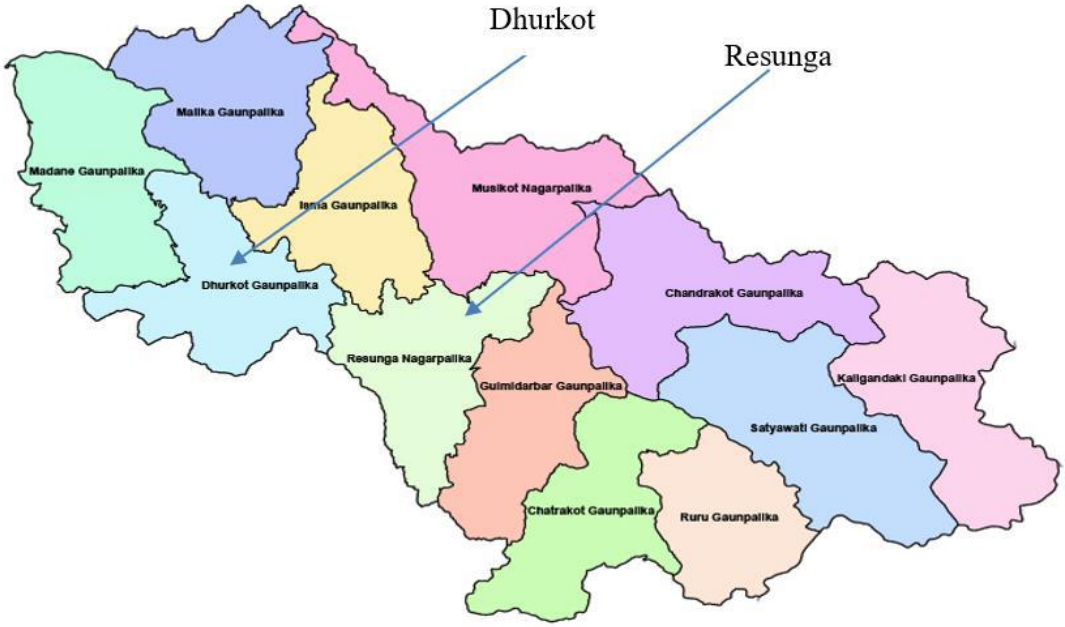


*Fig.5 Map of Gulmi showing the study area*

### 3.4 Research Instruments/ Design

#### 3.4.1 Preparatory Phase

During the preparatory phase, desk review of documents will be done. A questionnaire for the study relating to the post-harvest loss in Mandarin will be prepared. The sampling criteria and process of methodology will be finalized.

#### 3.4.2 Literature Review

Different literature regarding the study areas and other relevant documents will be reviewed.

#### 3.4.3 Questionnaire survey

A field survey will be carried out in the target location and a series of questions will be asked to collect some useful data. There will be a field visit, an informal discussion, and a questionnaire survey.

#### 3.4.4 Socio-demographic and Farm Characteristics

It will be used for descriptive analysis of the study areas and study populations. Utilizing descriptive statistical tools like percentage, mode, means, etc., different variables like family size, and land holding will be studied.

### 3.5 Source of Data

#### 3.5.1 Primary Source

The primary source of data will be farmers and a field survey will be carried out to gather the information. A field survey will be carried out through a structured and semi-structured questionnaire, and direct observation. In addition to farmers, AKC and Citrus Zone Program under the PMAMP project will be consulted to gather information related to Mandarin.

Informal talks will be done with local traders, retailers, and middlemen to get the necessary information.

#### 3.5.2 Secondary Source

The secondary sources of information will be collected from:

- Annual report of PMAMP, Gulmi
- Publications of DDC, NARC, Local levels, AKC Gulmi profile
- Previous survey report recommendations
- Journals
- Articles

### 3.6 Data Analysis

Data analysis will be done using software like SPSS and MS Excel. Descriptive data like frequency count, percentage, charts, and diagrams will be used as needed and the final report will be given to the AFU.

### 3.7 Index of agreement

The farmer's perception of pest and disease management strategy was analyzed by using different variables.

