Plant
2022; 10(4): 89-96
http://www.sciencepublishinggroup.com/j/plant
doi: 10.11648/j.plant.20221004.11
ISSN: 2331-0669 (Print); ISSN: 2331-0677 (Online)

Assessment of Postharvest Losses of Fruits in West Shewa Zone, Oromia, Ethiopia

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To cite this article:
Asfaw Shaka Gosa, Mosisa Chewaka Aga, Refisa Jebessa Geleta. Assessment of Postharvest Losses of Fruits in West Shewa Zone, Oromia, Ethiopia. *Plant*. Vol. 10, No. 4, 2022, pp. 89-96. doi: 10.11648/j.plant.20221004.11

Received: September 29, 2022; **Accepted**: November 7, 2022; **Published**: November 11, 2022

Abstract: Fruit postharvest losses are a serious problem that many Ethiopian farmers face, and quantifying the magnitudes of postharvest losses is critical for identifying causal variables and developing strategies to reduce losses. This study was carried out in 2018/19 in west Shewa, Ethiopia, to assess the magnitude of selected fruits postharvest losses and the causes of losses at the farmer level. The study found that in the study area, postharvest fruit losses are highly significant in fruit production. Fruit losses were found at four key stages: harvesting, storage, transpiration, and marketing. The extent of fruit loss for mango, orange, and banana was estimated to be 19.8 percent, 12.6 percent, and 17.2 percent, respectively. Harvesting immature fruits, fruits dropped on the ground due to disease, untimely harvesting and packaging materials, harvesting diseased fruits, methods of fruits starting at temporary storages, and harvesting fruits at improper stages, particularly harvesting fruits at fully ripened stage were the major factors responsible for fruit losses during harvesting. At the storage stage, insect pest attacks, disease, and mechanical injury were identified as related factors, whereas at the transportation and marketing stages, injured fruits decay, damage to packaging materials, damage during loading and unloading, over piled fruits transportation, fruits scratching in the market, and market failure were identified as the major factors responsible for fruit losses. Farmers must be educated about the economic relevance of postharvest losses and control, as well as learn improved postharvest handling practices. Furthermore, research would play a significant role in testing and implementing better harvesting and packing materials to decrease fruit postharvest losses.

Keywords: Fruit, Postharvest Loss, Assessment

1. Introduction

Production of fruits has recently become one of the key objectives in developing countries where many parts of the country are suitable for growing temperate, sub-tropical or tropical fruits. Despite the great emphasis on increment of fruit crops, losses after harvest until the food reach the consumer are significant [1]. Fruits are perishable products and therefore sensitive which leads to greater losses than for non-perishable crops [2]. The high perishable nature of fruit, lack of storage facilities, mechanical injuries due to improper handling, packaging, transportation, and microbial infection, are the major reasons for postharvest loss in fruits [3]. Post-harvest losses in developing countries can range from 15 percent up to 50 percent [1].

Like other developing countries of the world, in Ethiopia, fruits have significant importance with a potential for domestic and export markets and industrial processing. The country has suitable agro-ecology to grow both temperate and tropical fruit crops. Ethiopia has suitable agro-ecology to grow both temperate and tropical fruit crops. However, fruit production activity is at infant stage in most parts of the country and both small-scale fruit producers and traders have very limited knowledge and skill on fruit production and postharvest handling practices. In this connection, high amount of fruits is expected to be wasted due to several inappropriate production and postharvest handling practices. Banana postharvest loss was reported in Ethiopia; out of 45.9% about 15.7% was incurred at farm, 22.1% at whole sale and 8.1% at retailer levels [4]. On the other hand, post-harvest losses in developed countries are an average of 12% from production to retail warehouse, and an estimated 20% at retail stores and food service sites [5].

Improper harvesting and postharvest handling practices result in loss due to spoilage of the produce before reaching

to consumers along with the loss in quality ofthe produce such as deterioration in appearance, taste and nutritional value. The high perishable nature of fruit, lack of storage facilities, mechanical injuries due to improper handling, packaging, transportation, and microbial infection are the major reasons for postharvest loss in fruits [3]. Woldu *et al.* *[*4] pointed out market distance, duration of transport, storage condition, storage duration, duration of ripening, ripening room types, means of transport, and experience in banana marketing as important determinants of the postharvest loss of banana in Ethiopia.

