Assessment of Mango Post-Harvest Losses along Value Chain in the Gamo Zone, Southern Ethiopia

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ABSTRACT

Even though the Gamo zone is a prevalent mango producing area in Ethiopia, the lack of comprehensive post-harvest loss research along the mango value chain prevents respective stakeholders from recognizing the socioeconomic, nutritional and environmental significance of the post-harvest loss problem. Improving the post-harvesting handling practice not only increases the production by reduction of post-harvest loss but also increases food access at the market level with prices adjustment. Therefore, this study was intended to assess the post-harvest loss along the mango value chain and the challenges that actors and stakeholders face in the process. To do this, 120 mango producers were selected following a multistage sampling procedure. The analysis result shows that the main reasons for the low productivity of mango are the use of the local variety, disease and insect pests and lack of improved harvesting technologies. The result also shows about 41% of mango loss in the study area was due to a lack of improved harvesting mechanism and infection by disease and pests and poor transportation mechanisms. From this loss, the harvesting stage shares the largest share (18%) along the mango value chain. In addition, lack of improved mango varieties, lack of cooperative and wholesale marketing and lack of value addition practice are the major identified problems in the study area. There is also a huge loss of mango production in the study area that needs immediate intervention from respective stakeholders. Thus, dissemination of improved varieties through the distribution of seedlings, modifying the existing harvesting materials and introduction of improved harvesting technologies, strengthening the cooperative marketing and supporting alternative products development through processing was suggested.

INTRODUCTION

Ethiopia has suitable agro-ecology to grow both temperate and tropical fruit crops (Yigzaw et al., 2016). Fruit production plays a significant role in the local economy as a means of earning livelihoods for nearly five million farmers, creating jobs and generating foreign exchange revenues in Ethiopia (FAO Food and Agriculture Organization, 2019). Consequently, the Ethiopian government in its second Growth and Transformation Plan (GTP) that covers 2015–2020 provided a greater emphasis for increasing production of fruit crops nearly by 50% from the existing (NPC National Planning Commission, 2016). Among the fruits, banana, mango, orange, avocado and papaya are the major fruits that are grown with great emphasis in the country (Kassa et al., 2020).

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Mango is the second most important fruit crop next to banana in Ethiopia (CSA (Central Statistics Agency of Ethiopia), 2019). It covered about 19,497.92 hectares (ha) of 119,908.57 ha total covered area by fruit which is 16.21%. A total of 1,337,049.26 quintals\(^1\) of mango was produced in the 2018/19 production season with a productivity level of 68.57 quintals per ha (CSA, 2019). Among the regions of Ethiopia, Harari, west and east Oromia, Southern Nations, Nationalities, and People’s Region (SNNPR) and Amhara are the main mangoes producing regions (Banjaw, 2017).

South Nation Nationality Peoples’ Region (SNNPR) is famous for its mango production with its 47% share of total production in the country (CSA, 2020). The region has relatively higher mango productivity which is about 80.41 quintal per hectare as compared to the national average which is 63.4 quintal per hectare (CSA, 2020). Due to this productivity change in the region, it is the leading region in the country for mango production in the 2020 cropping season. The region also holds a 27% share of Addis Ababa’s wholesale mango market. Within the region, the Gamo zone is a key supplier of mango to the national market due to its conducive climate for production (Birhanu et al., 2015).

Mangoes are grown by the majority of farmers living in Arba Minch Zuria, Mirab Abaya and Bonke districts of Gamo Zone (Farm Africa, 2020). Farmers in the zone were relying on old and big unmanageable mango trees (Birhanu et al., 2015). Recently, climate change has caused newly emerging pests and diseases, such as fruit flies, which are causing an increasing number of mangoes to rot (Gizachew et al., 2016). Despite its largest mango production in the Gamo zone, farmers could not generate as much benefit from the production of the crop. On the other side, due to its perishable nature mango need maximum care during harvesting, transporting, and storing (Kayier et al., 2019). So far, the lack of improved harvesting, collection, storage and transportation techniques and materials have significantly affected farmers’ bargaining power in the zone because they cannot wait with their product any longer (Farm Africa, 2020). This enables traders to cut prices, which further reduces producers’ bargaining power to sell their products at a price that is convenient for them.

