

Assessment of Banana Postharvest Handling Practices and Losses in Ethiopia

Zenebe Woldu¹ Ali Mohammed¹ Derbew Belew¹ Zekarias Shumeta¹ Adam Bekele²
1.Jimma University College of Agriculture & Veterinary Medicine, P.O.Box 307, Jimma, Ethiopia
2.Melkasa Agricultural Research Center, P.O.Box 436, Adama, Ethiopia

Abstract

The study was conducted to assess the status of post-harvest handling practices and loss of banana in Ethiopia. The farm level post harvest handling and loss data were collected from 3 major banana producing zones, 5 districts, 10 farmer villages and 14 large-scale commercial farms. The market level post-harvest handling and loss data also encompassed 19 major towns or market outlets scattered throughout Ethiopia. As such a total of 150 small-scale and 14 large-scale growers, 59 wholesalers/ripeners, 53 retailers and 53 consumers were interviewed using structured questionnaires. Secondary data was also collected from written documents and focus group discussions (stakeholders) across the survey areas. Results of the study indicated that the aggregate post-harvest loss of banana was estimated to be 45.78%, of which about 15.68% was incurred at farm, 22.05% at wholesale (including transport from farm gate and ripening), and 8.05% at retailer or purchase to end-user sale levels. Of the causes of postharvest loss accounted during banana transport from the farm gate, impact and finger breakage damages purely accounted to 20% while the remaining 80% also included physiological and other mechanical damages like compression, abrasion, bruising and puncturing. Being a delicate and highly perishable crop, results of the multiple regression analysis indicate that market distance, duration of transport, storage condition, storage duration, duration of ripening, type of ripening rooms, means of bunch transport, experience in banana marketing, etc. were found to be important determinants of the post-harvest loss of banana in Ethiopia. The study generally indicate that even though the country has vast potential for banana production, the supply chain is facing several limitations and constraints that include high yield variability, crop management practices, and high produce perish ability and post-harvest losses throughout the handling stages. These points out the need for increased research and extension services as well as improvement in postharvest handling (transportation, storage, packaging and ripening) and marketing infrastructure and facilities.

Keywords: Banana, supply-chain, post harvest handling, postharvest loss, determinants

1. Introduction

Dessert banana and plantain (*Musa sp.*) are the fourth most important staple food crops in the world after rice, wheat and maize (Salvador et al., 2007). They are also important sources of income for many smallholder Sub-Saharan Africa farmers (FAOSTAT, 2012). In Ethiopia, dessert banana is the major fruit crop that is most widely grown and consumed in Ethiopia. It grows in several parts where the growing conditions are conducive. It contributes around 47.83% for producers' own consumption, 49.19% for income generation, 0.47 for animal feed and 2.52% for other purposes (CSA, 2014). Banana covers about 59.64% (53,956.16 hectares) of the total fruit area, about 68.00% (478,251.04 tones) of the total fruits produced, and about 38.30% (2,574,035) of the total fruit producing farmers in Ethiopia (CSA, 2014). On the other hand, about 68.72% (37,076.85 hectares) hectares of land covered by banana, about 77.53% (370,784.17 tones) of the banana produced and 22.38% (1,504,207) of the banana producers in Ethiopia are found in the Southern Nations Nationalities and Peoples' National Regional State- SNNPRS (CSA, 2014). Gamo-Gofa, Bench-Maji and Sheka zones are among the major banana producing zones of the SNNPRS, of which Gamo-Gofa zone alone covers over 70% of the total banana marketed across the major market outlets in Ethiopia (CFC, 2004 and own survey, 2014/15).

Despite the above stated facts and the concerted effort being made by the government of Ethiopia to promote and diversify its agricultural outputs as well as exports at large, the attention given to banana especially in terms of research, extension services, investment endeavors and overall value-chain management has been very limited. As stated by CSA (2009), banana in Ethiopia is so far grown on less than 1% of the Ethiopia's gross cropped area contributing less than 0.8% of the gross value of agricultural outputs and quite negligible in export earnings. In most parts of the country, its production has yet been limited to backyard and small-scale productions with the produce largely supplied to local markets. Although there have been some renewed endeavors for large scale banana production, their impact is so far insignificant and operationally not much beyond the role played by small-scale farmers. Large scale banana production in Ethiopia covers only 0.19 % (1,910.97 hectares) of the total area covered by banana and 0.22% (17, 924.59 tones) of the total banana produced in Ethiopia (CSA, 2014). All the same, about 93.38 % (1,784.39 hectares) of the total area covered and about 92.73% (16, 620.76 tones) of the total banana produced by large-scale production in Ethiopia is found in the Southern Nations Nationalities and Peoples' National Regional State- SNNPRS (CSA, 2014).