Higher postharvest losses not only reduce the availability of fruits but also result in increase in per unit prices of the produce and thus limit the accessibility by the majority of community segments. Kughur *et al.* [6] pointed out the multiple effects of postharvest loss as going beyond the loss of the actual crop to include loss in the environment, resources, and labor needed to produce the crop and livelihood of the individual involved in the production process. However, it is important to note that much is being invested to production compared to postharvest handling, though 30 to 50% of the produce is wasted in few days after harvest.

Like other parts of Ethiopia, West Shewa zone is fruit producing area where many smallholders are using fruits as income sources. Fruits production in this area is mainly constrained by poor postharvest managements; lack of organized marketing system, disease on the other often resulted in higher postharvest losses (Personal observation). So far, there are very limited reports on the causes and amount of fruit postharvest loss particularly information on the cause and extent of fruits postharvest loss at producer level in West Shewa is scarce. Therefore, the present study was conducted to assess causes and estimate amount of fruit postharvest losses in West Shewa considering the pre-harvest and harvest handling practices.

2. Methodology

2.1. Description of the Study Area

The study was conducted in the Oromia regional state's west Shewa zone during the 2018/19 academic year. The West Shewa zone is located at 8°57 N latitude and 38°07 E longitude, with elevations ranging from 1380 to 3300 meters above sea level. The annual mean maximum and lowest rainfall is 1900mm and 600mm, respectively. The area's mean minimum and maximum air temperatures are 11.7 and 25.4 degrees Celsius, respectively. The survey was limited to three primary fruits grown in the research areas: orange, banana, and mango.

2.2. Data Collection Methods, Sources, and Types

The study looked at and described how fruits are handled and managed after harvest in the West Shewa Zone. Both quantitative and qualitative data collecting approaches were utilized to acquire primary and secondary information from fruit farmers. The primary data was gathered by a survey utilizing semi-structured questionnaires with open and closed ended questions, in-depth interviews with key informants, and observations. Open-ended questions were created to allow responders to freely express their thoughts. Secondary data was gathered through published and unpublished reports from various chain players, including national, regional, research, and non-governmental organizations (NGOs), as well as information gained from the internet (web search).

2.3. Sampling Techniques

To collect all required primary data, multi-stage purposive and random sampling techniques were used. Initially, three fruit-producing districts were purposively chosen in collaboration with prospective agricultural offices based on the volume of fruits produced. Then, in collaboration with district agriculture offices, 9 major fruit producer farmer villages/peasant associations (3 PA (kebeles) /district) were purposively selected. Finally, 40 farmers were chosen at random from each PA/kebele from the entire list of households supplied by each PA/kebele level agricultural office. For this study, 360 smallholder fruit producers (120 from each district) and 12 key informants were used.

2.4. Method of Data Analysis

For data input and analysis, the SPSS (Statistical Package for Social Sciences) software was utilized. Descriptive statistics such as percentage, mean, standard deviation, and so on were employed. Furthermore, mean comparison techniques such as ANOVA were used to analyze the variations in fruit postharvest loss among respondents with varying levels of education.

Multiple linear regressions were used to determine the drivers of postharvest losses at the producer level, with the degree of postharvest losses by different components as dependent variables and additional explanatory variables. As mentioned in the equation, the model employed was defined for farmers / producers level fruit loss:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+B_9X_9+\varepsilon$$

where Y is farm level postharvest fruit loss; X1 is age of the respondents; X2 is sex of household heads; X3 is fruit farming experiences in years; X4 is education level of the respondents; X5 is contacts with extension (1=Yes; 0=No); X6 is access to credit services (1=Yes; 0=No); X7 is the time of the day when fruits are harvested; X8 is types of packaging materials used and X9 is membership to cooperatives (1=Yes; 0=No) and ε is error term.