Strongly agree, agree, neutral, disagree and strongly disagree were used to analyze perception. Perception towards the management strategy was analyzed by using an index of agreement. The frequency of agreement was calculated by the summation of the frequency of response of scale as strongly agree and agree and the frequency of disagreement was calculated by the summation of the frequency of response of scale as neutral, disagree, and strongly disagree. The index of the agreement was calculated by using the formula (Pereira et al., 2018):

Index of agreement (Frequency of agreement- Frequency of disagreement)/ n

Where n total sample size

The value of the index of agreement may range from 1 to -1. When the value of the index of agreement is less than 0.5 then the variable is considered to have a positive perception whereas when the index of agreement is greater than 0.5 then the variable is considered to have a negative perception.

### 3.8 Indexing and Ranking

The ranking was done with the use of the indexing method. Scaling techniques provide the direction and extremity attitude of the respondent towards any proposition used to construct the index. The intensity of response to production problems, marketing challenges, and support needed were identified by using the five-point scaling technique for using scores of 0.2, 0.4, 0.6 and 0.8, 1.0 (i.e., least serious, little bit serious, moderate, serious, most serious), and similarly the score of 0.2, 0.4, 0.6, 0.8 and 1.0 (least, little bit, moderate, much, very much). The formula given below was used to find the index.

$\mathbf{I}_{imp}=\sum \frac{SiFi}{N}$ ( $\mathbf{I}_{imp} = 0 < I < 1$)

$\mathbf{I}_{imp}$ = Index of importance

Si = Scale value at $i^{th}$ priority

Fi = frequency of $i^{th}$ priority

N= Total number of respondents

A similar technique was also used by Subedi et.al for the ranking of the problems in potatoes (Subedi et al., 2019).

## IV. RESULT AND DISCUSSION

### 4.1 General household characteristics

This section deals with the socio-demographic characteristics of the respondents such as gender, ethnicity, age, education, marital status, family type, primary occupation, and family experience. The distribution of respondents based on socio-demographic characteristics is presented in Table 3. In this study, men made up the majority of the respondents (79%). This is because women were confined to domestic duties while the majority of men engaged in economic activity. The respondent population was dominated by the age group of 55 and above (48%).

Based on ethnicity, the majority of the surveyed respondents were Chhetris with 47% of the population. Similarly, about 45% had a nuclear type of family while 55% had joint families. Of the population, 24% were illiterate, and 76% were educated.

Out of the respondents whose primary source of income was agriculture (67%), only 7% had a maximum income percentage (76-100%). In the area, 29% of citrus growers had experience duration of 5-10 years, while the lowest percentage i.e., 12% had experience of 16-20 years. It is clear from the data that farmers were engaged in citrus cultivation for a long duration.

*Table 3: Distribution of respondents based on socio-demographic characteristics*

| Parameters | Frequency | Frequency |
|---|---|---|
| Gender | | |
| • Male | 79 | 79 |
| • Female | 21 | 21 |
| Ethnicity | | |
| • Brahmin | 37 | 37 |
| • Chhetri | 47 | 47 |
| • Janjati | 11 | 11 |
| • Dalit | 5 | 5 |
| Age | | |
| • Under 25 | 0 | 0 |

| | | |
|---|---|---|
| • 25-34 | 6 | 6 |
| • 35-44 | 13 | 13 |
| • 45-54 | 33 | 33 |
| • 55 and above | 48 | 48 |
| Education | | |
| • Illiterate | 24 | 24 |
| • Primary education | 10 | 10 |
| • Secondary education | 41 | 41 |
| • Higher education | 17 | 17 |
| • University | 8 | 8 |
| Marital status | | |
| • Married | 99 | 99 |
| • Unmarried | 1 | 1 |
| Family type | | |
| • Nuclear | 45 | 45 |
| • Joint | 55 | 55 |
| Primary occupation | | |
| • Agriculture | 67 | 67 |
| • Business | 12 | 12 |
| • Government service | 8 | 8 |
| • Non-government service | 9 | 9 |
| • Retired | 3 | 3 |
| • Foreign worker | 1 | 1 |
| Income percentage from Mandarin | | |
| • Less than 25% | 22 | 22 |
| • 25-50% | 35 | 35 |
| • 51-75% | 36 | 36 |
| • 76-100% | 7 | 7 |
| Farming experience | | |
| • Less than 5 yrs | 13 | 13 |
| • 5-10 yrs | 29 | 29 |
| • 11-15 yrs | 27 | 27 |
| • 16-20 yrs | 12 | 12 |
| • More than 20 yrs | 19 | 19 |

### 4.2 Farm Characteristics

#### 4.2.1 Farm Characteristics

The distribution of respondents according to farm characteristics is presented in Table 4. The majority of respondents (45%) had 5-10 ropani of land, but only 31% had a mandarin farm of that size. It explained that the land holding was not solely utilized for the cultivation of mandarin. A citrus grower in the area obtained average yields of 4326.20 kg per season, and they sold their mandarins at an average price of Rs.60.51, ranging from a minimum of Rs.45 to a maximum of Rs.75.

