




DETERMINANTS AND EXTENT OF PRE- AND POSTHARVEST LOSSES OF FRUITS IN NORTHWESTERN ETHIOPIA

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ABSTRACT

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The study was conducted to identify determinants of losses during pre-harvest and postharvest activities of fruits and their extent at producer's level in Northwestern Ethiopia where tomato, papaya, avocado, banana and mango were used as fruit samples. Questionnaires were used to collect data from 180 randomly selected respondents of six districts (FinoteSelam, BurieZuria, Bahir Dar, Bahir Dar Zuria, Dangla and Farta). Descriptive statistics and multiple regressions analysis were used to identify determinant factors. The results of the findings revealed that the total fruit loss was estimated to be 44.8% where about 20.7% of the fruits were lost due to improper activities in the pre-harvest stages while about 24.1% loss was due to improper activities during post-harvest stages. The shares of pre-harvest and postharvest losses to the total fruit loss were about 46.2% and 53.8%, respectively. Income sources, use of pesticide, and use of compost or manure during production were the determinant factors that influenced fruit losses during pre-harvest while experience and educational levels of producers in fruit production and shortage of labor were the determinant factors of fruit losses during harvesting. Moreover, chemical treatments of fruits before storage and educational levels of the producers were the determinants that influenced fruit losses in producer's storage while experiences of the fruit producers, distance to market and educational levels were the significant factors of fruit losses during marketing. Further researches and trainings of producers about use of pre- and post-harvest technologies that minimize losses at the value chain of fruits are vital.

Contribution/Originality: This survey is one the few researches that has estimated fruit loss and identified the major factors responsible for loss. The research paper contribution is finding that about 44.8 percent fruit is lost and use of pre- and post-harvest technologies as well as educating producers about fruit loss is vital.

1. INTRODUCTION

Agriculture is the mainstay of Ethiopian economy. The sector provides raw materials for industries and the main source of products for export market. The country's agricultural potential is known to be immense and over 90% of its export earnings come from this sector. Coffee, oil seeds, spices, fresh fruit and vegetables contribute the largest portion of the export earnings. From a total of 39.7 million tons of total crops produced in Ethiopia, about 23.1 million tons are durable crops while about 6.6 million tons are highly perishable. Of which about 0.5 million tons are tropical fruits including Tomato, Banana, Mango, Papaya, Avocado, Guava and Pineapple which are highly perishable (CSA (Central Statistical Authority), 2013).

The production and processing of tropical fruits can contribute to economic development of the country if they are produced in large amount and managed appropriately, as they have high productivity as compared to national average crop productivity (2.0 t/ha). According to CSA (2013) the productivity of tomato, papaya, avocado, banana, mango in Ethiopia is 2.95, 17.0, 8.1, 8.12 and 9.03 t ha⁻¹, respectively. Moreover, the country has suitable environmental and edaphic conditions for the expansion and development of these fruit crops. Expansion of tropical fruits reduces natural resource degradation, checks challenges of climate change, increases export earnings and triggers the emergence and development of fruit processing industries.

In addition to the low productivity, postharvest loss of crops in developing countries is a serious issue. In this regard, FAO (2011) estimated that globally about 32% of the crop is wasted due to postharvest losses. Leghari (2001) reported that postharvest losses of vegetables and fruits in Pakistan were about 35%. Postharvest loss in south of the Sub-Saharan African countries where hunger and food insecurity remains highest is even more (about 37%) as indicated by FAO (2011). According to Shepherd (2012) postharvest losses on crops can be occurred during harvesting, drying, threshing as well as during storage and transportation. Umar *et al.* (2015) estimated that postharvest losses of kiwi fruit in Pakistan were 72%, 25%, 3% at farm, wholesale, and retail level, respectively.