3. Result and Discussion

3.1. Socio-demographic Characteristics of the Respondents

The socio-demographic characteristics of the respondents

examined included gender, age, education levels, and fruit farming and handling experiences (Table 1).

The analysis of socio-demographic characteristics of the respondents revealed that the majority of the respondents (82.5%) were male while the remaining 17.5% was female. The majority (55.8%) of respondents was found in age ranges of 41-50 followed by 51-60 (19.2%), above 60 aged (15.8%) and 31-40 aged (9.2%) respondents.

The analysis also revealed that 35% of the respondents were not attended formal education while 51.7% attained primary education. Post Hoc Tests for farmers' education level postharvest loss means multiple comparisons showed that there were significant differences among the groups with different education levels (Table A1). Accordingly, there was highly significant differences ($p<0.01$) between the illiterates respondents and others with secondary education level. Similarly, there was highly significant ($p<0.01$) differences between respondents with secondary and tertiary education levels. This finding is in agreement with Sabo [7] who stated that education is generally enhances adoption of new technologies, especially, fruit preservation technology. Education has the potential to enhance understanding and communication in postharvest technology [8]. The average fruit farming and handling experiences for the respondents was 12 years (Table 1).

Table 1. *Socio-demographic characteristics of the respondents.*

Soicio-demographic characteristics		
Sex of respondents	**Frequency**	**Percent**
Male	297	82.5
Female	63	17.5
Total	360	100.0
Age of respondents		
31-40	33	9.2
41-50	201	55.8
51-60	69	19.2
Above 60	57	15.8
Total	360	100.0
Education level of respondents		
Illiterates	126	35.0
Primary level	186	51.7
Secondary level	36	10.0
Tertiary level	12	3.3
Total	360	100.0

3.2. Fruits Handling and Management Practices at Farmers' Level

Data given in Table 1 revealed that majority of farmers (57.5%) responded that fruit harvesting is carried out when fruits are fully ripen while the remaining 42.5% farmers harvest fruits at half ripe stage. This finding indicates that the farmers in the study area harvest fruits at fully ripen stage and this maximize the chances of mechanical damage and reduces the shelf life of fruits to reach long distance and even for nearest markets. This finding is in agreement with Musasa *et al.* [9] who found that 90.14% of respondents harvest fruits when they are ripe. On the other hand, this finding is in contrast with the recommendation by Shahnawaz *et al.* [10] that fruits hard to harvest compare to fully ripened ones and are not easily damaged during harvesting and transportation but when fruits are fully ripened, the spoilage is easier because of high amount of sugar and water. Similarly, Kereth *et al.* [11] reported that unripe fruits are hard to harvest compared to ripen one and it is not recommended to pick fruits when fully ripen because of danger of post-picking loss mounting up. Therefore, fruits must be harvested firm enough to withstand handling and to keep for a number of days and also allow long distance if required [12].

Table 2. *Fruits handling and management practices.*

Fruits handling and management practices	**Frequency**	**Percent**
Stage of fruits harvesting		
Half ripe	153	42.5
Fully ripe	207	57.5
Total	360	100.0
Packaging materials used by farmers		
Wooden crates	24	6.7
Baskets	78	21.70
Polyethylene Sacks	201	55.8
Plastic crates	57	15.8
Total	360	100.0
Means of transport used by farmers		
Using animal driven cart	18	5.0
Using men's shoulder	91	25.3
Using women's back	49	13.6
Using animals back	202	56.1
Total	360	100.0

Majority of farmers (55.8%) use polyethylene sacks as fruits packaging materials while the remaining 21.7%, 15.8% and 6.7% use baskets, plastic crates and wooden crates respectively (Table 2). This result agrees with Musasa *et al*. [9] who reported that 40% of respondents use plastic sacks, 20% use baskets while 15% of the respondents use wooden crates. According to the author, these packaging materials are reported to be cheap and mostly available. Fruits have soft cover which is easily destructed and easily attacked by microbes which bring deterioration. Packages should be designed to have sufficient openings for allowing air ventilation to the fruits. The use of sacks does not protect the fruits from mechanical damages as they cause fruit losses by crushing. Moreover, large congestion fruits create high heats in the sacks due to physiological by metabolic reaction which in turn accelerates mechanical damage and microbial attacks [13]. The wooden crates packaging material has a slight effect on mechanical damage of fruits compared to others. The cost of packaging materials has escalated sharply in recent years, consequently, poor quality; lightweight containers that are easily cause damage by handling or accelerate moisture are no longer tolerated by farmers [14].

