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Postharvest Losses Assessment of Tropical Fruits in the Market Chain of North Western Ethiopia

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Abstract
Postharvest loss assessment of tropical fruits Avocado (*Persia americana*), Banana (*Musa spp*.), Guava (Psidium guajava), Mango (*Managifera indica*), Papaya (*Carica papaya*) and Tomato (*Solanum lycopersicum*) were surveyed using data collected from 180 fruit producers and 80 traders. The estimated postharvest loss of tropical fruits as replied by the producer ranged from 18% to 28 % and the highest postharvest handling loss occurred during harvesting followed by storage and then transportation and also a total loss from18% to 25 % was recorded at trader level and the postharvest handling loss during storage is higher than both transportation and marketing. The highest postharvest loss was on Avocado, Tomato and Mango at producer level and March, April and May are the highest loss months of the year for these fruits. The loss at trader level was similar for all the six fruits studied. The major causes of postharvest losses of fruits at harvest as replied by the respondents are harvesting injury caused by dropping of fruits from tall height varieties, finger damage during harvesting, sun burning, harvesting container damage and harvesting immature fruits; At producers storage; mechanical injury, postharvest insects, diseases and physiological disorders; transportation media, sun burning, loading and unloading damage during transport and marketing. At trader level the major loss contributing factors include mechanical damages, postharvest diseases, physiological disorders and postharvest insects accordingly at storage and overloading, loading and unloading damage, high temperature and sun burning at transportation and marketing. Thus, further research that can reduce postharvest loss of fruits, maintain fresh quality and enhance fruit processing need to be conducted.
Keywords: Postharvest, Climacteric fruit, losses, Market chain, Fruit processing

1. Introduction

Despite the remarkable progress made in increased food production at the global level approximately half of the population in the third world does not have access to adequate food supplies. There are many reasons for this one of which food losses occurring in the postharvest and marketing system. Postharvest losses of fruits and vegetables are estimated 5-20% in developed countries and 20-50 % in developing countries (Mashav, 2010). On the other hand, FAO (2011) estimated it 32 percent globally and 37 percent in Africa south of Sahara where hunger and food insecurity remains highest. This huge loss is contributed through different biological and human made factors starting from the point of harvesting up to the point of consumption (Anon, 1969). They include onfarm losses such as when it is harvested, dried, threshed, as well as losses along the chain during storage and transportation. On farm losses occur during storage, when the crop is being stored for auto-consumption or while the farmer awaits a selling opportunity or arise in prices (shepherd, 2012).

Agriculture is the mainstay of Ethiopian economy and it provides all the necessary dietary foods, raw materials for food industries and quality products for export market. The country's agricultural potential for food production is known to be immense and over 90 percent 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 tonnes of total crops produced in Ethiopia, 23.1 million tonnes are not highly perishable whereas 6.6 million tonnes are highly perishable. From the highly perishable 0.5 million tons are tropical fruits including Tomato, Banana, Mango, Papaya, Avocado, Guava and Pinapple (CSA, 2012).

Tropical fruits have relatively high and fast post harvest loss because of their inherent biological behavior. On the other hand these fruits have high productivity; Tomato (29.5 Q/ha), Papaya (170.5 Q/ha), Avocado (81.0 Q/ha), Banana (81.2 Q/ha), Mango (90.3 Q/ha) as compared to national average crop productivity (20.0 Q/ha) (CSA, 2012). Tropical and subtropical fruits will have high economic and environmental contribution if they are produced in large amount and managed appropriately in the postharvest and also Ethiopia has suitable environment to expand production and increase productivity of these fruits. Moreover, expanding fruit production improve the natural resource degradation, check climate change challenges, increase fresh export to international markets and trigger emergence and development of fruit processing industries.

According to the study made in South Wollo by Seid, *et al* (2013) the postharvest loss of banana (1.5 %, 1.2% and 4.5 %); tomato (2.5 %, 2.5% and 5.9 %); mango (1.6 %, 1 % and 3.7 %) and papaya (1.5 %, 1% and 3.3 %) at farmers level, transportation and storage respectively and the major causes are pre harvest infection and injury. Furthermore, the handling and packaging material they are using are sacks in which there is no palletizing and large mass of commodity is tightly packed. The kind of transportation system is the use of pack animals and on the back of man and woman which leads to bruising during loading and unloading. In terms of market condition, most of the farmers sell their products on nearby markets and a few sell both on farm and in nearby markets. The marketing condition is unsatisfactory, discouraging mainly because higher supply of the product and middle man exploitation and the nature of the crop that makes to deteriorate fast and absence of storage structure. In other study of tomato postharvest loss, the farmer harvest when they have buyer, harvest at fully ripe stage and most still use traditional basket and sacks as their packaging material in conveying produce that leads to massive postharvest losses (62.5 %) (Olayemi, *et al.*, 2012). So far a number of researches have been done on these fruit in different countries and regions; however no more research was done in Northwestern Ethiopia production and marketing system. Therefore this research was designed with the objectives to assess postharvest loss of tropical fruits at different level of handling in the market chain of northwestern Ethiopia; identify and prioritize the major contributing factors responsible for post harvest losses at producer and trader level.

2. Material and Method

i) Area description

The research was conducted in 2014/15 at West Gojam and South Gonder Zone of North western Ethiopia. Both of them are potential for tropical fruit production, marketing and processing. The research gathered information regarding postharvest losses and factors responsible for postharvest losses in fruit producing districts of Burie, Bahirdar Zuria, Zegie, Woreta, Dangla, and Finoteselam. Whole sellers and retailers involved in fruit trade at Bahirdar, Finoteselam, Burie, Woreta, Dangla towns were sampled. The researchers collected both quantitative and qualitative data on Avocado (*Persia americana*), Banana (*Musa spp*.), Guava (Psidium guajava), Mango (*Managifera indica*), Papaya (*Carica papaya*) and Tomato (*Solanum lycopersicum*)

ii) Sampling Procedure and data collection

Purposive sampling method was used to select fruit production and trading areas whereas respondent farmers and traders sampled randomly. Six fruit producing districts from the two administrative Zones were identified. Thirty tropical fruit producing farmers were selected from these six districts randomly. A total of 180 sample farmers were selected from the six fruit producing districts. The research samples included a total of 80 traders (20 whole sellers, 60 retailers) from Bahirdar, Burie, Finote selam, Dangila, Woreta towns that were selected randomly. Semi-structured questionnaire was prepared both for farmers and traders. Observation and key informant interview were used to get additional data.

iii) Method of data analysis

Data analysis was made using statistical software (SPSS version 22). Descriptive data analysis; mean, minimum, maximum values, standard deviation and percentages were computed. Correlation analysis was made to check the existence of relationship between estimated postharvest loss and other socio-economic and other variables. Tables, graphs and charts were used to display results of the research findings.