*Table 4: Farm characteristics of farmers involved in mandarin farming in Gulmi, 2024*

| Parameters | Frequency | Percentage (%) |
|---|---|---|
| Landholding | | |
| • Less than 5 ropani | 7 | 7 |
| • 5-10 ropani | 45 | 45 |
| • 11-20 ropani | 35 | 35 |
| • More than 20 ropani | 13 | 13 |
| Mandarin cultivation land | | |
| • Less than 5 ropani | 20 | 20 |
| • 5-10 ropani | 31 | 31 |
| • 11-20 ropani | 39 | 39 |
| • More than 20 ropani | 10 | 10 |

*Table 5: Production distribution of respondents growing Mandarin in Gulmi, 2024*

| Parameters | Minimum | Maximum | Mean |
|---|---|---|---|
| Total production (kg) | 140 | 22000 | 4326.20 |
| Selling price (per kg) | 45 | 75 | 60.51 |

#### 4.2.2 Variety

Among 100 respondents surveyed, 83% of people use local varieties of Mandarin, 4% people use improved varieties, and 13% people use both local and improved varieties. This illustrates that people were content with the results of the local variety they were using and were unwilling to employ improved variety because they were unaware of its advantages.

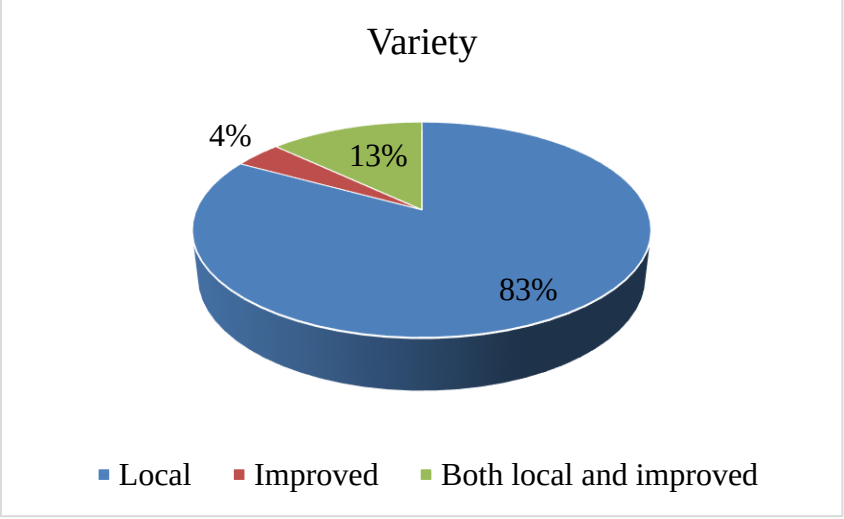


*Fig.5 Variety used by mandarin farmers in Gulmi, 2024*

### 4.3 Harvesting status

#### 4.3.1 Harvesting time and criteria

The shelf life of mandarin after harvest may vary depending on when it is harvested. A total of 99 farmers harvested their fruits from Mangsir to Magh, which is suggested to be the suitable season for mandarin harvesting (Shah, 2010.). Similarly, 23% of farmers harvest mandarin fruit in the midday time. Elevated midday temperatures and subsequent handling techniques could affect the post-harvest quality of mandarin. However, the arrival of traders determined the majority of harvesting daytime schedule.

Harvesting criteria are regarded as the first stage of the post-harvest operation. The various harvesting parameters may have some impact on the quality of mandarin after harvest. According to the results, the majority of farmers harvest mandarin based on the fruit's color (81%) and then traders' order (7%).