Data presented in Table 1 also revealed that animals' back is used as major transport means (56.1%) in the study area followed by men's shoulder (25.3%), women's back (13.6%) and animal driven carts (5%). Due to lack of access to vehicles, roads and other means of transport, transportation of fruits to collection centers and markets are carried out using animals' back and these results in increased fruit damages and losses.

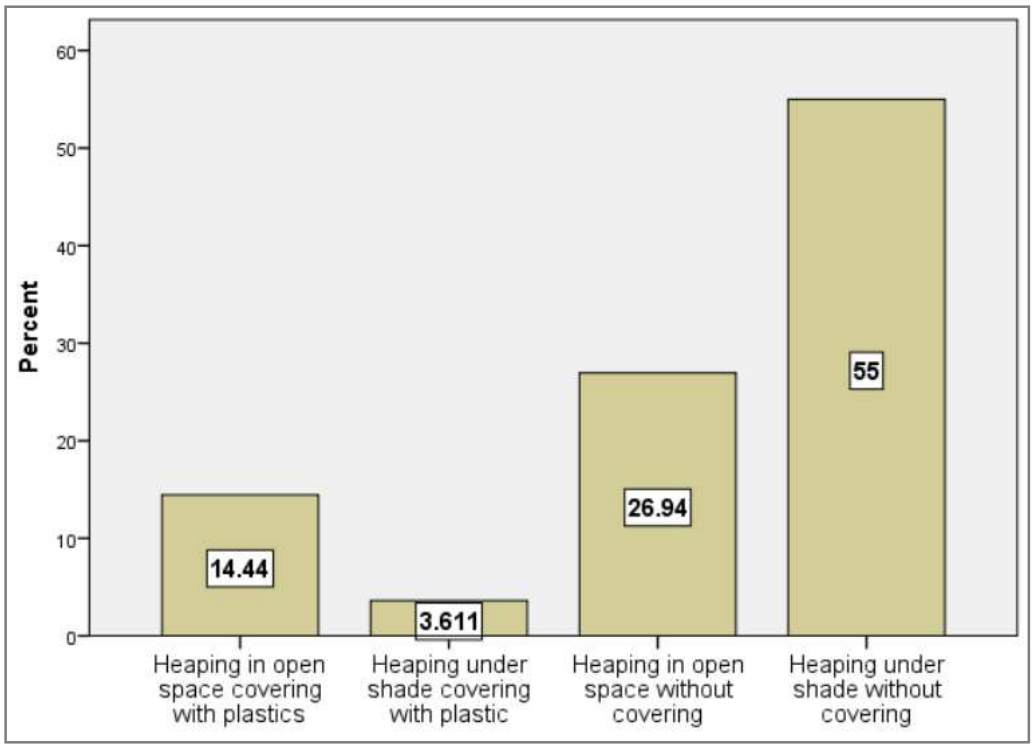

Figure 1. *Fruits storage methods used by farmers after harvesting.*

On the other hand, poor storage facilities at collection sites also expose to high temperature and hasten fruits ripening and deteriorations. Data presented on figure 1 revealed that 55% of the respondents store the fruits they harvest by heaping under shade without covering while 26.94% store by heaping fruits in open spaces without covering, 14.44% store in open spaces covering with plastics and the remaining 3.61% store fruits under shade covering with plastics.

This finding is in line with Aujla *et al.* [15] who reported that the existence of poor infrastructures, poor farm practices and storages and transportation facilities causes up to 40% losses.