Tropical fruits have relatively high and fast postharvest loss because of their inherent biological behaviors. Postharvest losses of fruits and vegetables are estimated to be about 5-20% in developed countries and 20-50 % in developing countries (Mashav, 2010). According to the results of Seid *et al.* (2013) postharvest losses of banana, tomato, mango and papaya in South Wollo, Ethiopia were high both at farmers level, transportation and storage which were mainly caused by pre-harvest infection of diseases and mechanical injuries. Farmers used jute sacks as handling and packaging material where large mass of commodity was tightly packed together. According to Seid *et al.* (2013) fruits were transported on pack animals and on the back of man and woman which leads to bruising and mechanical damages during loading and unloading.

Most farmers in Ethiopia sell their fruits on nearby markets. The absence of storage facilities in the market and their perishable nature generally make the marketing of horticultural crops including tropical fruit crops unsatisfactory and associated with high postharvest loss. In other study done by Olayemi *et al.* (2012) farmers (Bari, 2004).

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The research was conducted in four districts of West Gojjam Administrative Zone (FinoteSelam, BurieZuria, Bahir Dar, Bahir DarZuria) in Awi (Dangla) and South Gondar (Farta)Administrative Zones with one district each. The districts are suitable of the production, marketing and processing of fruit crops.

2.2. Data Collection and Sampling Procedures

Both quantitative and qualitative data on postharvest losses and their possible factors of six fruits were collected using semi-structured questioners and key informant interviews where Avocado (*Persia americana*), Banana (*Musa spp.*), Guava (*Psidium guajava*), Mango (*Managifera indica*), Papaya (*Carica papaya*) and Tomato (*Lycopersicon esculentum*) were used in the present study. While the fruit producing districts were purposively selected, thirty respondent households (farmers) from each district were selected randomly.

2.3. Method of Data Analysis

The collected data were analyzed using statistical software (SPSS version 22) where descriptive statistics (averages and percentage) were used to estimate the postharvest losses on the selected fruits. The major determinant factors of postharvest losses of selected fruits were identified using multiple regression analysis methods. In the present study, an effort was made to develop an economic model to estimate the extent of

postharvest losses of the fruits during four different stages (Pre-harvesting, harvesting (picking), storage and marketing) at farmer's level. The developed models are presented below.

Model to Assess Pre-Harvest Fruit Loss

$$PL_1 = \sigma_0 + \sigma_1 W_1 + \sigma_2 D_1 + \sigma_3 D_2 + \sigma_4 D_3 + \sigma_5 D_4 + E \quad [1]$$

Where

PL₁=Pre-harvest loss of fruit

W₁=Distance from market in km

D₁=Dummy variable for means of income

D₁=1, if fruit production

D₁=0, if other

D₂= Dummy variable for marital status

D₂=1, if married

D₂=0, if unmarried, divorced, widowed

D₃= Dummy variable for use of compost and manure for fruit production

D₃=1, if yes

D₃=0, if no

D₄= Dummy variable for pesticide use during fruit production

D₄=1, if yes

D₄=0, if no

E=disturbance term

σ₀=constant term(intercept) and

σ₁, σ₂, σ₃, σ₄, σ₅ are the coefficients of estimates in the model

Model to Assess Fruit Loss at Harvesting

[2]

$$PL_1 = \beta_0 + \beta_1 X_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 D_3 + \beta_5 D_4 + E$$

Where

PL₁=Postharvest loss of fruit

X₁= Experience in years

D₁=Dummy variable for education

D₁=1, if formal education

D₁=0, if no formal education

D₂= Dummy variable for labor shortage during harvesting

D₂=1, if yes

D₂=0, if no

D₃= Dummy variable for method of harvesting

D₃=1, if using cutters/scissors

D₃=0, if without cutting tools

D₄= Dummy variable for fruit collection material

D₄=1, if using plastic/wooden collecting materials

D₄=0, if using clothes/sacks

E=disturbance term

β₀=constant term(intercept) and

β₁, β₂, β₃, β₄, β₅ are the coefficients of estimates in the mode

Model to Assess Fruit Loss at Producer Storage

[3]

$$PL1 = \alpha_0 + \alpha_1 Y_1 + \alpha_2 D_1 + \alpha_3 D_2 + \alpha_4 D_3 + \alpha_5 D_4 + E$$