Postharvest loss is one of the major problems along the mango value chain in Ethiopia as well as in the Gamo zone (Mohammed and Afework, 2018). On the other hand, the United Nation’s Sustainable Development Goal (SDG) and the African Union Agenda 2063 are both committed to halving the postharvest losses from the current levels by the years 2030 and 2023, respectively (FAO, 2019). Reducing post-harvest loss without any cost of production by intervening on its determinants will increase production and food security (Banjaw, 2017; Bart et al., 2021; Benyam et al., 2018). Since postharvest loss reduction throughout commodity value chains is an important pathway for food and nutrition security (Mengistie et al., 2021), research on post-harvest loss and associated factors along the value chains is a pertinent issue to operationalize postharvest loss mitigation strategies and reduce the product waste by maintaining the quality of the product (Ahmad et al., 2020; FAO, 2019; Muluken et al., 2019).

According to Addo et al. (2015), Anna et al. (2020) and Oyekanmi (2007) assessing postharvest loss prevention technology techniques becomes paramount as more produce is transported to non-producing areas to supply the growing population as well as storing for a longer period to obtain a year-round supply. To increase the efficiency of food supply chains and enhancement of food security, mango value chain improvement through postharvest research and development is crucial (FAO, 2019). A study by Yigzaw et al. (2016) assessed postharvest losses and handling practices of fruit in Northwestern Ethiopia found that due to inappropriate handling and lack of proper storage facility about 20% of the fruits purchased by retailers were lost before reaching consumers. Theodosy and Elde (2011) conducted a study on the management of post-harvest losses of fresh mango in Tanzania and found that loss of fruit occurred along the mango value chain at the marketing, transporting and harvesting stage. Yebirzaf and Esubalew (2021) investigated the main causes of post-harvest loss for horticultural crops in the Amhara region of Ethiopia. The study found that transportation methods used, the selling place, storage methods, and materials, mechanical damage, and poor handling as

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\(^1\) quintal = 100 Kg.
major causes for postharvest losses. A study by Hagos et al. (2018) assessed post-harvest losses of fruits in northern Ethiopia and found that lack of awareness, poor market access and poor post-harvest handling practices significantly determine fruit post-harvest losses.

Numerous studies were conducted with regards to mango value chain constraints and post-harvest loss assessment in Ethiopia so far (Derebe, 2021; Mengistie et al., 2020; Chala et al., 2019; Mesay, 2017; Muluken et al., 2018; Kayier et al., 2019; Tewodros et al., 2019; Mohammed and Afework, 2018). However, the majority of the researches have focused on mango production practices, marketing channels, disease and adaption of improved varieties. Although most of these studies offer useful insights into identifying production potentials and constraints, marketing supply channels, and potential factors influencing value chain participation, they are limited in many ways. Firstly, the previous studies do not focus on the Gamo zone of Southern Ethiopia while it is the highest mango producer area as compared to other zones in Ethiopia. Secondly, most of the previous studies focus on market chains analysis by ignoring post-harvest loss. Thirdly, the previous studies conducted on post-harvest and related issues were only limited to the harvesting stage and excluded the loss along the mango value chain.