3.3. Estimated Postharvest Loss Extents of Selected Fruits

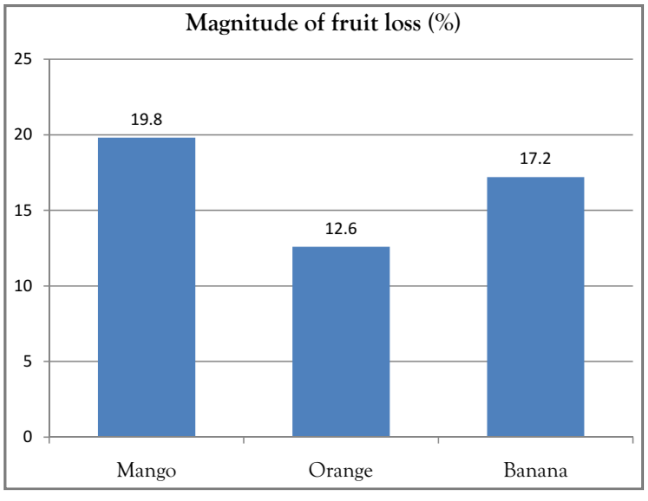

Figure 2. *Extents of selected fruits postharvest losses.*

Data presented on figure 2 showed that 19.8%, 17.2% and 12.6% of postharvest loss at farmers' level was recorded for mango, banana and orange respectively.

In line with this finding, Murthy *et al.* [16] assessed the postharvest losses in Banganapalli mango at different stages of marketing in Andhra Pradesh and estimated average mango postharvest losses to be 15.6% at farmers' level. Similarly, Nanda *et al.* [17] reported that 10.64% mango loss was found in farm operations like harvesting (4.11%), sorting and grading (2.8%) and transportation (2.53%).

Similarly Musasa *et al*. [9] reported that Rusitu Valley of Zimbabwe encountered about 42% losses of the orange they produced. According to the authors, several reasons such as pests and diseases, poor production practices, poor temporary storage facilities and poor physical structures (access to roads, transport, and communications). Research done by Mebratie *et al.* [18] reported 17% losses of banana at farmers' level and the lower loss percentage at farmer level as compared to wholesale and retail level is due that farmers are mostly dealing with green fruits. Green fruits are more tolerant to handling problems though the damage is prevalent later at ripening.

3.4. Causes of Fruits Postharvest Losses at Farmers' Level

3.4.1. Factors Responsible for Postharvest Loss of Fruits During Harvesting

Data presented on figure 2 revealed that majority (64%) of fruits postharvest losses at harvesting stages are caused by harvesting disease affected (44%) fruits and rough handling of harvesting containers (20%).

The remaining losses were contributed by dropping of fruit

on ground (14%), harvesting stick injury (10%), harvesting immature fruits (7%) and crushing by legs (5%). According to key informant interview with district agriculture office, sweet orange scab is one of serious disease in orange farms causing premature fruit drop and tree decline. Besides, white mango scale (Aulacaspis tubercularis -Homopter: Diaspididae) was another disease problem resulting in higher fruit losses in the study area.