Where:

PL1=Postharvest loss of fruit

Y1=Experience in years

D1=Dummy variable for chemical treatment

D1=1, if yes

D1=0, if no

D2= Dummy for Educational level

D2=1, if yes

D2=0, if no

D3= Dummy variable for storage material

D3=1, if sacks and clothes

D3=0, if plastic wooden containers

D4= Dummy variable for sorting and grading before storage

D4=1, if yes

D4=0, if no

E=disturbance term

α_0 =constant term (intercept) and

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ are the coefficients of estimates in the model

Model to Assess Fruit Loss at Marketing of Producers

[4]

$$PL1 = \gamma_0 + \gamma_1 Z_1 + \gamma_2 Z_2 + \gamma_3 D_1 + \gamma_4 D_2 + \gamma_5 D_3 + \gamma_6 D_4 + \gamma_7 D_5 + E$$

Where:

PL1=Postharvest loss of fruit

Z1=Experience in years

Z2= Distance of producers market in Kilometers

D1=Dummy variable for education of producers

D1=1, if formal education

D1=0, if no formal education

D2= Dummy labor shortage for fruit transportation and sell

D2=1, if yes

D2=0, if no

D3= Dummy for transportation method

D3=1, if back of human/animal

D3=0, if using other transport methods

D4= Dummy for use of storage during transportation

D4=1, if using sacks/clothes

D4=0, if using containers (plastics, wooden)

D5= Dummy for ripening problem

D5=1, if yes

D5=0, if no

E=disturbance term

γ_0 =constant term (intercept) and

$\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, \gamma_7$ are the coefficients of estimates in the model

3. RESULTS AND DISCUSSION

3.1. Preharvest and Postharvest Losses of Fruit

Losses of fruits occur during the development and maturation of fruits as well as in the postharvest handling practices including harvesting, pre-cooling, field storage, sorting and grading, packaging, loading/unloading, transportation as well as selling at farmer's level. Based on the results of the present study, about 44.8% of the fruits produced in the study area were lost where 20.7% was due to pre-harvest factors and about 24.1% was due to postharvest handling practices as shown in Table 1. The contribution of pre-harvest losses to the total fruit loss were 46.2% while that of postharvest losses were about 53.8%.

The results of the present study are generally in agreement with the findings of various researchers where losses of fruits and vegetables were occurred at the different value chains and ranged from 25 to 40% (Srivastava, 2002; Bari, 2004; Aujla *et al.*, 2007). According to Bari (2004) about 39% of mango fruits were lost during harvesting and other activities at farm level. Similarly, Mohyuddin (1998) indicated that about 17-20% of the fruits were lost during harvesting and that of 6.8% were lost at storage which requires an establishment of cold storage units in the production centers to reduce storage losses. On the other hand Basavaraja *et al.* (2007) reported that about 75% grain losses were occurred at production field level.

Table-1. Pre- and postharvest losses of fruits and their share to the total loss at producer's level

Levels	Percentage of fruit loss to the total production	Share to the total losses (%)
Pre-harvest fruit loss	20.7	46.2
Harvesting losses	8.7	19.4
Storage losses	6.8	15.2
Marketing losses	6.6	14.7
Total Postharvest loss	24.1	53.8
Total fruit loss	44.8	100

Synthesized from the collected row data of the survey research

3.2. Factors Offruit Losses at Various Level

3.2.1. Pre-Harvest Loss (Fruit Development and Maturation)

The model used in the present study generally explains the factors of pre-harvest losses of fruits since 39% of the total variations ($R^2 = 0.39$) in the dependent variable were explained by the estimated explanatory variables as presented in Table 2. Accordingly, all the variables in the pre-harvest activity had inverse relationship with losses except use of compost and manure during fruit production. The mean coefficient of income revealed that fruit loss can be reduced by 51% when fruit production is the major source of income of the producers. Moreover, spraying fruit orchards with pre-harvest pesticides can reduce fruit loss by 41% compared to those orchards without pesticide spray. Usage of compost and manure during fruit production showed a positive relationship with fruit loss and addition of compost and manure might increase fruit loss by 37.7 % as compared to fruit production without manure and compost.