The research on post-harvest food losses of mango in Ethiopia is not adequate to conduct a comprehensive post-harvest food loss assessment (Solomon, 2019; Muluken et al., 2019). The lack of such information prevents the government, development organizations, research institutes, and other stakeholders from recognizing the socioeconomic, nutritional and environmental significance of the post-harvest loss problem (Affognon et al., 2015). Unlike the previous studies, this study relied on the assessment of post-harvest handling practices and loss along the mango value chain since it is the main problem of the commodity in the study area. Improving the post-harvesting handling practice not only increases the production by reduction of post-harvest loss but also increases food access and prices adjustment at the market level (Jahanbakhshi et al., 2018; Mujuka et al., 2020). In addition, reducing post-harvest losses instead of increasing food production is not only makes food available to consumers but also saves scarce resources and reduces environmental pollution due to intensive farming (Chala et al., 2019). Thus, this study result has multiple effects both from the production and consumption side. By doing so, this study contributes to evolving literature on the post-harvest improvement of mango value chains. Due to the importance of mango as an agricultural product and lack of much knowledge about how to reduce its post-harvest loss, this research study was carried out to fill this gap. The results of the research will be very useful in designing different technologies for harvesting and post-harvest reduction purposes along the mango value chain.

**Research Methodology**

**Description of the Study Area**

Arba Minch Zuria is one of the districts in the Gamo zone of Southern Nations, Nationalities, and Peoples’ Region of Ethiopia (Abayneh, 2018). Arba Minch Zuria which is a part of the Gamo Zone located in the Great Rift Valley is bordered on the south by the Darashe special district, on the west by Geresa, on the north by Gacho Baba and Chencha, on the northeast by Mirab Abaya, on the east by the Oromia Regional state, and on the southeast by the Amaro Special Woreda. This woreda also includes portions of two lakes and their Islands, Abaya and Chamo. Nechisar National Park is located between these lakes (see Figure 1). Arba Minch Zuria district surrounded the city of Arba Minch (http://en.wikipedia.org/Arbaminch).

The district has different agro-ecology suited for farming system and received average rainfall of 892 mm with a maximum and minimum temperature of 30.4 and 15.6°C, respectively, in the last ten years (Abayne & Aweka, 2021). Fruit-based farming is the dominant farming system in the Arba Minch Zuria district. The district is known for its high potential in tropical fruit production (mainly banana, mango, lemon and papaya) in the Gamo zone of southern Ethiopia (Gebre et al., 2020). The area contributes 10 to 15% of the estimated 135,000
tonnes of national fruit production. However, its potential is much higher and supply to the Addis Ababa market could be as high as 40% of the total amount delivered to the capital city (Timoteos, 2009).

**Sampling Methods and Sample Size**

This study followed a multistage sampling procedure to select the sample respondents since it allowed researchers to make clusters and sub-clusters until the researcher reached the desired size. First, Arba Minch Zuria district was selected purposefully based on its mango production potential from the Gamo zone. Secondly, from the selected district, three kebeles (the smallest administrative hierarchy in Ethiopia) namely Lante, Chano mile and Chano dorga were selected purposefully again based on their mango production volumes. Thirdly, with help of each selected kebeles’ Development Agents (DA) and kebeles’ administration, the farmers were stratified and listed into two groups (mango producers and non-producers). Finally, from the mango producers group, 120 sample farm households were selected by simple random sampling technique based on Probability Proportional following formula given by Yamane (1967).

$$n = \frac{N}{1 + N\left(e^2\right)}$$

Where n is a sample size, N is the total number of households of the Arbaminch Zuria district which is 26931 and e is the desired level of precision which was taken to be 9%.

In addition, for stakeholders’ interviews, 3 DA from each kebele and 2 experts from the district office of agriculture were interviewed using key informant interviews (KII). Finally, in each kebele, one focus group discussion (FGD) was held with selected 6–10 mango producers.
Method of Collection and Analysis

Data were collected using data collection instruments such as an observation, semi-structured questionnaire and checklists. During an observation, the availability of mango farms, the farming system, farm tools used to harvest, post harvesting, storage, packing and transporting, retail shops, and roadside traders was observed. Checklists for FGD and KII were used to collect data from, selected mango producers, kebeles and district level agricultural experts to get the overall outlook on the post-harvest loss along the mango value chain. A total of three focus group discussions each consisting of 10 mango producers were conducted. The participants of the interview process were excluded from both FGD and KII. By allowing them suitable conditions to discuss issues, the participants discussed the issues by using their local language with help of kebele development agents. Each focus group discussion was conducted with the assistance of the development agent and the researchers. To capture more firsthand data, KII instruments were used in this study. Based on the data collected from both the FGD and the household survey and the data that need further elaborations the KII guide was prepared since it helped to triangulate the data by using multiple data collection tools (Ariho et al., 2015; Creswell, 2009).