*Table 6: Harvesting time and criteria followed by mandarin farmers in Gulmi, 2024*

| Parameters | Frequency | Percentage (%) |
|---|---|---|
| Harvest time | | |
| • Kartik-Mangsir | 0 | 0 |
| • Mangsir-Poush | 47 | 47 |
| • Poush-Magh | 52 | 52 |
| • Magh-Falgun | 1 | 1 |
| Harvest day-time | | |
| • Late morning | 5 | 5 |
| • Mid-day | 23 | 23 |
| • As per the arrival of traders | 70 | 70 |
| • Both in the late morning and as per the trader's arrival | 2 | 2 |
| Harvesting criteria | | |
| • Fruit color | 81 | 81 |
| • As per trader's order | 7 | 7 |
| • Both fruit color and as per trader's orders | 12 | 12 |
| • Fruit size | 0 | 0 |

#### 4.3.2 Modern harvesting equipment

As seen in the table, the secateurs were a common piece of modern harvesting equipment. About half of the respondents lacked any modern harvesting tools. This clarifies the more conventional methods of farming in the study area.

*Table 7: Distribution of respondents according to the use of modern harvesting equipment in Gulmi, 2024*

| Parameters | Observation | Frequency | Percentage (%) |
|---|---|---|---|
| Use of modern harvesting equipment | | | |
| • Use | 100 | 56 | 56 |
| • Do not use | 100 | 44 | 44 |
| Type of modern harvesting equipment in use | | | |
| • Knife | 100 | 0 | 0 |

| | | | |
|---|---|---|---|
| • Secateurs | 100 | 53 | 53 |
| • Ladder | 100 | 3 | 3 |
| • None | 100 | 44 | 44 |

### 4.3.3 Harvesting method and techniques

The following Table 8 shows that out of 100 respondents, 55 farmers harvested their fruits by twisting them with their hands which is a traditional method. When fruits are picked by hand rather than clipped, the harvesting rate is faster and harvesting costs are lower (Sonkar et al., 1999). However, fruits with intact stalks are less likely to become infected with fungi while being stored (Purbiati & Supriyanto, 2013). Thus, clipping is preferable to hand-twisting since it can assist in picking fruit with a stalk.

*Table 8: Harvesting methods followed by mandarin farmers in Gulmi, 2024*

| Parameters | Observation | Frequency | Percent |
|---|---|---|---|
| Harvesting methods | | | |
| • Picking | 100 | 55 | 55 |
| • Shattering | 100 | 0 | 0 |
| • Using secateurs | 100 | 2 | 2 |
| • Both by picking and using secateurs | 100 | 43 | 43 |
| Harvesting technique | | | |
| • Clipping including fruit stalk | 100 | 2 | 2 |
| • Clipping with stalk and a few leaves | 100 | 3 | 3 |
| • Hand twisting | 100 | 55 | 55 |
| • Both by hand twisting and clipping with stalk and leaves | 100 | 40 | 40 |

## 4.4 Post-harvest status

### 4.4.1 Activities Performed After Harvest

Among the respondents, 88% said they didn't store their fruit because they sold it right away once it was harvested. Other measures, such as cold room and storeroom storage were being used in very few numbers. Given that none of the respondents mentioned using the processing industry, and very few were using storage, we can conclude that the lack of storage and processing facilities were the main issues in the area.

*Table 9: Activities performed after harvesting of the mandarin in Gulmi, 2024*

| Activities | Frequency | Percentage (%) |
|---|---|---|
| Storage mechanism | | |
| • Keep in the storeroom | 4 | 4 |
| • Keep in cold storage | 7 | 7 |
| • Sell immediately after harvest | 88 | 88 |
| • Both keep in the storeroom and sell | 1 | 1 |
| Field heat removal | | |
| • Remove | 3 | 3 |

| | | |
|---|---|---|
| • Do not remove | 97 | 97 |
| Fruit placement in the field after harvest | | |
| • Under shade | 5 | 5 |
| • Under sunlight | 95 | 95 |
| Storage duration in cold storage | | |
| • Does not store | 94 | 94 |
| • 1-2 month | 1 | 4 |
| • 3-4 months | 3 | 0 |
| • More than 4 months | 2 | 2 |
| Storage duration in the storeroom | | |
| • Does not store | 96 | 96 |
| • 1 week | 3 | 3 |
| • 2 weeks | 1 | 1 |
| • More than 2 weeks | 0 | 0 |

### 4.4.2 Collecting material

Among different materials, most of the farmers were using both doko and plastic bags (46%) to collect fruits, and few were using only doko (10%). This shows that people preferred to use easily available materials for collecting their fruits in the study area.

