

Determinants of Postharvest Banana Loss in the Marketing Chain of Central Ethiopia

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Abstract

A survey was conducted to estimate the postharvest loss of banana and identify the causes at the major banana producing and marketing areas of Ethiopia. The total postharvest loss of banana was estimated to be 26.5% where 56% of the loss occurred at the retail level, while 27% and 17% of the losses occurred at wholesale and farm levels, respectively. Mechanical damage was identified as the main cause for postharvest banana loss at farm and wholesale levels while rotting was the main cause at retail level. Poor postharvest handling practices from farm to the retail were the major factors influencing banana loss in the supply chain. Regression analysis shows that sex, farming experience, decision to harvest and cooperative membership were found to significantly influence banana loss at farm level while education level, marketing experience, fruit quantity handled and destocking date were significantly influencing the loss at wholesale level. Sex, education, fruit quantity handled and destocking date were also the significant determinants influencing banana loss at the retail level. Hence, it can be concluded that significant amount of banana loss occurred in the supply chain which is mainly attributed to lack of knowledge and poor postharvest handling practices. Thus, there is a need for awareness creation about the importance of the loss and adoption of improved handling practices of banana as part of the loss reduction effort in the supply chain.

Keywords: Banana, postharvest losses, causes, determinants.

1. Introduction

Postharvest loss of fresh produce is a major challenge in the postharvest sector. Fruits are the most perishable agricultural produces facing a tremendous loss from harvest to consumption. As in many developing countries, proper attention was not given to postharvest loss of fruits in Ethiopia. Therefore, it is very difficult to give proper estimation of postharvest losses for the different commodities due to limited investigations in the field. On the other hand, documenting the levels of losses and identifying the causes are key steps towards designing appropriate future loss prevention efforts at local as well as national levels for a specific commodity. It helps to improve the expertise and awareness of the causes and extent of postharvest losses to policy makers, extension workers and other responsible bodies (Kitinoja *et al.*, 2011). In spite of this, very little emphasis has been given to research focusing on estimating the postharvest losses and factors affecting it in the main fruit supply chain in the country. The need for emphasis in Ethiopia is supported by the presence of poor infrastructure and lack of marketing facilities where 25 to 35% of fruits and vegetables have been lost after harvest (Tadesse, 1991).

Banana is a very important fruit not only in Ethiopia but all over the world. Banana is a climacteric fruit with poor storage characteristics as it presents high respiratory rate after harvest and ethylene production, which make it highly perishable and prone to postharvest losses (Turner, 2001). The postharvest loss of banana associated with storage and marketing is reported to be prominent and reaches up to 80% as in the case of Rwanda (WFLO, 2010). A review by Affognon *et al.* (2015) indicated that the information on postharvest loss research for banana is spotty and scanty, and the condition is more severe in southern and eastern Africa. It is, therefore, important that postharvest management should be given due attention as production practices (Kader, 2005).

Generally, the primary factors causing postharvest loss in fruits can be categorized into mechanical, physiological, pathological or environmental factors (Kader and Rolle, 2004). The losses are favored by secondary factors resulting mainly from inadequate technology applications and quality control. A high postharvest loss caused by inadequate and inefficient postharvest handling practices, is reported to be one of the major problems limiting the expansion of banana production in Africa (Olorunda, 2000). Similarly, lack of postharvest and marketing infrastructures such as packaging, cold storage, pre-package and distribution, postharvest treatment and washing facilities together with production constraints are reported problems leading to low productivity and considerable postharvest loss of banana in Ethiopia (Gabre-Mariam, 1999).

Although Ethiopia has great potential to produce and export high quality bananas, the actual yield and

quality of the fruit is poor. The reason is partly due to postharvest loss as a result of miss-handling of fruit. Considerably high quantity of banana is wasted before it reaches the target market or consumers due to poor postharvest handling and limited shelf-life (Gabre-Mariam, 1999). However, there is very limited research on the magnitude and causes of postharvest loss of banana in Ethiopia. Thus, having information about the magnitude and causes of the loss is imperative to know the level of loss and seek for solutions in reducing postharvest loss. Therefore, this study identified where the major losses occurred, determine the extent of losses, and identified the determinants of postharvest banana loss at the major production and marketing chains of banana in Ethiopia.