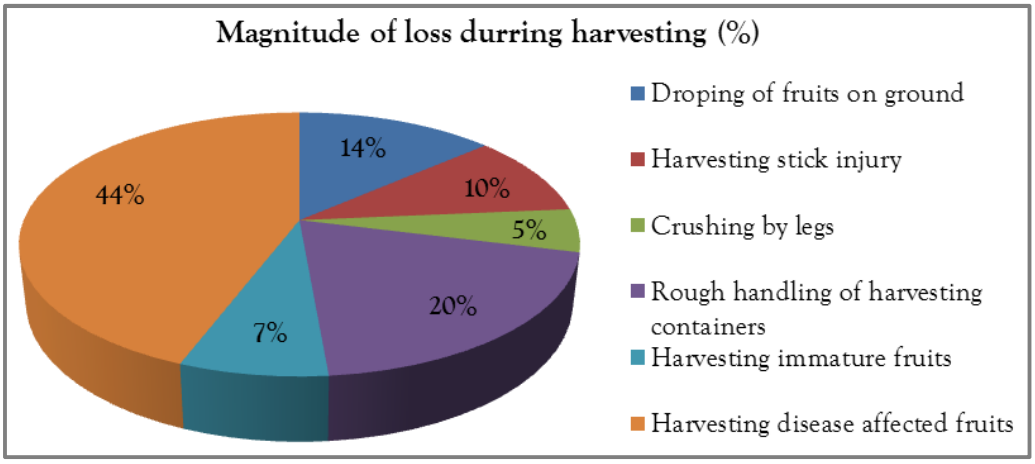

Figure 3. *Causes for postharvest loss of fruits during harvesting.*

The result indicated that farmer handle their fruits poorly during harvesting and this is causing losses of fruits. In agreement with this finding, Dixie [19] reported that poor handling can result in development of entry points for mould and bacteria, increased water loss and an increased respiration rate.

3.4.2. Rated Factors Responsible for Fruit Loss at Storage

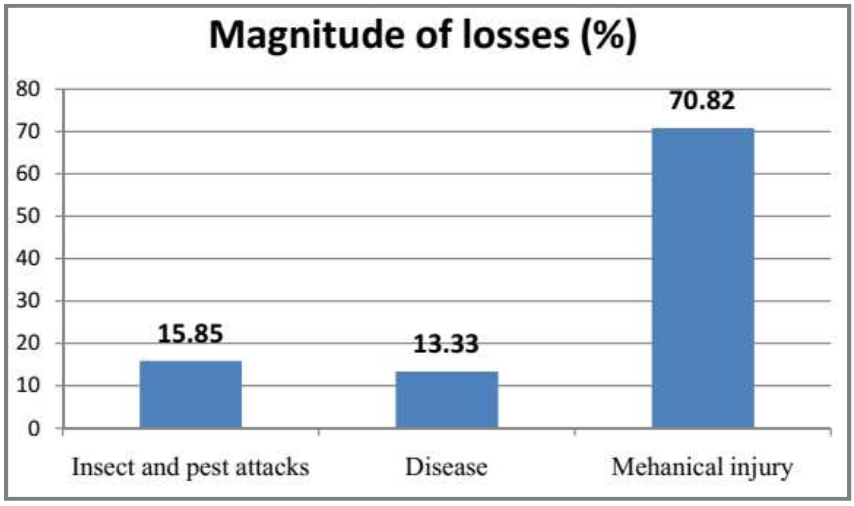

Figure 4. *Causes of fruits losses at storage.*

Data presented on figure 4 indicated that fruits postharvest losses at farmers' level are caused by mechanical injury (70.82%) followed by insect pest attacks (15.85%) and disease (13.33%).

In line with this finding, Delele *et al.* [20] reported that mechanical injury is the major causes of fruit loss at storage followed by postharvest insect, physiological disorder and postharvest diseases.

3.4.3. Rated Factors Responsible for Fruit Loss During Transportation and Marketing

Figure 5 below indicated that fruits losses during transportation and marketing are caused by over piled transportation (38%) followed by market failure (26%), damage during loading and unloading (14%), injured fruits decay (12%), scratching by finger (6%), and damage on packaging materials (5%).

This finding is in line with Iordachescu *et al.* [21] who reported that fruit losses at transportation stage are caused by loading and unloading, poor infrastructures, lack of appropriate transport systems, lack of refrigerated transport and poor temperature. The finding also in agreement with the finding of Bari [22] who stated that postharvest in fruits and vegetables highest due to picking (19.6%), packing (3.5%), carrying (2.2%), and during loading and transportation (7.1%).