3. Result

3.1 Socioeconomic status of fruit producers and fruit production

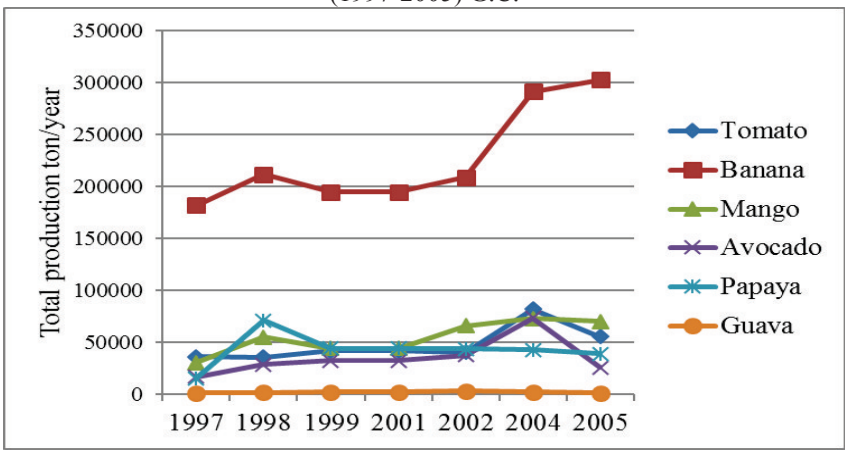
As shown in Table (1) below the average age, family size and number of working person in a family at producer level is 45.6, 5.5 and 3.94 respectively. Age of the respondents in the sample ranged from 24 to 73 years. The average area of cultivated land and fruit land was 1.38 and 0.29 respectively; that means on average 21% of the land was allocated for fruit production. Sampled households do have nine years of experience on fruit production. The storage duration for fruits ranges from zero to 15 days indicating that farmers need to consume or market their produce in less than a month time. Given that usually all farmers harvest their crops at the same time this will have its own negative effect in the price they are receiving.

Table 1: Socio-economic and demographic variables of tropical fruit producers in northwestern Ethiopia

Variable	Mean	Std.Dev.	Min	Max
Age (Years)	45.9	9.41	24	73
Family size	5.5	2.12	1	12
Working person	3.94	1.55	1	8
Distance to market (Hrs on foot)	8.34	5.97	0.5	30
Total crop land (Hectar)	1.38	0.94	0.25	7
Total fruit land (Hectar)	0.29	0.18	0.01	1.5
Experience in fruit production (Years)	9.09	5.15	2	30
Storage duration (days)	3.98	3.17	0	15

As indicated in figure 1 below the major tropical fruits produced in Ethiopia include Banana, Tomato, Mango, Papaya, Avocado, and Guava. As the fruit production data obtained from CSA (1997 -2005) showed banana is the top produced fruit with increasing trend followed by Mango and Tomato. Avocado and Papaya ranked fourth and fifth but the production of Guava looked low and constant across the years.

Figure 1. Trend of tropical fruit production (Tomato, Banana, Mango, Avocado, Papaya and Guava) in Ethiopia (1997-2005) G.C.



3.3 Postharvest handlings losses at producer level

The result of the assessment showed that the mean percentage of fruit loss at producers' level in north western Ethiopia estimated between 15% to 30%. The average loss was high for Avocado (28%), Tomato (22%), Mango (21%), Papaya (19%), Banana (18%) and Guava (16%) (Figure 2). The fruit loss was found to vary in different postharvest handlings at farmers' level and 83% of the producers perceived and estimated loss during harvesting but 17% said that there was no loss at harvest. From the respondents 48%, 34% and 18% estimated 1-5 %, 6-10% and 11-35% loss respectively during harvesting. At farmers storage; 71 % perceive loss and the remaining 29 % said no loss and 68%, 18% and 14 % estimated 1-5 %, 6-10% and 11-40 % accordingly. 65%, 22% and 13% of fruit producers estimated 1-5 %, 6-10% and 11-30% fruit loss during transportation and marketing.