2. Material and Methods

2.1. Study area and sample selection

A survey was conducted in the year 2012 to estimate the postharvest banana loss and identify its determinants through the supply chain. The study was conducted in Gamo Gofa zone of Southern Nations Nationalities and Peoples Region (SNNPR), major banana producing zone in the country and, Addis Ababa and Adama cities which are the major consuming cities, respectively. Gamo Gofa is located at about 500 kms south of Addis Ababa and is the dominant source of banana in the country. Arba Minch zuria and Meerab Abaya districts were purposively selected as they are the major contributors of banana to the national market. Addis Ababa and Adama cities were also purposively selected as they are renowned for large volumes of wholesale and retail trades of banana. Thus, the population for this study consists of banana growers in Gamo Gofa zone and wholesalers and retailers at Addis Ababa and Adama cities. A total of 50 sample farmers were selected randomly from six peasant associations of the two districts based on probability proportional size. Postharvest loss at wholesalers and retailers were also surveyed in Addis Ababa and Adama taking a total of 42 wholesalers and, 50 retailers who were randomly selected based on probability proportional to size.

2.2. Methods of data collection

Primary data were collected with the aid of structured questionnaire. Based on the present context of banana marketing, three stages were identified to assess the postharvest loss: farm, wholesale and retail levels. Three sets of questionnaires were scheduled and information on socio-economic characteristics, production practices, harvesting, postharvest handling and marketing practices were collected from participants at the three levels of the marketing chain. Data regarding losses at different levels were also collected separately. This was supplemented by key informant interviews (with agricultural office managers, agricultural extension officers and selected fruit handlers) to augment the information supplied by respondents. Banana farms, harvesting, transportation and handling at different levels of the market were also observed to have more reliable information.

2.3. Data analysis

Averages and percentages were used to compute the postharvest losses at the three stages. The total postharvest losses were estimated as the sum of all these losses. Multiple linear regression analysis was employed to identify the determinants of the postharvest loss of banana at different handling levels as used by Adewumi *et al.* (2009). The model used was specified for farmers, wholesalers and retailers as stated in equations 1, 2 and 3.

$$Y_1 = \beta_0 + \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 + \beta_4 F_4 + \beta_5 F_5 + \beta_6 F_6 + \beta_7 F_7 + \beta_8 F_8 + \varepsilon \quad (1)$$

Where Y_1 is farm level postharvest banana loss per trip (%); F_1 is sex of the household head ; F_2 is number of active labor force; F_3 is farm experience in years; F_4 is total farm land size (ha); F_5 is decision to harvest '1' if fruit harvested when mature and '0' otherwise; F_6 is packaging '1' if packaging used during transportation and '0' otherwise; F_7 is membership to cooperative (1 = Yes, 0 = No); F_8 is extension contact (1 = Yes; 0 = No) and ε is error term.

$$Y_2 = \beta_0 + \beta_1 W_1 + \beta_2 W_2 + \beta_3 W_3 + \beta_4 W_4 + \beta_5 W_5 + \varepsilon \quad (2)$$

Where Y_2 is wholesale level postharvest banana loss per trip (%) ; W_1 is education level of wholesalers; W_2 is experience in banana trade; W_3 is quantity of banana bought per trip (kg); W_4 is number of days to ripe bananas; W_5 is number of days to finish selling bananas; and ε is error term.

$$Y_3 = \beta_0 + \beta_1 R_1 + \beta_2 R_2 + \beta_3 R_3 + \beta_4 R_4 + \beta_5 R_5 + \beta_6 R_6 + \varepsilon \quad (3)$$

Where Y_3 is retail level postharvest banana loss per trip (%); R_1 is sex of retailers dummy (1 = female; 0 = male); R_2 is educational level of retailers; R_3 is experience in banana trade; R_4 is quantity of banana bought per trip (kg); R_5 is number of days to finish selling bananas and ε is error term.

3. Results and Discussion

3.1. Socio-economic characteristics of the respondents

Analysis of the socio-economic characteristics of respondents revealed the dominance of males across the supply chain actors (Table 1). The average age for farmers, wholesalers and retailers was 46, 38 and 32, years respectively. Twenty eight percent of farmers were not attending formal schooling while 60% of wholesalers and retailers attain secondary level of education. The average banana farming experience for farmers was 14 years while wholesalers and retailers were having 6 and 5 years experience in banana marketing, respectively. It is further revealed

that majority of the respondents across the chain actors were married and the average farm land size for farmers was 2.78 ha.