Table-2. Relationship of pre-harvest variables to postharvest losses of fruits at Farmer's level

Variables	Coefficients	Standard error	t-value	Sig.	Overall Fitness
Constant	3.054	0.249	12.273	0.000	R ² =0.39 F-value=4.39 at 5 degree of freedom
LnX1 (Distance to the nearest market in Km)	-0.051	0.087	-.582	0.561	
D1 (Dummy Means of income)	-0.503	0.239	-2.103	0.037	
D2 (Dummy Marital Status)	-0.269	0.191	-1.409	0.161	
D3 (Dummy for use composting and manure)	0.377	0.133	2.843	0.005	
D4 (Dummy for pesticide application)	-0.438	0.155	-2.826	0.005	

Synthesized from the collected row data of the survey research

3.2.2. Losses at Harvesting Activities

The model used in the present study generally explains the factors of pre-harvest losses of fruits since 62.0% of the total variations ($R^2 = 0.62$) in the dependent variable were explained by the estimated explanatory dependent variables as presented in Table 3.

Coefficients showed that experience, education level and method of harvesting had inverse relation with postharvest loss of fruits whereas shortages of labor and collection material showed direct relationship with losses. Accordingly, for every one year increase in fruit production experience, there would be 39.4% reduction in postharvest losses.

Moreover, formal education of the farmers may reduce postharvest loss by 29% compared to those farmers with informal education. On the other hand, shortage of labor and methods of fruit harvesting influenced the postharvest losses of fruits. Shortage of labor during harvesting of fruits increased postharvest losses by 24%. Similarly, the use of cutters and scissors during harvesting reduced fruit loss by 12.4% compared to pulling of fruits with hand. The results of the present study clearly showed that education and experience of the farmers, availability of labor during harvesting and methods of harvesting and postharvest handling influence the extent of postharvest losses of fruits at producer level which is in agreement with the reports of various researchers. Leghari (2001) and Srivastava (2002) in this regard reported that the time and method of harvesting are very important in the reduction of postharvest losses in fruit crops.

Table-3. Relationship of harvesting variables to postharvest losses of fruits at Farmer's level

Variables	Coefficients	Standard error	t-value	Sig.	Overall Fitness
Constant	2.626	0.259	10.134	0.000	R ² =0.62 F-value=4.609 at 5 degree of freedom
LnX1 (Experience in years)	-0.394	0.104	-3.784	0.000	
D1 (Dummy for Educational level)	-0.292	0.125	-2.343	0.021	
D2 (Dummy shortage of labor)	0.242	0.126	1.925	0.056	
D3 (Dummy Methods of harvesting)	-0.124	0.211	-0.587	0.558	
D4 (Dummy Materials for collection)	0.035	0.133	0.266	0.791	

Synthesized from the collected row data of the survey research

3.2.3. Losses at Producer's Storage

The value of R^2 shows that about 31% of the postharvest losses of fruits were caused by the variables where F value of the model was about 1.784 at 99% level of significance (Table 4). Based on the results of the study, experiences of the farmers in the production of fruits and treatment of the fruits with chemicals had significantly affected postharvest losses of fruit at farmer's storage.

Generally, for every one year increase in experience of fruit production, the postharvest loss of fruits would be reduced by 26.9% at producer's storage. Similarly, treating the fruits with pesticides before storage reduced fruit loss by 27.5% compared to storage without chemical treatment. On the other hand, the fact that farmers are selling their fruits after short storage, the contribution of sorting and grading to the reduction of postharvest losses at farmer's level was relatively low (17.7%). Based on the results of the present study, experience of the farmers expressed in terms of proper handling of harvested fruits including chemical treatment is critical in the reduction of postharvest losses of fruits at producer's level. In this regard, findings of different researches indicated that storing of harvested fruits in relatively cool and dry conditions prolonged their shelf life and reduced postharvest losses (Kader, 1992; Leghari, 2001; Bari, 2004; Basavaraja *et al.*, 2007).