Figure 2. Fruit loss estimation of different tropical fruits at farmers level

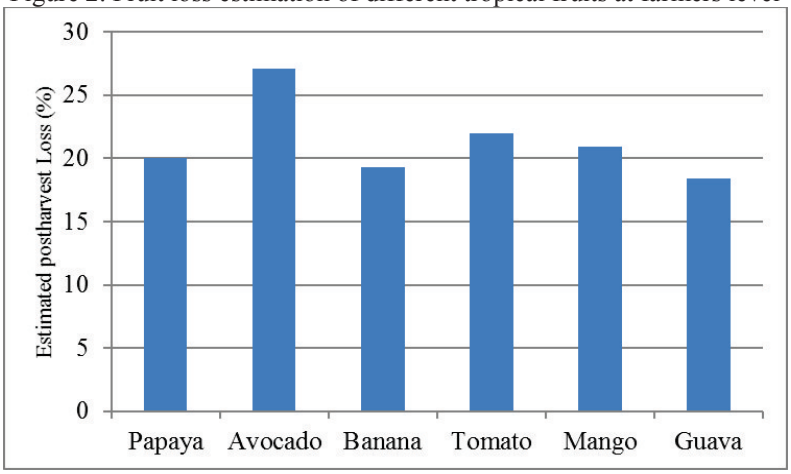
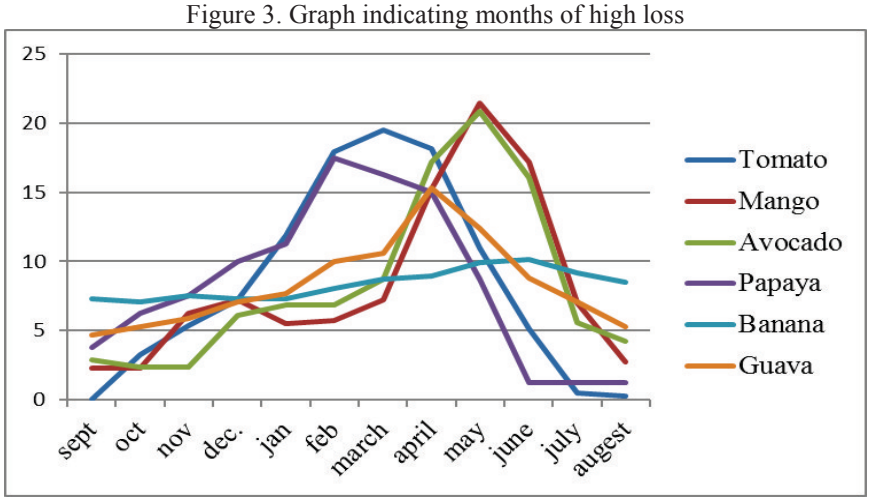


Figure 3 below indicated months of the year with high and low fruit loss, as shown in the graph there is high fruit loss in March, April and May as compared to other months of the year. There is low price and high

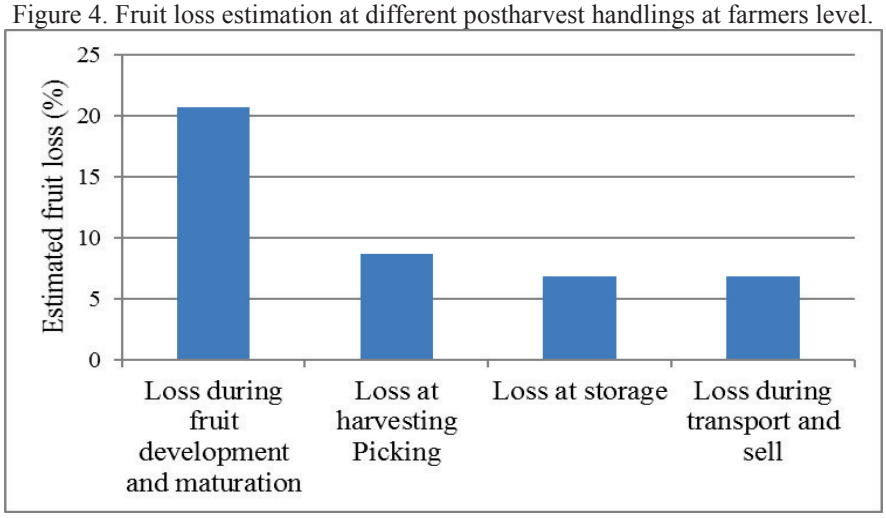
postharvest loss in the peak production season and high demand and high price in the low production months. As these fruits are needed throughout the year by consumers, effort should be important to have constant supply throughout the year in the country.

Figure 3. Graph indicating months of high loss



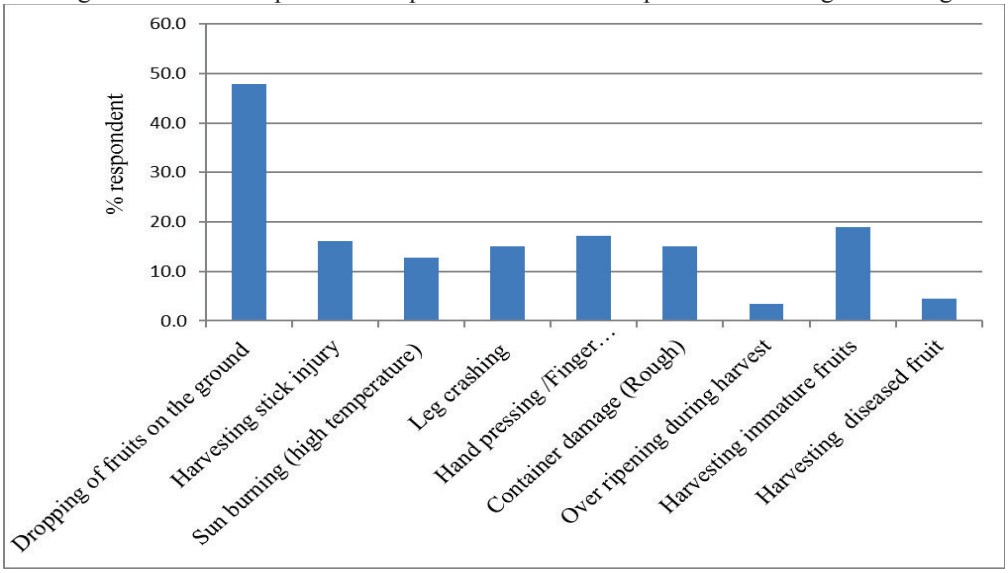
Fruit postharvest loss varies across the different postharvest handling and the largest loss occurred during harvesting (picking) followed by storage and then transportation and marketing (figure 4). According to the respondents, the major factors contributed to fruit loss during harvesting (picking) are dropping of fruits on the ground from tall varieties, harvesting stick injury, high temperature, and sun burning in temporary field storages and harvesting immature fruits together (Figure 5).

Figure 4. Fruit loss estimation at different postharvest handlings at farmers level.