3.2. Management practices

3.2.1. Management practices at farm level

Majority of the farmers (76%) responded that harvesting is based on fruits maturity while the remaining 24% harvest even before they are mature. Sixty eight percent of farmers used men's shoulder to transport their fruits to the collection site and majority of the farmers (54%) also do not use any packaging material while transporting. This might expose fruits to physical injury as a result of abrasion damage during transport. The absence of temporary storage structure at the collection sites also exposes fruits to high temperature. The only way farmers store their banana fruits is by covering it with its own leaves. Eighty three percent of the farmers heap their fruits under open space while the remaining 17% heap under shade covering with banana leaves. According to most of the farmers response, the fruits stay more than half a day waiting to be loaded in a truck. According to the interview with some transport traders, 50 - 60 quintals of banana bunch will be loaded in an open truck only lined with banana leaf. It was also possible to observe during the assessment that fruit handling during loading was rough as loaders throw bunches and walk even on top of them while loading. Bunches are also stacked horizontally with no cushioning between layers. Generally, bananas are bruised by very rough handling, throwing bunches, stacking too high, loading vehicles too deep, which might enhance the chance for losses at all levels of the value chain.

3.2.2. Banana handling at wholesale market

Fruits reaching the wholesale market are off loaded and weighed before entering it to the ripening rooms. It was possible to observe during the assessment that labor handling during unloading was also very rough as they are in hurry just to finish their work. In the ripening room, fruit bunches are stacked horizontally and receive airtight smoke treatment using kerosene burners to initiate the ripening process. There is no temperature and humidity control in the ripening rooms except that rooms are ventilated for some time. The smoke treatment days vary between 2 to 3 depending on the weather condition, relatively shorter time when temperature is high. Treated fruits are sold to retailers where further ripening is also expected at the retail market. Bananas which are not sold immediately after heat treatment will be de-handled and kept for sale heaped on floor, covered with newspaper (40.5%), or kept on the shelf. Forty eight percent of wholesalers responded to finish selling their bananas within two days while it takes 3 to 7 days for the remaining 52%. Wiping was the major means to keep sanitation for ripening and storage rooms. Only 12% of wholesalers responded to wash the rooms with tap water.

3.2.3. Banana handling at the retail market

Retailers use different types of packaging materials to transport and store banana. Thirty two percent of the retailers use plastic crates to transport their banana whereas majority of them use wooden crate, bamboo basket or sack and even some retailers (4.3%) use no packaging to transport fruits (Table 4). Most of the retailers (49%) use plastic crate and wooden crate (34%), for overnight storage of their bananas. Hanging bananas under tent-like structure was also a means of banana display for most of the retailers (83%). It takes 5 to 8 days for most of the retailers to finish banana selling. Only 30% of the retailers responded to finish selling their bananas within 1 to 4 days.

3.3. Causes of postharvest banana loss

3.3.1. Farm level causes

Farmers mentioned different types of causes for banana loss at farm level. Mechanical damage was considered by most of the farmers (58%) as the main cause for banana loss while improper maturity at harvest and sun browning were also the other main causes for banana loss by 27% and 15% of the respondents, respectively (Figure 1). Farmers also reported the need for immediate money and inefficient care during harvesting and transport are the main secondary factors influencing banana loss at farm level. Secondary factors are those that lead to conditions encouraging the primary factors, usually resulting from inadequate technology applications and quality control (FAO, 1989). The contribution of mechanical damage to banana loss might be attributed to the inefficient handling during harvesting and transport of bananas. The prevalence of mechanical damage could be high since majority of the farmers (68%) responded men's shoulder as means to transport and most of them

(54%) are not using packaging material to protect fruits. del Aguila *et al.* (2010) noted that the major problem affecting bananas during and after harvest is the susceptibility of the mature fruit to physical damage. Their tender texture and high moisture content makes them very liable to physical damage and deterioration during harvesting and following handling chains.

Improper maturity as a major factor to banana loss might be as a result of the delivery of immature bananas to the collection site. Collectors are not willing to pay for bananas with reduced quality, especially at times where there is good banana supply in the area. Though 75% of farmers responded as they harvest fruits based on fruit maturity, still the contribution of improper maturity for the loss is considerable from their response of ranking. According to farmers response, they tend to harvest immature fruits when they are in an immediate need for money. However, the stage of maturity is one of the most important factor determining at-harvest fruit quality and storability. Furthermore, harvesting immature fruit during cold season can lead to extended ripening period with poor eating quality and several kilogram loss of bunch weight (Dadzie and Orchard, 1997; Robinson and Saucó, 2010).

Sun browning might be due to excessive radiation that can cause sunburn to banana leaves and fruits. In some instances excessive pruning of banana leaves expose the fruits to the sun resulting in sunburn. The exposed bunches can be burnt at the top hand and bunch stalk. The fruit peel turns yellow with mild burning and black with severe cases (Robinson and Saucó, 2010).