3.2.4. Fruit Losses at Marketing of the Producers

Based on the results of analysis using the model number 4, about 51% of the fruit losses at producer's market were caused by the factors listed in Table 5. Experience of the producers, distance to the nearest market and

shortage of labor during transportation had significantly influenced the postharvest losses of fruits at producer's marketing.

Table-4. Relationship of storage variables to postharvest losses of fruits at Farmer's level

Variables	Coefficients	Standard error	t-value	Sig.	Overall Fitness
Constant	2.164	0.345	6.270	0.000	R ² =0.31 F-value=1.784at 5 degree of freedom
LnX1 (Experience in years)	-0.269	0.133	-2.017	0.047	
D1 (Dummy for Educational level)	0.085	0.145	.587	0.558	
D2 (Dummy for chemical treatment)	-0.275	0.164	1.684	0.095	
D3 (Dummy for storage materials)	0.176	0.151	1.163	0.248	
D4 (Dummy for sorting and grading)	-0.177	0.161	-1.104	0.272	

Synthesized from the collected row data of the survey research

Containers during fruit transportation and ripening stages had also considerable contributions. Keeping other factors constant, increasing the experience of the producers by one year reduced the fruit loss by 22.9%. Similarly, increasing the distance of market by one kilometer increased the fruit loss by 21.9%. Problems on fruit ripening stage and use of sacks and plastics for fruit transport increased fruit loss by 16.6% compared to those fruits without ripening problem and use of plastic and wooden containers, respectively.

The results of the present study are generally in line with the findings of various researchers where the distance to market, transport infrastructures and transportation containers played a significant role in the postharvest losses of fruits at market place (Chohan and Ahmad, 2008; Adeniyi and Omotosho, 2009).

Table-5. Relationship of marketing variables to postharvest losses of fruits at Farmer's level

Variables	Coefficients	Standard error	t-value	Sig.	Overall Fitness
Constant	1.488	0.335	4.444	0.000	R ² =0.51 F-value=5.05 at 7 degree of freedom
LnX1 (Experience in years)	-0.229	0.116	-1.983	0.050	
LnX2 (Distance to the nearest market in Km)	0.219	0.086	2.541	0.013	
D1 (Dummy for Educational level)	-0.058	0.129	-.445	0.657	
D2 (Dummy for shortage of labor)	0.479	0.121	3.945	0.000	
D3 (Dummy for method of fruit transportation)	-0.104	0.119	-.869	0.387	
D4 (Transportation container)	0.163	0.132	1.229	0.222	
D5 (Dummy for Ripening stages)	-0.166	0.151	-1.101	0.273	

Synthesized from the collected row data of the survey research

4. CONCLUSION

Total share of fruit losses during fruit development and maturation is about 46 percent whereas the share of fruit loss in the postharvest handling remains 53 percent. The share of fruit loss at harvesting was maximum i.e.19.4 percent of the total. In the pre harvest, means of income, pesticide spray, and use of compost and manure for fruit production were statistically significantly affecting fruit loss.

Education, Experience and shortage of labor had significant impact on fruit losses during harvesting while experience and chemical treatment for storage. Distance from the nearest market, education and labor shortage during transport and sell had significantly affect loss during marketing. The huge fruit losses are due to improper fruit production, poor harvesting and postharvest handling techniques, infrastructure, labor shortage and lack of market.

This study suggests adopting scientific approach like modern fruit production and harvesting methods, improved transportation and storage facilities, outreaching (training and education) and marketing to minimize fruit pre-harvest and post-harvest losses and to fetch maximum gain. The study was made on producers' level on tropical fruits in six districts of north western Ethiopia. A detailed analysis is required on producer, whole saler and retailer level in more districts and fruits.

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