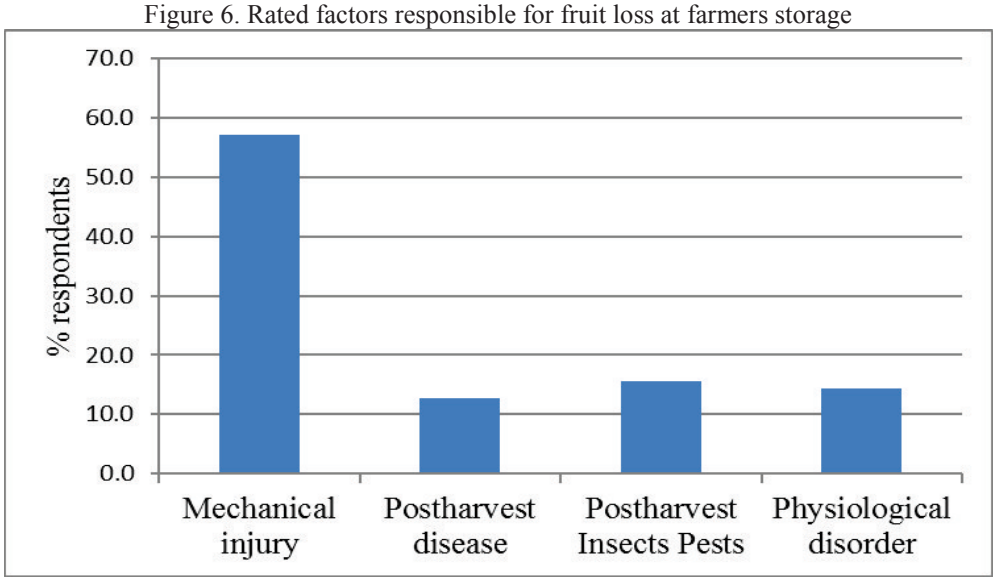
Most of the varieties being grown by farmers are tall and there is no improved harvesting technology as a result long sticks are used to kick matured fruit from tall trees and fruits detached and dropped to the ground and harvested in to a container and this creates fruit injury that leads to fast postharvest decay. Moreover, harvesting should be made when the temperature drops but harvesting is practiced normally during the day time when there is high temperature, low relative humidity and high sun shine that brought and wilting. Moreover, there is no cool temporary field storage for pre cooling.

Figure 5. Factors responsible for postharvest loss of tropical fruits during harvesting



At farmers storage condition, high storage loss is caused by mechanical injury followed by postharvest insect, physiological disorder and postharvest diseases (Figure 6).

Figure 6. Rated factors responsible for fruit loss at farmers storage



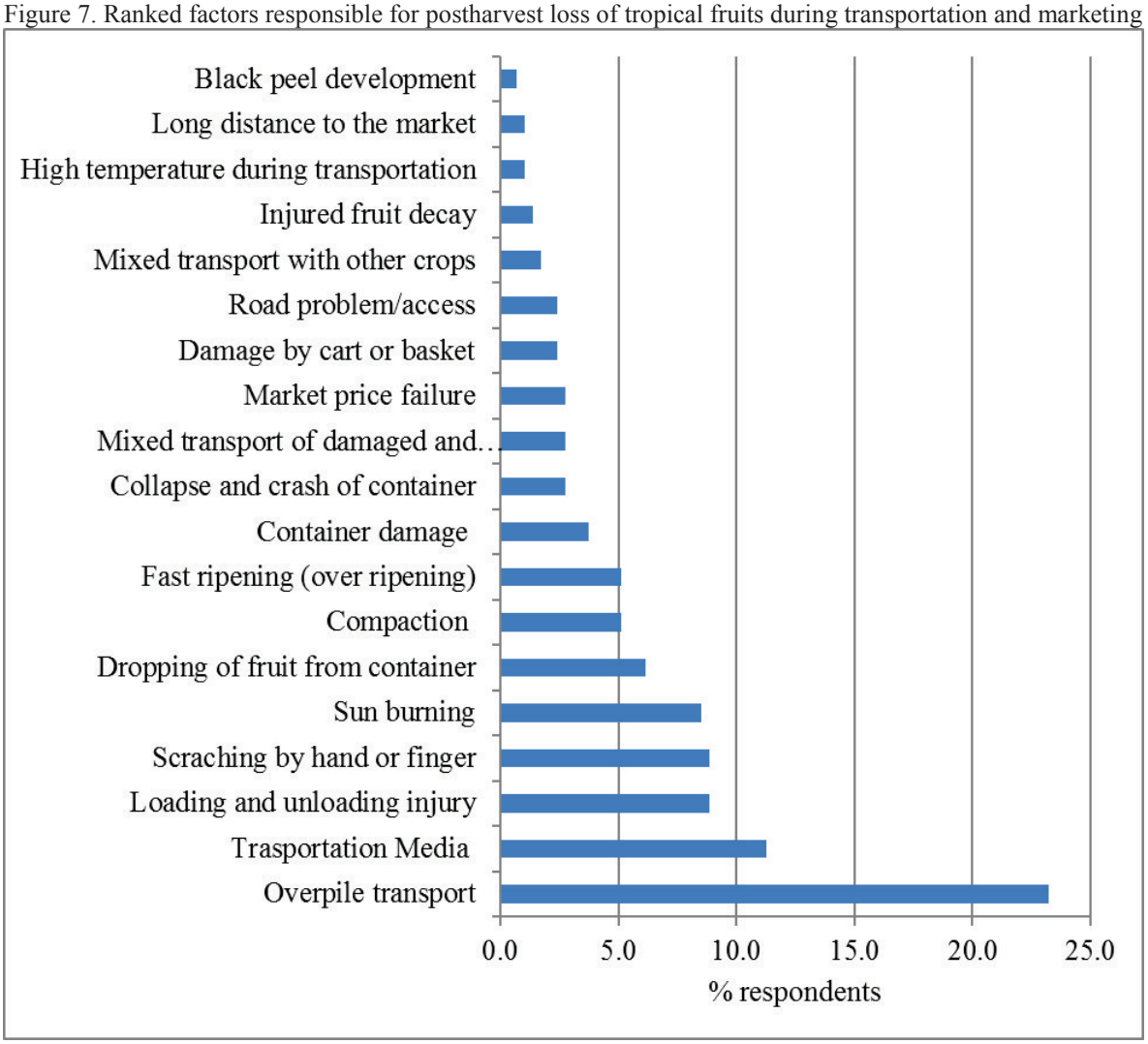
The causes of postharvest loss that brought mechanical injury at farmers storage include damage caused by vertebrate and invertebrate pests (rats, ants, termites and domestic animals), compaction, overcrowding and roughness of container (Table 2). Fruits are transported to farmers' house and temporally stored in the house till fruit ripening and then transported to the markets. There are no cool, well aerated and protected storage structures. The second important cause of postharvest loss includes postharvest insect pests (worm, fly and thrimps) and diseases (rust, anthracnose, powdery mildew and microbial decay). Tomato worm and Guava worm damage existed in high rate and control measure should be devise to reduce the postharvest loss. Fruits are perishable commodities and required optimum temperature and relative humidity in the postharvest handlings. If the temperature and relative humidity is not optimum, it brings physiological disorder and the major cause of postharvest physiological disorder ranked included chilling injury, cracking, shrinking, high temperature injury and sun burning.