3.3.2. Causes of postharvest loss at wholesale level

Mechanical damage was also mentioned by majority of the wholesalers (60%) as the main cause for banana loss at wholesale level while failure to pulp softening and improper maturity were noted by the remaining 25% and 15% of the respondents, respectively (Figure 2). The processes of fruit handling and packing from harvest through transport and marketing might contribute for mechanical damage to banana at whole sale market. Poor handling, unsuitable containers, improper packaging and transportation are indicated to easily cause bruising, cutting, breaking, impact wounding and other forms of injury leading to fruit deterioration (del Aguila *et al.*, 2010). Similar results were reported by Ilayas *et al.* (2007) stating higher mechanical damage to bananas at whole sale and retail marketing than at harvesting level within the supply chain.

The reason for failure to pulp softening during ripening might be due to the uncontrolled environment in the ripening rooms. Low temperatures, insufficient ethylene and too low humidity are indicated to cause uneven and incomplete banana ripening (Dadzie and Orchard, 1997; Kerbel, 2004). This also could happen due to early removal of fruit from the ripening room. Immature banana fruits (less full) are indicated to take longer time to ripen than more mature fruits. Ripening rates are noted to vary to some extent on the growing weather conditions, maturity and temperatures during handling of the fruit (Kerbel, 2004).

According to the response of wholesalers, the main secondary factors enhancing banana loss were long distance transport followed by poor packaging during transport and uncontrolled ripening environment (Table 5). Transporting banana bunches without cushioning material may expose fruits to mechanical damage resulting in losses (George and Mwangangi, 1994). This is particularly true when fruits are transported for long distance on rough roads, as it was the case in the present assessment. Rough handling at off-loading and ripening is one of the factors which perceived by wholesalers to have lower contribution to enhance banana loss. This might be because the wholesalers have limited awareness about the impact of their handling practice contribution to poor banana quality and then losses down the supply chain.

3.3.3. Causes of postharvest loss at retail level

At retail level, fruit rotting was mentioned by majority of the retailers (44%) as the main cause for fruit loss while fruit softening and mechanical damage are noted by 32% and 24% of the retailers, respectively (Figure 3). The high percent score in rotting could be explained by the fact that during handling, fruits are infected with various pathogens which can be established at any time before or after harvest but will cause decay and rot during storage. Banana pathogens gain entry through injuries created during harvesting and injuries related to poor handling and transport. During storage, banana fruit deteriorates through the action of spoilage microorganisms, which become activated due to the changing physiological and biochemical state of the fruit (Turner, 2001). As evidenced from this assessment, unsatisfactory sanitation at the ripening and storage environments might also be the source of contamination and quality loss from microbes all of which contribute to the spread of diseases to fruits. Moreover, the storage of fruits in boxes at retail market might result in more losses due to cross-contamination inside the crates. Similarly, poor hygienic conditions in the field and handling and mechanical injuries associated with poor transport and handling were reported to be the main causes for banana rot in Kenya (FAO, 2014). It is therefore, advised to reduce the incidence of physical injury and the risk of contamination of microbes and dust as a means of preventing fruits quality loss.

Fruit softening is mainly because of the increased respiration rate as the ripening proceeds. The ripening associated softening in banana fruit also leads to an increased susceptibility to physical damage and pathogen attack during storage which increases the risk of fruit spoilage at retail market. Microbial and mechanical damage also interact with the changing physiology and chemistry of the fruit during ripening and

storage will result in great fruit losses (Turner, 2001; Jun-Ping, 2006). It is revealed from this study that the woven plastic material used by most of the retailers for shading was insufficient to protect the fruit from heat of sunny days. High temperature will increase the rate of respiration in fruits which subsequently leads to the breakdown of the inner tissues (Kader, 2005). Inefficient environmental protection in the display area coupled with similar practices in the previous handling chains will lead to the enhanced fruit softening. Shelf life is affected not only by temperature during the ripening and display period but also by temperature during the prior period of ripening (Turner, 2001).

The impact of mechanical damage might be magnified at retail level because injuries from the previous handling chains will be more prevalent on the ripe fruit. The physiological state of the fruit (ripening) by itself also makes the fruit more sensitive to handling damages. Wasala *et al.* (2014) also reported higher postharvest loss of bananas due to mechanical damage at the retail stage. Since bananas are climacteric, mechanical injury causes increased respiration rate, ethylene production, water loss and deterioration by microorganisms thereby shortening postharvest life and directly affecting fruit quality and retail prices (Dadzie and Orchard, 1997; Giametta and Bonfà, 2008).