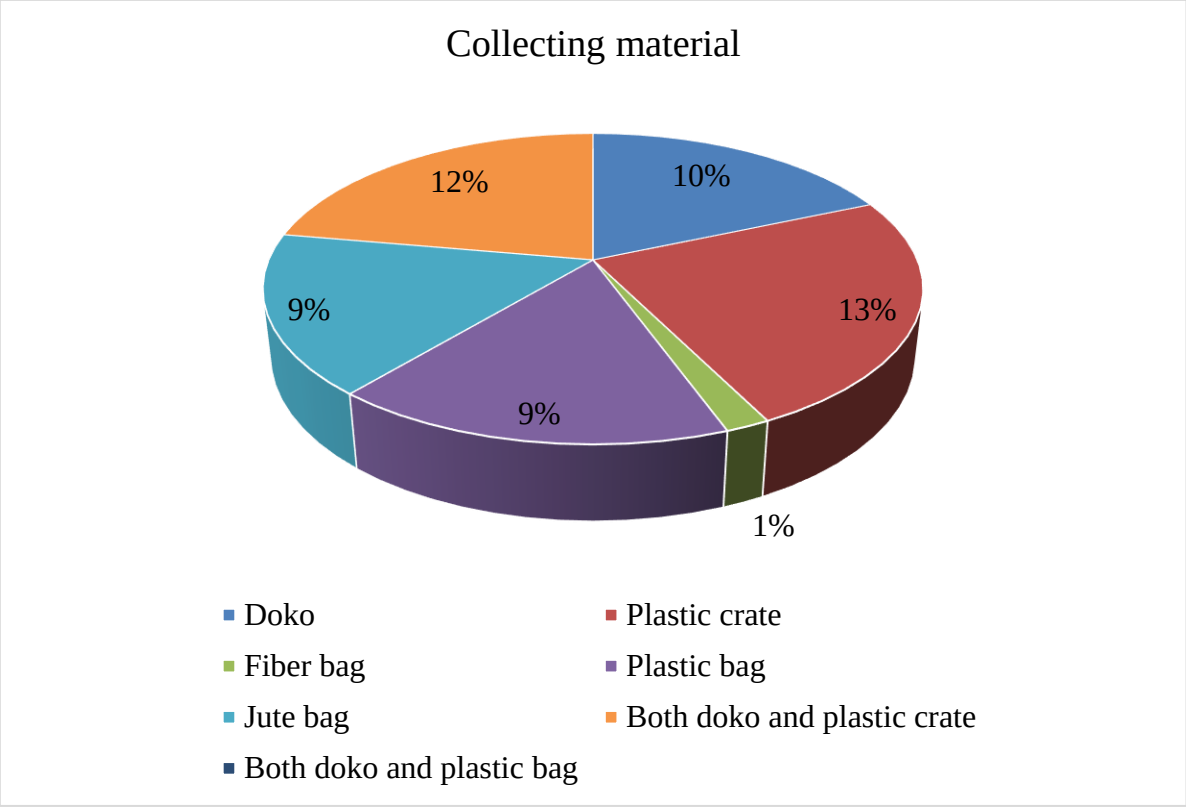


*Fig.6 Pie-chart showing collecting materials used by mandarin farmers in Gulmi, 2024*

### 4.4.3 Sorting and Grading

A large number of farmers (98%) adopted the sorting technique while selling the fruits. Similarly, 97% of respondents graded their fruits as large, medium, and small according to the fruit size. However, the farmers did not employ any standards in their grading process. Thus, farmer-to-farmer may have variations in size within the same grade.

*Table 10: Distribution of respondents according to the sorting and grading technique in Gulmi, 2024*

| Parameters | Frequency | Percentage (%) |
|---|---|---|
| Sorting technique | | |
| • Use | 98 | 98 |
| • Do not use | 2 | 2 |
| Grading technique | | |
| • Use | 97 | 97 |
| • Do not use | 3 | 3 |
| Grading category | | |
| • Fruit size | 97 | 97 |
| • Fruit shape/dimension | 0 | 0 |
| • Fruit color | 0 | 0 |
| • None | 3 | 3 |

Farmers who were performing sorting operations were questioned about what they did with the sorted fruits. The findings showed that the majority of farmers kept the sorted fruits for personal consumption and distributed them to other families. Some farmers (24%) used them to make local wine and made additional small income, while 3% did nothing and left them in the orchard.