Table 2: Ranking of factors responsible for postharvest loss at farmers' storage

Rank	Mechanical injury	Postharvest diseases	Insect pests	Physiological disorders
1 st	Animal damage (rats, ants, termites, domestic animals)	Rust	Worms	Chilling injury
2 nd	Over crowding	Microbial decay	Fly	Fruit cracking
3 rd	Compaction	Anthracnosis	thrimph	High temepature injury
4 th	Roughness of container	Powdery mildew		Shrinking
5 th	Roughness of container			Fruit hardness
6 th	Fast ripening and decay			Fruit curling
7 th	Fall on the ground			
8 th	Over ripened damage			
9 th	Falling immature fruits			

After temporary storage at farmers home, fruit are transported to the nearest market. During fruit transportation and sell in the market, the major causes of loss assessed were over piling during transportation, scratching by consumer hand and fingers, inappropriate transportation means (on the back of animals and woman), poor road, no fruit packing/waxing, fast ripening, damage injury during loading and unloading, poor marker infrastructure (high temperature, low relative humidity and sun burning), market price failure, long distance transport, mixing different fruit during transport and no sorting (ripe/unripe fruit and diseased/disease free) (Figure 7).

Figure 7. Ranked factors responsible for postharvest loss of tropical fruits during transportation and marketing

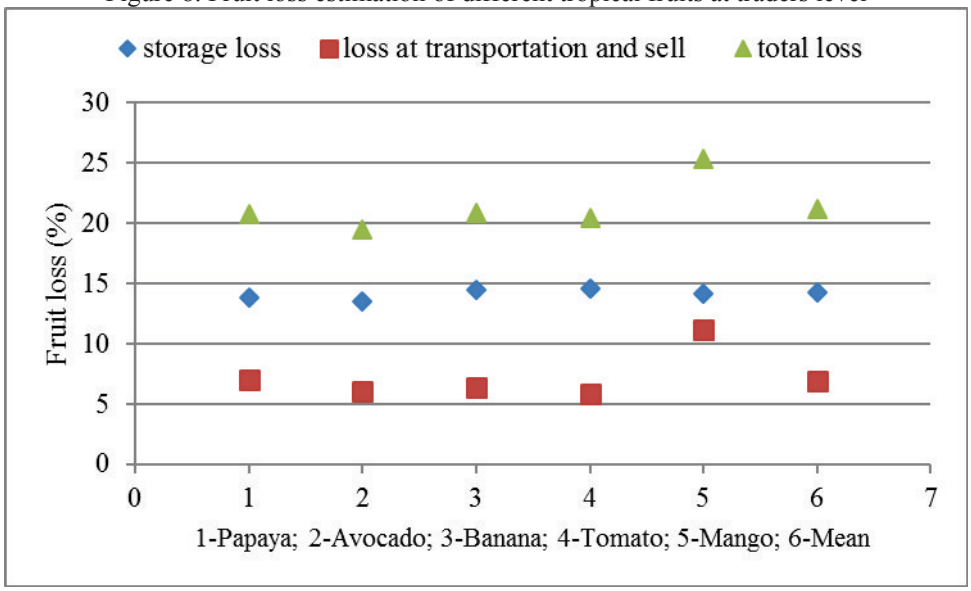


3.3 Postharvest handlings losses at trader level

The mean percentage loss of fruits ranged from 5% to 25 % at traders level and maximum loss occurred during

storage followed by transportation and marketing both at wholesaler (local collector) and retailer. As it is indicated in figure 8 high estimated fruit loss up to 25% existed at traders level in Mango and the estimated fruit loss for the remaining fruits were more or less similar. The unique high loss of mango occurred during transportation and marketing chain in the postharvest period.