The retailers noted that rough handling at wholesale market and taking relatively longer days to sell fruits are the main causes favoring the loss of their fruit in the market (Table 6). It has been revealed from this study that it takes 5 days and more for most of the retailers (70%) to finish selling their fruits. Results also show that inefficient fruit protection from sunlight and inappropriate packaging facilities has moderate and/or low influence on banana loss. However, it has been discussed in the previous sections that most of the retailers provide inefficient protection to their fruits against sun light/high temperature. Though most of the retailers are using plastic crates, wastages also occur due to over packing and careless handling. Low temperature and proper hygienic handling of the materials are reported to be the prime factors that can curb the deterioration processes in the harvested produce (Sen *et al.*, 2012). Awareness creation about handling of perishables will help to reduce the risk of rough handling and there by contribute to reduction of the losses.

3.4. Extent of losses

The total postharvest loss of banana at farmer, wholesale and retail level were found to be 26.5% (Table 7). The higher proportion of losses (56%) was observed at retail level while the wholesale and farm levels' loss were 27% and 17%, respectively. The high percentage loss at the retail could be accounted for the cumulative effect of improper handling from harvest to retail level. The perishable nature of ripe fruits also makes the problem worse at the retail level. The relatively lower magnitude of loss at farmer and wholesale level could be explained by the fact that farmers and wholesalers are mostly dealing with green fruits. Though the damage is prevalent later at ripening, green fruits are more tolerant to handling problems. Similar to this, lower losses were reported by Wanjari and Ladaniya (2004) for unripe bananas compared to the ripe ones.

3.5. Determinants of postharvest banana loss in the marketing chain

A multiple linear regression model was used to determine the major factors affecting banana postharvest loss at farm, wholesale and retail levels. The value of the F-statistic was found to be significant at 1% probability level for all the three levels implying that all explanatory variables had a joint impact on the dependent variable.

3.5.1. Determinants of postharvest banana loss at farm level

The model results showed that sex, farming experience, criteria to harvest and membership to cooperative were statistically significant and negatively affect banana loss at farm level (Table 8). The results are in-line with our hypotheses. The result indicated that male farmers tend to experience less banana loss than females. This might be related with the labor intensity of the activities involved in fruit management and handling. The result also showed that those farmers with more experience tend to have lower levels of postharvest losses. With more years, farmers seem to be good in managing their farm and handling harvests, hence the less the postharvest loss. Similarly, the probability of experiencing loss is low for farmers who harvest their fruits based on maturity. This is in line with the expectations that harvesting at the right maturity stage helps to attain fruits quality and hence reducing the chance for spoilage. Harvesting the fruit at the right maturity physiologically influences its postharvest performance (Turner, 2001). The result also revealed that farmers who are members to cooperatives have lower probability of experiencing postharvest loss as they have link with traders who buy their fruits after harvest. Similar results were reported by Adewumi *et al.* (2009) for banana and Aidoo *et al.* (2014) for tomato who stated that farmers who are members to cooperatives have less probability of experiencing postharvest loss.

3.5.2. Determinants of banana loss at wholesale level

At wholesale level, four variables were found to have significant effect on banana postharvest loss as indicated in Table 9. Education level, market experience and quantity handled were found to be negatively and significantly affect postharvest loss at the wholesale market while destocking date was positively and significantly affect banana loss.

The result showed that the higher the level of education and the more the wholesalers are experienced,

the lesser will be the probability of the loss incurred. This is mainly due to the fact that educated traders are assumed to adopt better postharvest practices. This is also supported by their marketing experience. With more years, the wholesalers seem to be good in handling their fruits thereby reducing the proportion of the loss to be incurred. Similar results were reported by Adewumi *et al.* (2009) who argue that marketing experience showed a negative and significant effect on banana postharvest loss.

Quantity of banana handled also showed a negative relationship with the proportion of the loss incurred implying that the more the wholesalers bought, the less will be the proportion of the banana loss. This is in line with the fact that bulk purchase is at a lower cost and the wholesalers can afford to sell at relatively lower prices at reduced time period thereby minimizing the probability of fruit spoilage. Mbuk *et al.* (2011) reported similar relationship between the quantity handled and the probability of tomato spoilage.

Destocking date at whole sale market was significant and positively affecting the loss experienced implying that the more the number of days to finish selling, the more will be the probability of experiencing the loss. Similar results were also presented by Mbuk *et al.* (2011) who stated that the number of days to finish selling showed a positive impact on the proportion of the spoilage of tomatoes. Produce deterioration rate increases as the time it stays in the market increases (Kader, 2005).