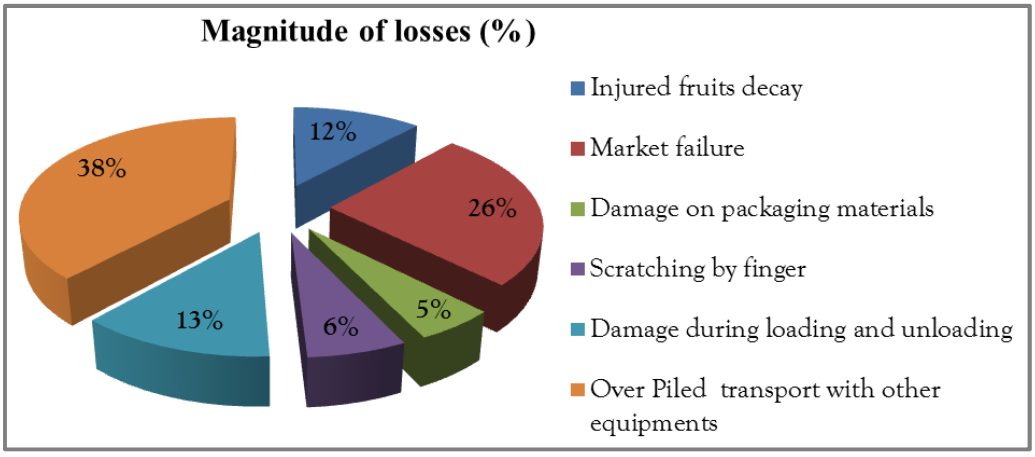

Figure 5. *Causes of fruits loss during transportation and marketing.*

3.5. Determinants of Fruits Postharvest Loss at Farmers' Level

The summary of multiple linear regression results on determinants of fruits loss at farmers' level is given in Table 3. The adjusted coefficient of determination (R^2) was 0.39 indicating that 39% of the variation in the quantity of fruits lost during and after harvesting was explained by the specified variables in the model.

Table 3. *Regressions results on the determinants of fruits losses at farmers' level.*

Variable	Coefficients	Standard Error	P-value
(Constant)	28.481***	2.836	.000
Age of respondents	-1.184***	0.194	.000
Sex of respondents	-1.761***	0.482	.000
Education level of respondents	0.537*	0.216	.013
Fruits farming experiences	0.343***	0.048	.000
Contact with extension agents	1.628***	0.527	.002
Access to credit services	-1.225***	0.334	.000
Type of packaging materials used	-2.410***	0.559	.000
Membership to cooperatives	-4.218***	0.532	.000

Adjusted R^2=0.39; *, ***=Significant at 10% and 1% respectively.

The F-statistic was found to be significant at 1%, which implies that all the explanatory variables had a significant joint impact on the level of fruits lost after harvest.

The analysis result indicated that gender and age were demographic variables that had a significant effect on postharvest losses of in fruits production. Accordingly, female farmers were found to be more victims to high levels of losses than their male counterparts. This might be related with the labor intensity of the activities involved in fruit management hence male households tends to have many man-hours available and more time for fruit harvesting and other farm activities as compared to female-headed households who have family responsibilities to attend as well. In this regards, the study finding contrast with Babalola [23] reported that there was little or no gender in equality in tomato farming and hence no effect of gender on postharvest losses.

Results from the multiple linear regressions (Table 3) indicated that there is significant ($p< 0.01$) relationship between age of respondents and quantity of fruit loss. Education status was hypothesized to have a positive impact on the extent of fruit loss assuming the higher the education level of the respondents, the lower the extent of fruit loss. From the study result, it was recognized that education level had statistically significant ($p<0.05$) effect on the extent of postharvest fruits loss recorded. The unit change in education level of the respondents decreases fruit loss by 0.537.

With respect to the fruit farming experience of respondents, the study result (Table 3) showed that farming experience had a significant ($p<0.01$) and positive influence on quantity of fruits loss. The unit change in experience of fruit farming, will lead to 0.343 unit decrease in quantity of fruit loss. With more years of fruits farming experiences, farmers expected to develop better skills in managing their farms and handling harvests, hence facing less postharvest loss.

The multiple linear regression analysis result (Table 3) indicated that contacts with extension agents had significant ($p<0.01$) influence on quantity of fruit loss. The unit change in frequency of extension agent contact lead to 1.628 units decrease in fruit loss. Farmer those are having better access to extension agent contacts have better understanding about

postharvest fruit loss and fruit handling practices that might have positive impact on reducing quantity of fruits loss.