To collect the intended data from sampled households, each kebele development agents were selected as an enumerator. Before data collection of the DA, training was given on the prepared questionnaire and way of data collection. The draft questionnaire was pretested on fifteen respondents to evaluate the appropriateness of the design, the relevance of the questions, clarity and time taken for an interview. Thus, based on the feedback collected from the pretest appropriate modifications were made to the questionnaire before conducting a formal survey. Finally, the collected data were entered and cleaned by Statistical Package for Social Sciences (SPSS) before analyzing it. Then, using descriptive statistics such as frequency distribution, the collected data were analyzed and interpreted in line with the stated objectives.

Result and Discussions

Descriptive Results

Socio-Demographic Characteristics of Respondents

This section presents the profile of the sampled respondents’ age, family size, education level, land size and their mango production experience. The results on the age of respondents which is measured in year’s shows that the average age of the sample households was 48.4 years (Table 1). It ranges from 24–70 years where the largest proportions of the household head lie within a productive age i.e. between 24 and 58 years. The collected data showed that the average family size in the sampled households is 7. In addition, the result shows that many of the family members were participants in mango farming hence reducing the cost of labor. Therefore, it could be understood that bigger family

| Variables                   | Mean | Standard Deviation |
|-----------------------------|------|--------------------|
| Age of households           | 48.4 | 14.7               |
| Education level             | 7.9  | 3.5                |
| Family size                 | 7.2  | 32.7               |
| Total land size             | 1.5  | 0.9                |
| Land size for annual crops  | 0.5  | 0.1                |
| Land size for perennial crops | 0.6 | 0.3                |
| Land size for Mango         | 0.3  | 0.1                |
| Experience (Mango)          | 14.3 | 4.4                |
| Mango trees/household       | 11.8 | 4.9                |

Source: Survey result, 2021.
size has a positive impact on mango production to increase its productivity. The average education level attended by respondents is about 8 grades (Table 1). The study result indicates that more than half (54.8%) have attained secondary and tertiary education.

With regards to landholding, the study revealed that the respondents have an average area of 1.5 ha land allocated for both annual and perennial crops. From this, the sampled respondents allocate about 55% for perennial crops. Mango shares about 14% of total land and 30% of perennial crops in the study area as the survey result indicates. This shows that almost all of the respondents have used the greater portion of their land for mango production. This indicated that farmers in the study area give high attention to mango hence it brings cash income for their livelihood. Concerning mango production experiences, the sampled respondents had an average of 14.3 years of experience (ranging from 6 to 30 years). This implied that most of the respondents in the study area have good experience in mango cultivation. The average number of mango trees owned by the respondents in the study area is about 12 trees.

The production system of mango in the study is mixed. More than half of the respondents (58.1%) practiced intercropping production systems (Table 2). Specifically, they practiced mixed intercropping of mango with banana and a few of them with vegetables and other annual crops. The respondent’s reason out that spacing between mango trees is higher and the land size of farmers in the study area smaller, therefore, they are engaged in this cropping system. The majority of the mango producers (84.2%) did not use improved varieties of mango. This may be due to the low availability of improved mango varieties in the study area. Even though the regional nursery site is located in Cheno mile kebele of Arba Minch Zuria district, the mango producers are not getting the improved varieties in the district because mango seedling from the nursery site was taken to other areas of the region.