3.5.3. Determinants of banana loss at retail level

The regression result revealed that sex, education and quantity handled were significantly and negatively affecting the proportion of banana loss while the destocking date was significant but positively affecting the loss at retail level (Table 10). The negative relationship of the sex of retailers implies that the probability of banana loss experienced is lower for female retailers than males. This could be explained by the reason that females are better at handling activities in the value chain than males. Better handling of fruits at the market enables to maintain fruit quality and hence reduce the loss (Kader, 2005).

4. Summary and Conclusion

The study has estimated postharvest losses of banana in the supply chain with the total loss found to be 26.5%, more percent of the total loss being at the retail market (56%) followed by at wholesale (27%) and farm level (17%). Mechanical damage followed by improper maturity and sun browning were identified as the main causes of banana loss at farm level while mechanical damage followed by failure to pulp softening and improper maturity were identified as the main causes to the loss at wholesale level. Fruit rotting followed by softening and mechanical damage were the major causes identified for banana loss at retail level.

Mechanical injuries were therefore identified as the common causes resulting in increased postharvest losses of the fruits at all the stages of the supply chain. Despite the fact that poor postharvest handling during harvesting, transportation and marketing could have contributed more to the injuries noted, the respondents perception for these factors to influence the loss was lower. The level of information of the respondents may have some role in the lack of understanding the relationship between management and handling practices with fruit quality and loss. The result revealed that among others, sex, farm experience, criteria to harvest and cooperative membership explained the postharvest loss at farm level. Similarly, education level, marketing experience, quantity of fruit handled and destocking dates explained the loss at wholesale level while sex of retailers, education level, quantity handled and destocking dates significantly influenced banana loss at retail level.

It can be concluded from the study that significant amount of postharvest banana loss occurs with the causes varying along the supply chain. Based on the results and observations made during the survey, it seems that the current postharvest management system of banana both at farm and marketing levels is inadequate. The postharvest management of banana has not been given sufficient attention in the area hence, fruit handlers lack information about postharvest handling practices. It was also observed that there is a knowledge gap between the respondents in their experience of proper fruit handling techniques. Therefore, in order to reduce the levels of postharvest losses in the area, focus should be given to management practices. The loss can be minimized by awareness creation, education and training about the importance of postharvest losses, adopting better management operations, careful handling and packaging to the supply chain actors. Furthermore, testing and implementing improved postharvest handling techniques to reduce fruit spoilage could contribute much to the loss reduction effort.

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Table 1. Socio-economic characteristics of the respondents

Characteristics		Farmers	Wholesalers	Retailers
Sex (%)	Male	88.7	100	55.3
	Female	11.3	0.0	44.7
Marital status (%)	Married	98.1	73.8	59.6
	Single	0.0	23.8	38.3
	Widowed	1.9	2.4	2.1
Cooperative membership	Yes	60.4		
	No	39.6		
Contact with extension agent	Yes	77.4		
	No	22.6		
Age (years)		46.3 (12.3)	38.1 (10.1)	32.7 (8.3)
Educational level (years)		4.9	9.1	9.2
Farming/marketing experience (years)		11.0	6.4	4.9
Average number of active labor force		5.4		
Average farm land size (ha)		2.8		

Source: Field survey, 2012. Values in parenthesis are standard deviations.

Table 2. Post harvest management practices at farm level

Management practice		Percentage
Criteria to harvest	Market price	24.5
	Maturity	75.5
Harvest time	Morning	54.7
	Afternoon	7.5
	Anytime	37.7
Transport means to collection site	Animal driven cart	22.6
	Men's shoulder	67.9
	Women's back	9.4
Use of packaging during transport	Yes	45
	No	54
Temporary storage at the collection site	Heaping in open space and covering with banana leaf	83.0
	Heaping under shade and covering with banana leaf	17.0
Time gap between harvest and loading	Less than 2hrs	13.2
	Half day	54.7
	One day	18.9
	More than one day	13.2

Source: Field survey, 2012

Table 3. Banana handling practices at wholesale market

Handling practices	Percentage
Ripening and storage room sanitation	
Wiping	88.1
Wiping and washing with tap water	11.9
Storage of bananas after ripening	
Heaping on the floor and covering with newspaper	40.5
Heaping on the shelf and covering with news paper	59.5
Days to finish selling	
1-2	47.6
3-5	28.6
6-7	23.8