*Table 11: End use of sorted fruits followed by mandarin farmers in Gulmi, 2024*

| Management of sorted fruits | Frequency | Percentage (%) |
|---|---|---|
| • Left in the orchard | 3 | 3 |
| • Throw open the pit | 13 | 13 |
| • Burry in the pit | 29 | 29 |
| • Local winemaking | 24 | 24 |
| • Keep at home to eat and give others | 39 | 39 |

### 4.4.4 Mandarin marketing

The following table shows that about half of the respondents (45%) surveyed sold their mandarins in regional and national markets through collectors and wholesalers as middlemen. Farmers did not have a contractual agreement with the middlemen, even though they were involved in the majority of Mandarin marketing in the research area. This had made the farmers vulnerable to the exploitation by the middlemen. Additionally, 52% of the respondents did not have access to market information.

*Table 12: Mandarin marketing practices followed by Mandarin farmers in Gulmi, 2024*

| Parameters | Frequency | Percentage (%) |
|---|---|---|
| Selling method | | |
| • Using contractor | 97 | 97 |
| • Self-marketing | 1 | 1 |

| | | |
|---|---|---|
| • Both using contractor and self-marketing | 2 | 2 |
| Contractual agreement | | |
| • Have | 1 | 1 |
| • Do not have | 98 | 98 |
| Buyers | | |
| • Collectors/Traders | 46 | 46 |
| • Wholesalers | 2 | 2 |
| • Both contractors and Whole-salers | 51 | 51 |
| • None | 1 | 1 |
| Primary market | | |
| • No idea | 15 | 15 |
| • Local market | 8 | 8 |
| • Regional market | 25 | 25 |
| • National market | 5 | 5 |
| • Both local and regional mar-ket | 2 | 2 |
| • Both regional and national market | 45 | 45 |
| Access to market information | | |
| • Have | 48 | 48 |
| • Do not have | 52 | 52 |
| Means of market information | | |
| • Newspaper | 7 | 7 |
| • Phone calls | 10 | 10 |
| • Neighbors | 12 | 12 |
| • Market visit | 23 | 23 |

#### 4.4.5 Packaging materials

Fig. 8 depicts the trend of using plastic crates as a means of mandarin packaging in the study area.

#### 4.4.6 Post-harvest management

Farmers were lacking of knowledge regarding modern post-harvest technologies. Among the surveyed respondents, more than half of the population were not using any management technique to maintain the quality of their Mandarin. A small number of people were also using other methods such as storage in cellars, on trees, and in between straws.

#### 4.4.7 Barriers to the adoption of post-harvest technology

The detailed rank of the various barriers with the index value and frequency of the respondents is represented in Table 22. All 100 Mandarin farmers were asked to rank the barriers to the adoption of post-harvest technology among the barriers listed in the interview schedule. According to the calculated index, the first barrier to post-harvest technology adoption was found to be “Poor facility of post-harvest technology”, followed by “Unwillingness to adopt the technologies”, “Lack of reliable extension”, and “High initial cost of technology adoption”.