Figure 8. Fruit loss estimation of different tropical fruits at traders level



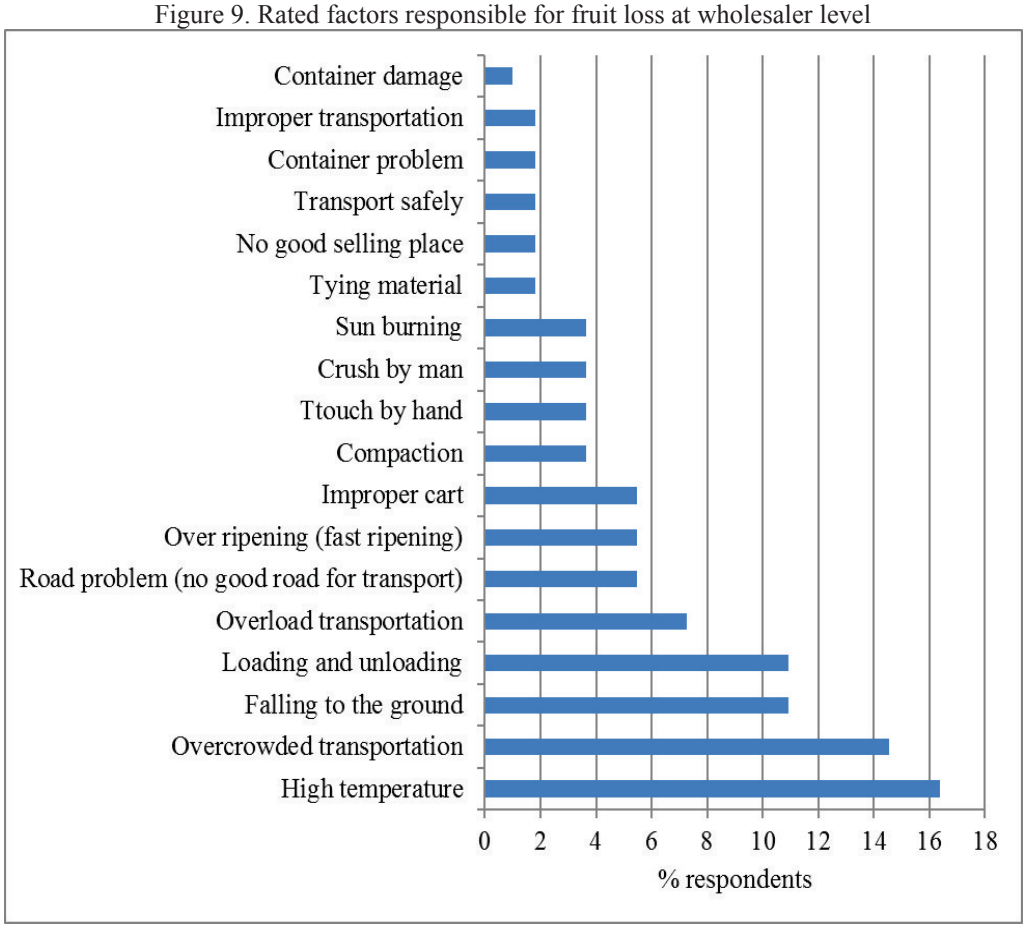
At wholesale level the first cause of postharvest fruit loss was mechanical damage followed by postharvest diseases, physiological disorder and postharvest insects. From the mechanical damages; damage caused by rodent like rat, overcrowding, compaction and container edge ranked top (Table 3). Worms are common postharvest insect pests found in most fruits at trader storage. Detailed study on biology and management of these worms on fruits require due attention. Rots, Mould and Decay from mechanically injured and microbial infected fruits are identified as the main postharvest diseases at this point of the market chain. Further identification and management of postharvest diseases; presence and level of mycotoxin and aflatoxin on these fruit in the postharvest chain need to be studied well. High temperature injury, sun burning, shrinking and fast ripening (decay) are common causes of physiological disorders.

Table 3: Ranking of factors responsible for postharvest loss at wholesaler storage

Priority (rank)	Mechanical injury	Postharvest disease	Postharvest insect	Physiological disorder
1 st	Overcrowded storage	Decay	Worm	High temperature
2 nd	Container edge	Rot	Rat	Sun burning
3 rd	Compaction	Mould		Fast (over ripening)
4 th	Hand touching			Low temperature
5 th	Overloading			Shrinking

The major causes of loss included high temperature, sun burning, overcrowding and overloaded transportation, falling to the ground, road problem, fast ripening, bad (improper) container and container damage, improper transportation, damage during loading and unloading and poor and unstable market price at whole seller level during transportation and marketing (Figure 9). Improved storage and transportation infrastructure as well as packing required at this level and local collectors and wholesalers need training on post harvest handling, maintaining quality and marketing of fruits.

Figure 9. Rated factors responsible for fruit loss at wholesaler level



As presented in figure 10 below mechanical damage, postharvest diseases, physiological disorder and postharvest insects are prioritized as the major cause of losses at retailer level. The causes of postharvest loss that brought mechanical injury include damage caused by vertebrate pests (rats, ants, termites and domestic animals), overcrowding, compaction, container damage. Postharvest diseases including microbial rot, decay and molds are identified and prioritized top. The major cause of postharvest physiological disorder included high temperature injury, chilling injury and sun burning (Table 4).