Source: field survey, 2012

Table 4. Banana handling practices at retail market

Management practices		Percentage
Packaging material to transport bananas	Plastic crate	31.9
	Wooden crate	21.3
	Bamboo basket	19.1
	Plastic + wooden crate	10.6
	Sack (madaberia)	10.6
	No packaging	4.3
Overnight storage	With plastic crate	48.9
	With wooden crate	34.0
	Bamboo basket	4.3
	Heaping on shelf and covering with news paper	8.5
	Hanging	4.3
Ways of display	Under tent	83.0
	In the house	17.0
Days to finish fruit selling	1-4	29.7
	5-6	40.4
	7-8	29.7

Source: Field survey, 2012

Table 5. Contribution of secondary factors to postharvest loss at wholesale level

Factor	Very high (5)	High (4)	Medium (3)	Low (2)	Very low (1)	Mean value	Rank
Long distance transport	20	13	6			4.05	1
Poor packaging during transport	6	14	13	5	1	3.24	2
Uncontrolled ripening environment	9	5	16	7	1	3.05	3
Untimely harvesting	6	6	1	14	7	2.19	4
Rough handling at off loading and ripening	1	5	7	13	14	2.05	5

Source: Field survey, 2012

Table 6. Contribution of secondary factors to banana postharvest loss at retail level

Factor	Very high (4)	High (3)	Moderate (2)	Low (1)	Mean value	Rank
Rough handling at wholesale market	27	15	5	-	3.47	1
Inability to finish selling with shorter time	14	24	5	4	3.02	2
Inefficient protection from sunlight	5	5	30	7	2.17	3
Improper packaging for transport and storage	1	3	7	34	1.30	4

Source: Field survey, 2012

Table 7. Postharvest loss of banana at farm, wholesale and retail level

Supply chain	Loss (%)	Share in total (%)
Farm level	4.5	17.0
Wholesale level	7.1	26.8
Retail level	14.9	56.2
Total	26.5	100.0

Source: field survey, 2012. Losses were estimated as the difference between quantity harvested/purchased and quantity sold in relation to total quantity harvested/ purchased.

Table 8. Regression results on the determinants of banana loss at farm level

Variable	Coefficients	Standard Error	P-value
Intercept	14.561***	2.002	0.000
Sex (male/female)	-2.341*	1.324	0.084
Active labor force (number)	-0.005	0.120	0.970
Farm experience (years)	-0.141**	0.064	0.032
Total farm land (hectare)	0.252	0.161	0.125
Criteria to harvest (1 = maturity; 0 = other)	-5.082***	1.345	0.000
Packaging (yes/ no)	-0.293	0.829	0.725
Cooperative membership (yes/no)	-3.688***	1.054	0.001
Extension contact (yes/no)	-0.841	0.967	0.389

Adjusted $R^2 = 0.66$; *, **, *** = significant at 5%, 1% and 0.1%

Table 9. Regression results on the determinants of banana loss at wholesale level

Variable	Coefficients	Standard Error	P-value
Intercept	13.418***	1.505	0.000
Education (grade completed)	-0.294***	0.084	0.001
Marketing experience (years)	-0.464***	0.083	0.000
Quantity handled (Qt)	-0.051**	0.019	0.011
Days to ripe	0.227	0.399	0.573
Destocking dates	0.516***	0.156	0.002

Adjusted $R^2 = 0.80$; **, *** = significant at 1% and 0.1%

Table 10. Regression results on the determinants of banana loss at retail level

Variable	Coefficients	Standard Error	P-value
Intercept	18.437***	3.655	0.000
Sex (female/ male)	-3.935***	1.180	0.002
Education (grade completed)	-0.499**	0.177	0.007
Marketing experience	-0.079	0.216	0.717
Quantity handled (Qt)	-0.011*	0.006	0.081
Display area (1 = in the house; 0 = under tent)	-2.672	1.843	0.155
Destocking dates	1.328**	0.446	0.005