The role of small-scale farmers is by and large limited to production and farm gate selling. After

harvest, they sell their banana to either local licensed farm-gate collectors, farmer cooperatives/unions when any, directly to distant market traders who purchase the banana at farm-gates, or to a limited extent to local market retailers and roadside vendors. When bananas are sold to local licensed farm-gate collectors and farmer cooperatives/unions, they are forwarded or transported piled in loose bunches without any package to major urban centers by open or non-refrigerated ISUZU or FSR trucks. They are then sold directly or on contractual agreement basis to wholesalers across the major regional and central towns of the country who at the same time do the ripening operation through the traditional kerosene smoking system. The wholesalers then distribute it to close or distant retailers (supermarkets, green grocers, street or roadside vendors, traditional open market retailers, etc.) in their respective localities. Retailers often purchase green ripe bananas from wholesalers and keep them till they develop the ultimate yellow color before they sell them to the final consumers.

The actors involved in the banana supply chain in Ethiopia invariably face some kind of post-harvest loss challenges as the produce moves from one chain to the other. The post harvest losses are related to a combination of factors including the inherent bulkiness and perishability of the produce, and rudimentary mode of transportation (vehicles and roads), handling (loading, unloading, packaging, storage, etc.), and ripening facilities and systems. Similarly, EHDA (2012) and CFC (2004) reported that the problem of banana export in Ethiopia is not merely due to low production and lack of markets, as it is located next door at least to the major consumer countries of the Middle-East, but due to a combination of factors that include improper mode of transportation (lack of logistics management for cool-chain management such as refrigerated trucks and refer containers, inadequate road infrastructure and rough produce handling, lack post harvest treatments, etc.), absence of packinghouses close to major production areas, and improper harvest maturity determination and harvesting techniques

Similar studies on post harvest loss of banana in Ethiopia were carried out earlier on certain localities and losses ranging from 26.5% (Mulualem et al., 2015) to 30-40% (Dawit Alemu et al., 2008) were reported at various levels of handling. Correspondingly, the present study was initiated with a major thesis to investigate the existing banana post harvest handling practices and associated losses in a wider scale at country level whereby gaps could be identified for concomitant holistic interventions into the future.

2. Research Methodology

2.1. Description of the Survey Areas

The banana production sites and market outlets covered through the survey are shown through Figure 1 below.

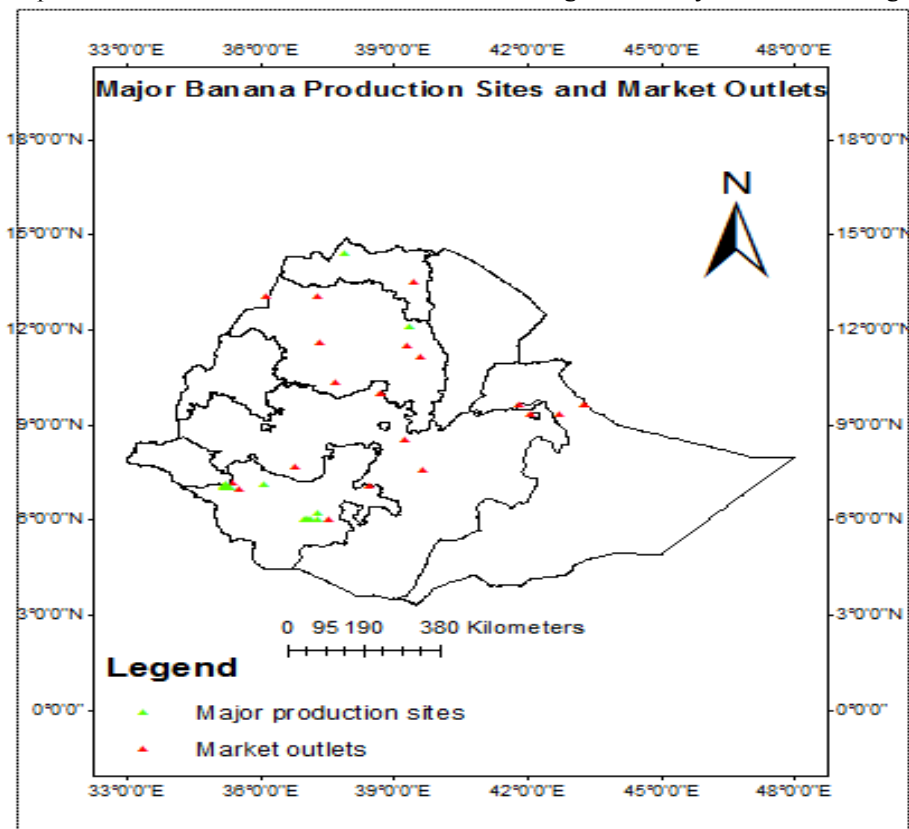


Figure 1. Major banana production areas and market outlets covered by the survey, 2014/15

2.2. Description of the banana production areas covered by the survey

The survey on post harvest handling and loss at smallholder banana producers level was solely conducted in the Southern Nations Nationalities and Peoples' Regional State (SNNPR) of Ethiopia covering 3 zones (Gamo-Gofa, Bench-Maji and Sheka), 5 woredas (districts) and 10 kebeles (farmer villages). It is an important regional where the bulk (77.53%) of the banana produced in Ethiopia is found (CSA, 2014). Almost all the banana commercially sold in all the major towns of Ethiopia, including Addis Ababa, is produced in this region, with Gamo-Gofa comprising over 65% of the market share, Bench-Maji 10% and Sheka 5% (CFC, 2004). Only the balance comes from other pocket areas of the country that are less known for banana production (CFC, 2004). Banana in those areas is a major component of livelihood strategies, which constitutes an important food security and household source of income for many farmers (CFC, 2004). Thus, in those zones, a total of five districts, 10 major banana producer villages, and 150 farm households were considered for the survey work at producers' level (Annex Table 1). All the same, as shown under Annex Tables 1, the study on the large-scale commercial production of banana was also carried out on a wider part of the country covering 14 farms from 3 national regional states (SNNPR, Tigray and Amhara).