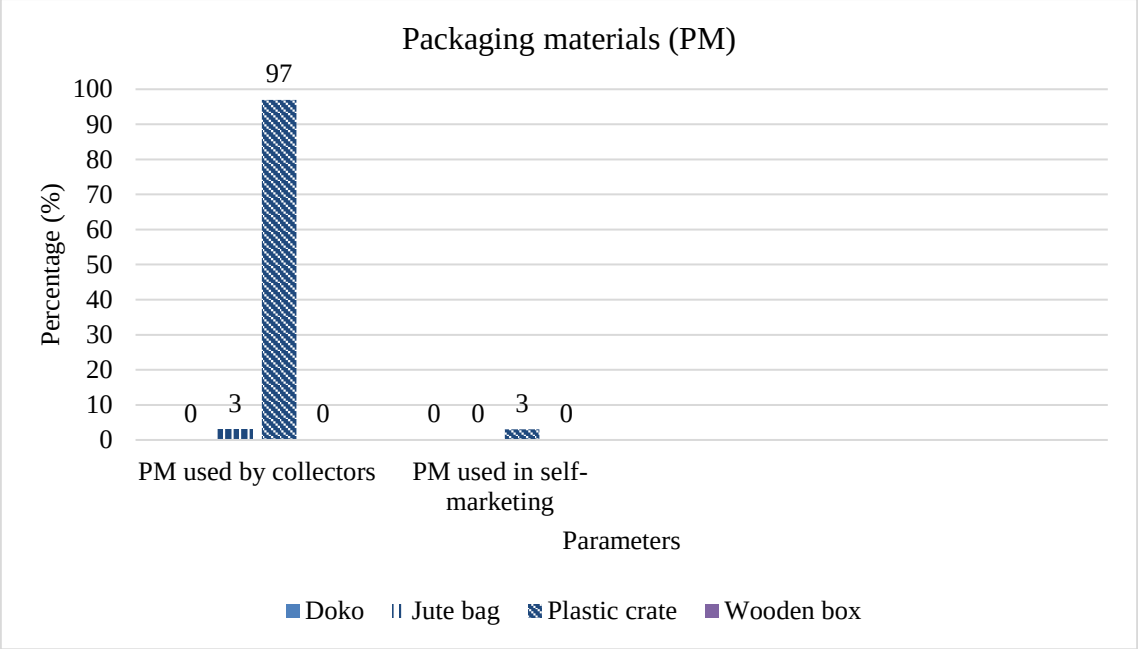


*Fig.7: Bar chart showing packaging materials used in Gulmi, 2024*

*Table 13: Post-harvest management technique adopted by mandarin farmers in Gulmi, 2024*

| Management technique | Frequency | Percentage (%) |
|---|---|---|
| No techniques have been used | 61 | 61 |
| Store in between straws | 34 | 34 |
| Store in trees with a net on | 4 | 4 |
| Cellar storage | 1 | 1 |

*Table 14: Barriers to the adoption of post-harvest technology among the mandarin farmers in Gulmi, 2024*

| Barriers | P1 | P2 | P3 | P4 | Index value | Rank |
|---|---|---|---|---|---|---|
| Lack of reliable extension service | 13 | 42 | 34 | 11 | 0.6425 | III |
| Poor facility of post-harvest technology | 40 | 32 | 24 | 4 | 0.77 | I |
| Unwillingness to adopt technologies | 38 | 20 | 26 | 16 | 0.7 | II |
| The high initial cost of technology adoption | 8 | 6 | 15 | 71 | 0.3775 | IV |

Where P denotes the priority level of the production. The weightage ranking from 1 to 4 was provided to each of the listed barriers to the adoption of post-harvest technology. Then, the frequency of respondents was counted according to the ranking order provided by them to each of the barriers. The sum of the obtained frequency and weightage was then divided by the total respondents and maximum weightage number which gave the index value. The barriers were ranked by the obtained index value.

**4.5 Losses at different stages of post-harvest operation**

On the overall basis, the maximum loss was incurred during the harvesting stage, i.e., 8.12%, followed by grading (4.05%), sorting (3.07%), and storage (3.07%).

*Table 15: Losses incurred by the respondents in Gulmi at the beginning stage of marketing, 2024*

| Parameters | Average Percentage (%) |
|---|---|
| Harvesting | 8.12% |
| Storage | 1.65% |
| Sorting | 3.07% |
| Grading | 4.05% |

## V. CONCLUSION

The Study found the status of post-harvest technology practiced by Mandarin producers. In the context of Dhurkot Rural Municipality, and Resunga Municipality, the majority of respondents were male, followed by those aged 55 and above. The predominant ethnic group was Chhetris, and all respondents followed the Hindu religion. Most of the farmers used their local variety and traditional methods of post-harvest management practices. Due to a lack of knowledge of proper implantation of appropriate post-harvest technology, poor availability, unwillingness the adopt the technology, high cost of the technology, etc., farmers in the study area, were not able to squeeze all the benefits from mandarin farming. The loss of Mandarin across the post-harvest chain resulted from a lack of knowledge about proper post-harvest management. Improper grading, packaging, lack of storage, and inadequate transportation facilities contribute more to the problem. One of the most important causes of post-harvest losses is harvest at inappropriate maturity, resulting in erratic ripening and poor quality. The forgoing results and analysis of data concluded that Mandarin production and marketing has great potential in the study area, despite some challenges faced by farmers. The main focus should be on developing the mindset of the farmers regarding post-harvest technology, disseminating the knowledge, ensuring input supply, and providing strong technological support. Growers directly sold their fruits to the contractors as they were scared of taking the risk of post-harvest losses during the post-harvest operation. They lack the resources and finances to expand and strengthen their Mandarin marketing. They also faced problems with poor facilities transportation, electricity, etc. The marketing of mandarins in the study area is mostly controlled by a few traders who exploit mandarin producers by buying their produce at very low prices and selling it to consumers at higher prices.

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