Adjusted $R^2 = 0.70$; *, **, *** = significant at 5%, 1% and 0.1%

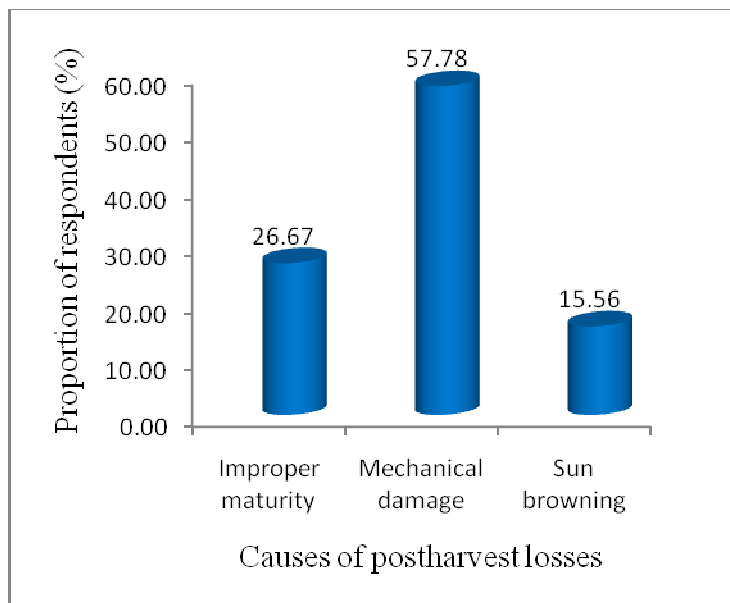


Figure 1. Primary causes of banana postharvest loss at farm level. Fruits considered as mechanically damaged are those culled due to sever bruising, cutting and breaking damages; improper maturity mainly refers to fruits harvested immature.

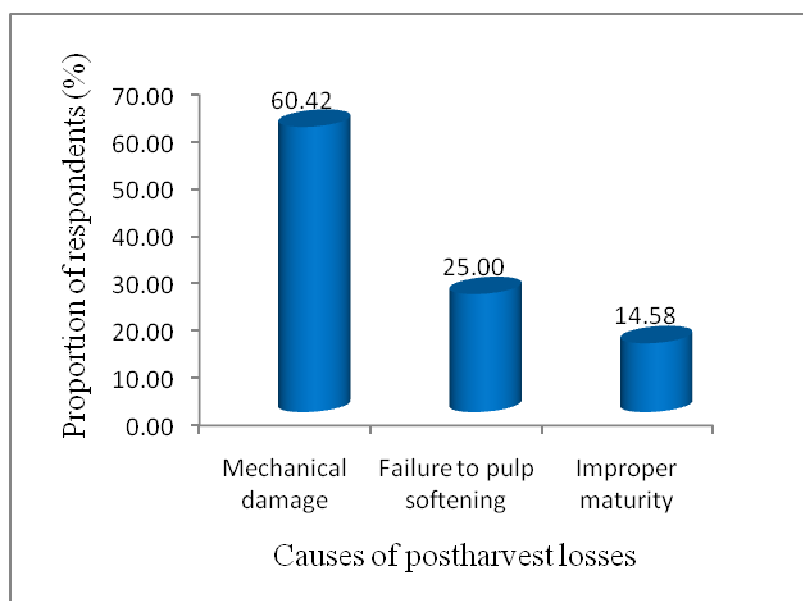


Figure 2. Primary causes of postharvest loss at wholesalers level. Failure to pulp softening refers to fruits in which the center of the pulp remains firm while the remaining pulp softens.

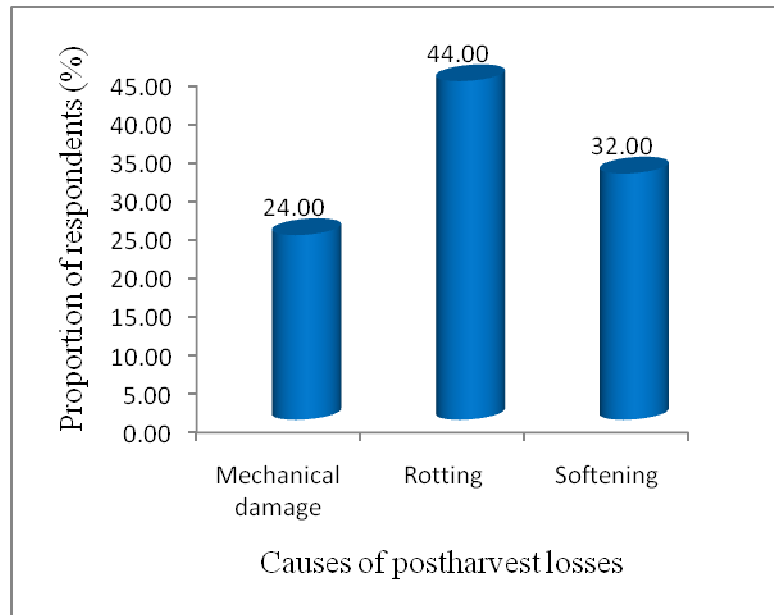


Figure 3. Primary causes of banana postharvest loss at retail level

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