Figure 10. Rated factors responsible for fruit loss at retail storage

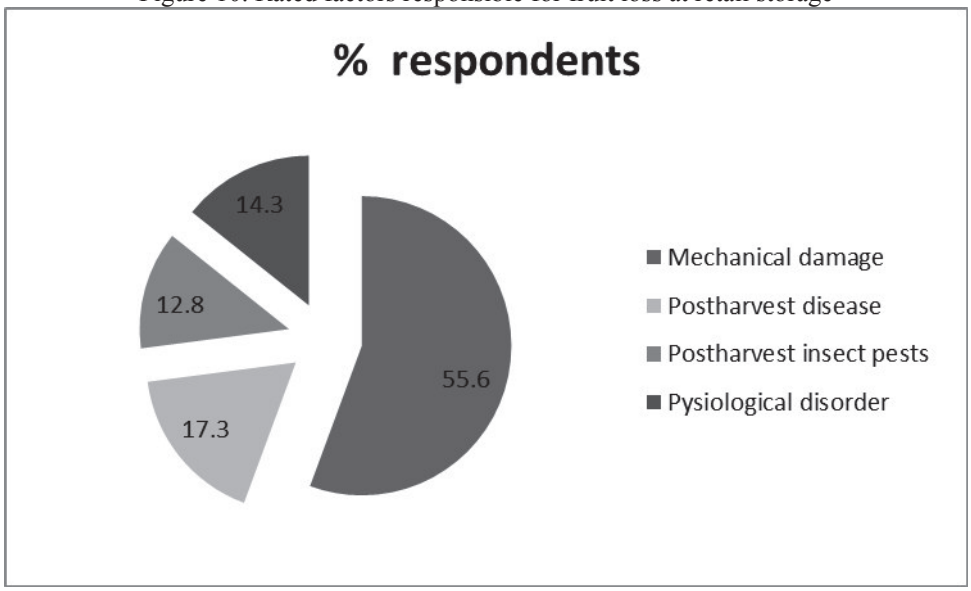
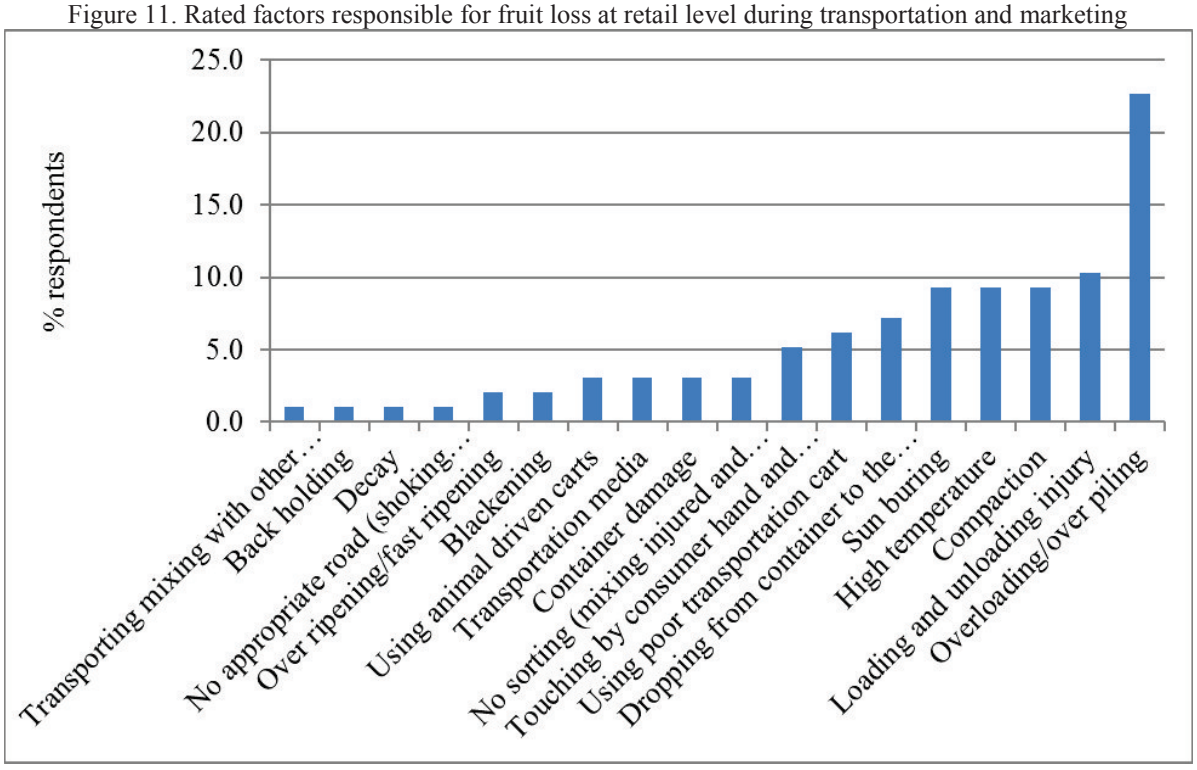


Table 4: Ranking of factors responsible for postharvest loss at retailer temporary storage

Priority (rank)	Mechanical injury	Postharvest disease	Postharvest insect	Physiological disorder
1 st	Rodents damage	Rot	Worm	High temperature injury
2 nd	Over crowding and overloading	Decay		Chilling injury
3 rd	Container damage (roughness of container)	Wilting		Sun burning
4 th	Compaction			Blackening
5 th	Break during transport			
6 th	Hand touching and scraching			
7 th	Poor storage media			
8 th	Domestic animal damage (pultry, sheeps, goats, cows)			
9 th	Children damage			
10 th	Crush by human leg			
11 th	Dropping on the ground			
12 th	High temperature			

At retailer level the major causes of loss identified and prioritized during transport and marketing included overloading, overcrowding and over pilling, loading and unloading problem, compaction, consumer hand / finger damage, high temperature and sun burning (Figure 11).

Figure 11. Rated factors responsible for fruit loss at retail level during transportation and marketing



Correlation of postharvest variables with postharvest loss

As indicated in table 5 some socioeconomic variables of fruit producers have correlated to postharvest loss. Educational level of the producer, distance to the nearest market, experience of fruit production, agro-ecology of the fruit production area, marital status, age of the producer and means of income generation showed significant and highly significant relationship with loss. From the mentioned variables, agro-ecology of the production area and distance to the nearest market showed relative high correlation coefficient. Agro ecologies vary in climate condition, access and distance to market, transportation and storage infrastructure and thus contribute to postharvest loss. The significant correlation of education level, experience, age, means of income, marital status, gender with postharvest loss indicated that developing the skill, knowledge and experience of fruit producers in postharvest handling of fruit can reduce loss. Similarly the production variables including source of irrigation water, type of land, labor shortage for fruit production, use of organic fertilizers, access and source of improved seed of varieties and pesticide spray showed significant and highly significant relationship with loss. The most

important variables that showed highly significant correlation with postharvest loss of fruit are source of water and labor shortage. These production inputs have effect both on fruit production and postharvest life and quality. The correlation between use of compost/manure and pesticides spray during fruit production and postharvest loss dictates that these activities need to be practiced during fruit production so as to reduce postharvest loss.