**Harvesting**

According to a focus group discussion with mango producers, mango is harvested mostly twice a year in the study area. The first season for harvesting mango fruit starts from December to January. While the second season starts from April to May. In the study area, mango is harvested mostly by daily laborers (71%) while the remaining percent was done by family labor (Figure 2). During the harvesting time, most of the daily laborers harvest both matured and immature mango by mixing.

With regards to harvesting tools, the respondents confirm that the improved harvesting tools and mechanisms were not widely practiced by mango producers in the study area. During harvesting, traditional ways of harvesting mechanisms like shaking of the mango tree, picking with a stick and cutting the fruit branch are used. In addition, the harvesting tools used by most of the farmers in the study area are the Gatile (Figure 3a) and to some extent Stafafero (Figure 3b) that were introduced recently by different NGOs.

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\text{Table 2. Mango production system in Arbaminch zuria district.}
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| Mango production system | Percent (%) |
|-------------------------|-------------|
| Sole                    | 22.5        |
| Intercropping           | 68.1        |
| Plantation              | 9.4         |
| **Use of an improved variety** |     |
| Yes                     | 15.8        |
| No                      | 84.2        |


Transport

Transport for mango occurs twice in those selected areas, the first is from mango farm area to collection areas while the second transport is to the areas where local traders (collectors) pick the ripe mango. Additionally, local collectors and sometimes wholesalers transport to the marketplace. For transportation purposes, about 87% of respondents used a traditional trolley and cart (see Figure 4a). Local collectors and wholesalers use vehicles to transport mango fruits from the studied kebeles to the fruit marketing areas of Ethiopia (see Figure 4b). A study by Benyam et al. (2018) in Ethiopia confirmed that the use of traditional ways of transport will increase post-harvest loss.

Collection and Marketing

In the study area, harvesting mature (ripe) and immature mango fruit is a problem from mango producers’ sides. Even though the local traders have experienced harvesters, they also harvest mango by mixing both matured and immature fruits. The survey results confirm that during collection time, the local collectors in some cases sort only the mature mango while the remaining immature were
considered as wastage. The local traders purchased mango from producers on a count basis, not weight-basis (Figure 5a). After purchase, local traders collect the mango on grass roofs or madaberia (factory-made plastic sacks) which deteriorate the quality of the mango (Figure 5b).

With regards to price, the maturity stage of mango affects the mango price. On average they sell 3 mango fruits/birr or 225birr/quintal or 600–1200/Cart. The FGD result revealed that the price varies by season and from variety to variety. More supply of mango fruits occurs in January and June. At the start and end of the harvesting season, the prices peak. But in between December and May, the mango price became low. The price of mango was fixed by traders while the farmers and consumers are only price takers. Ademonla et al. (2017) found a similar result that confirms traders are the main price-makers along the mango value chain in Sierra Leone.
Post-Harvest Loss along the Mango Value Chain

Mango losses occur in the maturation, harvesting, pre-cooling, field storage, sorting and grading, packaging, loading/unloading, transportation and marketing stages. As indicated in Figure 6, diseases, pests, harvesting and handling techniques, storage, transportation and market situations are the driving factors for post-harvest loss in the study area as mentioned by sample respondents. From these factors, harvesting techniques, collection and storage situation, disease and pests were the leading drivers for the highest post-harvest loss. Post-harvest loss and quality deterioration during harvesting and handling techniques were identified by 73% of the respondents (Figure 6). As the respondents confirm, they did not use the recommended equipment and materials for harvesting and handling due to lack of access to improved harvesting technologies. These aggravated the risks of post-harvest loss and quality deterioration of mango crops. Problems related to collection and storage facilities were stated by 36% of the respondents as factors for mango loss and quality deterioration (Figure 6).

Amount of Mango Harvested and Fruit Loss

The total postharvest loss along the mango value chain is shown in Table 3. According to the survey result, about 14 quintals of mango was produced per household per year in the study area (Table 3). However, mango losses occurred at different stages of the value chain. For instance, about 6 quintals of mango per household per year were lost which is about 41% of total production. From this, loss during the harvesting period holds the largest share which is about 18% of the total loss. This may be due to the lack of improved mango harvesting technologies in the study area. While the loss at the collection stage is about 9% and loss due to disease and pests attack is 7% were the next ones in the study area (Table 3).