The other important parameter in fruits postharvest loss management and reduction is farmers' access to credit services to use improved technology that can minimize fruits postharvest losses. The result of this study indicated that access to credit services had negative impact on fruits losses. As it is presented in Table 3, access to credit services significantly ($p<0.01$) influenced the quantity of fruits loss. The unit change in access to credit services lead to 1.225 unit reduced fruits loss.

Types of packaging materials used had negative influence on the extents of fruits loss encountered by the respondents. Packaging materials used by the respondents had significant ($p<0.01$) influence on quantity of fruits loss. The unit change in types packaging materials used results in 2.410 units reduced fruits loss.

Membership to cooperative had significant ($p<0.01$) influence quantity of fruit loss. The unit change in cooperative membership leads to 4.218 unit reduced fruits loss. Farmers those are member of cooperative are expected to have better access to harvest and postharvest fruit handling and mechanisms to reduce losses.

4. Summary and Conclusion

Fruit postharvest losses are regarded as a serious problem that affects many Ethiopian farmers, and quantifying the magnitudes of postharvest losses is critical in order to identify causal causes and give ways of loss reduction. The purpose of this study was to determine the amount of postharvest losses in chosen fruits (Mango, Orange, and Banana) as well as the kinds and causes of losses at the farmer level. The study found that postharvest losses of fruits are quite considerable in the study area's fruit production. Fruit losses were found as occurring at four critical stages: harvesting, storage, transpiration, and marketing. The degree of fruit loss was assessed to be 19.8 percent, 12.6 percent, and 17.2 percent for mango, orange, and banana, respectively. Harvesting immature fruits, fruits crashed by legs, fruits dropped on the ground due to disease, use of improper harvesting and packaging materials, harvesting disease affected fruits, methods of fruits storage at temporary storages, and harvesting fruits at improper stages, particularly harvesting fruits at fully ripened stage, were the major factors responsible for fruit losses during harvesting. At the storage stage, insect and pest attacks, disease, and mechanical injury were identified as related factors, whereas injured fruits decay, damage on packaging materials, damage during loading and unloading, over piled fruits transport with other equipments, fruits scratching by finger in the market, and market failure were identified as major factors responsible for fruit losses during transportation. Overall, the study found that farmers in the study area have suffered significant fruit losses, owing to a lack of information about postharvest losses, a lack of skills in postharvest handling, and infrastructures such as standard harvesting materials, storage facilities, and fruit damage caused by poor rural roads. As a result, strengthening management techniques and infrastructures in the study area can help reduce postharvest fruit losses. It is critical to raise farmer awareness and provide training regarding the economic relevance of postharvest losses and management, as well as better postharvest handling practices. Furthermore, research would play a significant role in testing and implementing better harvesting and packing materials in order to decrease fruit postharvest losses.

Authors' Contributions

This work was carried out in collaboration between the three authors. Author Asfaw Shaka designed the study, led the data collection and wrote the first draft of the article. Author Mosisa Chewaka managed the analysis and editorial aspects of the article. Author Refisa Jabessa organized and managed the data collection processes and editorial aspects of the article. All authors read and approved the final manuscript.

Appendix

Table A1. *Post Hoc Tests for farmers' education level postharvest loss means multiple comparisons.*

Multiple Comparisons						
Dependent Variable: Extent of fruits postharvest losses percentages **Tukey HSD**						
Education level of respondents		**Mean Difference**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Illiterates	Primary level	-1.13748*	.40104	.025	-2.1726	-.1023
	Secondary level	-2.22619*	.65686	.004	-3.9217	-.5307
	Tertiary level	2.02381	1.05006	.218	-.6866	4.7342
Primary level	Secondary level	-1.08871	.63288	.315	-2.7223	.5449
	Tertiary level	3.16129*	1.03523	.013	.4891	5.8334
Secondary level	Primary level	-3.16129*	1.03523	.013	-5.8334	-.4891
	Tertiary level	4.25000*	1.15859	.002	1.2594	7.2406

*. The mean difference is significant at the 0.05 level.

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