Table 5. Simple correlation socio-economic and production variables and estimated postharvest loss

Socio economic variables	Loss during harvesting	Loss during storage	Loss during transportation and sell
Zone		-0.184*	
Wereda		-0.239*	-0.383**
Educational level	-0.192*		
Distance to the nearest market	0.227**		0.237*
Experience of fruit production	-0.263**		
Age of the respondent			-0.184*
Means of income generation			0.229**
Marital status		0.205*	
Male family size		0.189*	
Production variables	**Loss during harvesting**	**Loss during storage**	**Loss during transportation and sell**
Use of compost/manure for fruit production	.355**		
Source of irrigation water	.302**		0.359**
Labor shortage	.181*		0.311**
Type of land for fruit production	-.162*		
Use of pesticide		0.213*	
Source of improved seed		-0.437**	
Access to improved seed		0.283**	

* significant ** highly significant

Table 6 below showed that from those postharvest handling practices, method of fruit harvesting and method of fruit collection during harvesting; type of container and sorting and grading during storage; method of transport, container used for transport and fruit ripening problem during transportation and marketing had significant and highly significant relationship with postharvest loss. It is still possible to indicate from this research that proper fruit harvesting and harvesting technologies, sorting and grading before storage, improved storage structure and transportation and packing facilities and ripening techniques at producers' level are needed to reduce the estimate postharvest loss.

Table 6 Simple correlation postharvest handling variables and estimated postharvest loss

	Method of fruit harvesting	Method of fruit collection		Type of container for home storage	Sorting and grading before storage		Method of transport	Container used for transport to the market	Fruit ripening problem
Loss during harvest	0.351**	0.196*	Loss at storage	0.208*	0.472**	Loss at transport and sell	0.335*	0.354**	0.54**

Discussion

Agriculture is the mainstay of Ethiopia's economy and it provides all the necessary dietary foods, raw materials for food industries and quality products for export market. Coffee, oil seeds, spices, fresh fruit and vegetables contribute the largest portion of the export earnings. Tomato, Papaya, Avocado, Banana, Mango and Guava are the common perishable tropical and subtropical fruits produced for domestic and export market but effort is important to meet the quality standards in different markets. Postharvest loss interms of quality and quantity affects is one of the factors responsible in affecting these commodities. Estimated postharvest loss ranged from 20% to 25% is found in production and market chain of northwestern Ethiopia. Mashav, 2010 estimated at 5-20% postharvest loss of fruits in developed country and 20-50 % in developing countries. Seid, *et al* (2013) estimated the postharvest loss of banana (1.5 %, 1.2% and 4.5 %); tomato (2.5 %, 2.5% and 5.9 %); mango (1.6 %, 1 % and 3.7 %) and papaya (1.5 %, 1% and 3.3 %) at farmers level, transportation and storage respectively.

High post harvest loss occurred at producers' level during harvesting. As the varieties with farmers hand are tall and there is no improved harvesting and collection technologies; introduction of short varieties or top working along with least cost harvesting and collection technology is vital to reduce the loss at this point. The time of fruit harvesting should be done when the temperature is low and field temporary storage are required to

collect the harvested fruits. Mechanical damage, postharvest insect pest and diseases and physiological disorders contributed to loss in different magnitude farmers' storage. The identified and top prioritized factors contributing to loss at farmers storage includes unavailability of low temperature storage facility and storage without sorting and grading of normal, disease, injured and immature fruits. Inappropriate media (packing), poor means of transport and road, high temperature, sun burning, low relative humidity, long distance to the market and market failure are identified and prioritized as the cause of postharvest loss at transportation and marketing. In line with this Olayemi. *et al*., 2012 investigated in a study done in Nigeria that the handling/packaging materials producers are using sacks (82.7%) in which there is no palletizing and large mass of commodity is tightly packed, with low gas exchange between commodities. In addition, the kind of transportation system is the use of pack animals (64.5%) and on back of man and women. These have a problem of bruising during loading and unloading. The farmer harvest mostly when they have buyer, harvest at full ripe stage (90%) and most still use the traditional basket and sacks as their packaging material in conveying produce resulting into postharvest losses (62.5%). Thus, improved low cost fruit storage and transportation technologies should be introduced and also marketing and transportation infrastructures that are currently available require upgrading. Fruits should be handled in the postharvest in the appropriate cool chain. Postharvest education and training of experts and producers is vital as the area demands considerate knowledge, experience and skill.

Postharvest loss at traders level occur both at wholesaler/local collectors/ and retailers. The estimated loss ranged from 20 % to 25%. Unavailability of well established market infra structure, cold and controlled atmospheric storage, packing material, transportation means contributed to loss during storage at traders level. The inherent high respiration rate, short green and shelf life together with the high temperature, low relative humidity and sun burning of the local markets brought high postharvest loss at retailer sell. Mechanical damage like cracking, bruising, and blemish has significant contribution to loss at traders level. The marketing condition is unsatisfactory and discouraging mainly because of higher supply of the product at a pick production especially in march, april and may and leading to high loss.

Postharvest handling procedures and conditions have profound effect on quality and postharvest life of fruits. Keeping fruits within their optimum ranges of temperature and relative humidity is the most important factors maintaining their quality and minimum postharvest losses. Above the freezing point, (for non-chilling sensitive commodities) and the minimum safe temperature (for chilling sensitive commodities), every $10^{o}C$ increase in temperature accelerates deterioration and the rate of loss in nutritional quality by 2-to 3-fold. Delays between harvesting and cooling or processing can result in direct losses (due to water loss and decay) and indirect losses (losses in flavor and nutritional quality). The extent of these losses depends upon the commodities condition at harvest and its temperature, which can be several degrees higher than ambient temperatures, especially when exposed to direct sun light. The distribution chain rarely has the facilities to store each commodity under ideal conditions and requires handlers to make compromises as the choice of temperature and relative humidity. These choices can lead to physiological stress and loss of shelf life and quality (Paull, 1999). The weakest link in the postharvest handling chain of fresh fruits is the home handling system; greatest potential for improvement includes development of more sophisticated home handling equipment and transfer of handling knowledge to the consumer (Shewfelt, *et al*., 2000). Supplementary treatments include cleaning, sorting to eliminate defects, procuring, sorting by maturity/ripeness stage, sizing, waxing, treatment with fumigation for insect control, and exposure of fruits to ethylene for fast and uniform ripening are useful in maintaining quality and extending postharvest life of the produce (Kadar, 1988). Therefore, further research and development effort is required in order to reduce loss and maintain quality in the postharvest and marketing chain of these fruit in the country.

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