Table 3. Mango post-harvest loss along the value chain.

| Variables                                | Amount of harvested in quintal | Percentage share |
|------------------------------------------|-------------------------------|------------------|
| The average amount of mango harvested    | 14.4                          | 100              |
| Loss due to disease and pests            | 1.0                           | 7.2              |
| Loss during harvesting (quintal)         | 2.6                           | 17.8             |
| Loss during collection (quintal)         | 1.3                           | 8.9              |
| Loss during transportation (quintal)     | 1.0                           | 6.8              |
| Total loss (quintal)                     | 5.9                           | 40.7             |

Source: Authors’ calculations based on mango value chain survey, 2021.
At the collection stage, considerable losses occurred from the use of bare land for collection as most local collectors don’t have their collection warehouse nearby. They used roadside free space bare land without any shelter. At that time the collected mangos are exposed to sunlight, rainfall and in some cases for flooding in the study area. As a result, there is a remarkable loss at this stage during sorting periods by wholesalers (Figure 7). While there is also a remarkable loss of fruit due to disease, pests and transportation problems in the study area as the FGD result confirms.

At the end, the respondents were asked about the reason for the low productivity of mango. The survey result showed that lack of improved mango variety, lack of improved harvesting technologies, disease and insect pests attack and poor agronomic practices were the main challenging factors for the low productivity of mango in the study area. Among the factors, lack of improved technologies is the leading factor for the low production and productivity of mango in the study area as confirmed by a majority of respondents (Figure 8). Currently, most of the producers in the study area cultivated local variety which is very tall and difficult for management and harvesting. In addition to this, farmers are not willing to replace the old mango trees with new improved varieties due to land shortage. This indicated that they need to be made aware of new mango varieties for easier management and improved yields. Also disease and insect pests specifically white scale (Aulacaspis tubercularis Newstead) and fruit fly (Bactrocera dorsalis) are the main challenges for mango productivity as well as quality in the study area. Overall, this study confirms that most of the highest loss is occurred at the harvesting stage due to a lack of improved harvesting technologies.
**Conclusion and Recommendations**

Even though mango is highly produced in the study area, the result from the survey shows that there are a lot of problems along the value chain. Of the problems, limited supply of improved mango varieties and chemicals for disease and pest control, lack of improved management at the production stage, lack of improved harvesting technologies, ways of collection materials problem, poor transportation access in terms of materials and roads and lack of cooperative marketing are major ones. The loss during harvesting is the first problem in along mango value chain. In addition, harvesting immature mango is another problem that increases the losses in the study area. This is due to a lack of capital to wait up to the maturity period and a lack of mango cooperative marketing in the study area. On the other hand, there is also a lack of value addition in terms of processing and packaging in different products that needs intervention to benefit the mango producers in the study area.

To develop the whole mango value chain, a lot of efforts were applied from input provision up to awareness creation by government and non-governmental organizations. However, this study shows about 41% mango loss was recorded per year in the study area along the value chain. Since loss during the harvesting period holds the largest share intervening in the harvesting stage has a great significance on reducing loss and increasing the total production of mango. Therefore, to improve mango productivity, quality and decrease the post-harvest loss along the mango value chain, introducing improved varieties and distribution of seedlings for farmers on large scale; increasing availability of disease, insect and pest control chemicals; modifying the existing harvesting materials like gatile and statafaro; introducing blue sheet withstands; development of sorting and grading guidelines; introducing improved mango harvesting, processing, storage machine/materials and strengthening cooperative marketing by suppp2019orting them to produce value-added products like juice, jam, wine, ice cream, powder, cheeps and mango yogurt are the suggested recommendations from this study.

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