2.3. Description of the banana market outlets covered and supply chain actors consulted across the survey areas

As shown in Annex Table 2, the market level study on banana post-harvest handling and loss was carried out across 19 major regional and central towns or market outlets in Ethiopia. They are normally the centers where the traders (wholesalers, retailers and exporters), market regulatory institutions as well as the bulk of the ultimate consumers are found. In this respect, the study was started at farm gate level and proceeds all the way to the end of the banana supply chain in Ethiopia. The study adopted a number of alternative approaches for generating both quantitative and qualitative data. It included extensive interviews and discussions with the direct marketing actors as well as private and public enterprises such as research, extension, marketing and regulatory institutions. A systematic random sampling was employed and accordingly a total of 12 licensed farm gate collectors, 6 farmer cooperatives/union, 59 wholesalers/ripeners, 53 retailers, 53 final consumers and 4 market regulatory institutions (i.e. Customs & Revenue Branch Offices) were considered for the study (Annex Tables 2).

2.4. Method, Source and Type of Data Collected

The findings in this study took into account and describe the existing situation of banana postharvest management in Ethiopia. Both quantitative and qualitative data collection methods were employed using a cross sectional type of research approach in the primary and secondary information collection process. The primary data was collected through interviews by using a semi-structured questionnaire with key informants from the supply chain actors, all the way from the producers up until the final consumers. The structure of the questionnaire was designed as both open and close ended questions. The close ended questions were designed as list or select any appropriate/correct answer and they were coded. The open ended questions were designed in such a way to allowing the respondents to freely express their ideas. In addition to the questionnaires, focus group discussions were carried out with all banana supply chain actors (producers, traders, farmer cooperatives/unions, researchers, extension workers and regulatory bodies). The secondary data was acquired from published and unpublished reports of different levels of actors such as line national, zonal, district and village level agricultural extension, research, marketing, cooperative, customs and revenue, statistics, and NGO offices as well as internet (website) search based information.

2.5. Sampling Technique

A multi-stage purposive and random sampling technique was employed to collect all the necessary primary data. Initially, five major banana producer districts were purposively selected jointly with the respective zonal agricultural offices on the basis of volume of banana production. Then, 10 major banana producer farmer villages (2 villages/district) were similarly selected purposively jointly with the respective district agricultural offices. Finally 15 households were randomly selected from each village from the total list of households provided by each of the village level agriculture offices.

Developments Agents (DAs) of the respective study villages were largely used as enumerators to work alongside the researcher. They were given about half a day briefing by the researcher on the contents of the structured questionnaire and way of handling of the interview. The other banana supply chain actors (farm-gate collectors, wholesalers, ripeners, retailers, consumers and other stakeholders) were interviewed using other separate structured questionnaires to generate primary data. As such a total of 150 small-scale farmer household, 14 large-scale (commercial) growers, 59 wholesalers/ripeners, 53 retailers and 53 consumers were interviewed in the primary data collection process using the respective structured questionnaires.

2.6. Method of Data Analysis

The SPSS (Statistical Package for Social Science) software was used for data entry and analysis. A descriptive statistics was used that include parameters such as sum, mean, percentage, etc. In addition, mean comparison techniques such as ANNOVA and independent sample-t test were employed to compare the differences in banana post-harvest losses among the supply chain actors or handling practices. In order to identify the determinants of the banana post-harvest losses, multiple linear regressions were used using the amount of post-harvest losses through various factors as dependent variables and other explanatory variables such as the type of postharvest handling and marketing systems as independent variables.

3. Results and Discussion

3.1. Evaluation of the performance of the banana supply chain and postharvest loss analysis

3.1.1. Harvesting and postharvest handling practices of banana across the major segments of the supply chain in Ethiopia

The banana supply chain in Ethiopia comprises the following major segments.

Producers

These are both small-scale farmers and large-scale commercial growers involved in banana production. After harvest, small-scale farmers get the banana to the farm-gate and sell it either to local licensed farm-gate collectors, farmer cooperatives/unions when any, directly to distant market traders who purchase the banana at farm-gates, or to a limited extent to local market retailers and roadside vendors. Large-scale commercial growers mostly sell their banana directly to regional and central market-based wholesalers and seldom to farm gate collectors. Producers determine the harvest maturity stage of banana variously on the basis of finger angularity, fullness of fingers, color of fingers, or age of the male bud (flower). While the problem is mostly inclined towards harvesting immature fruits, there are also cases where bunches remained longer after maturity due to labor shortages and lower purchases by traders often due seasonal barriers to get trucks the farm gate collections centers. In both cases, such fruits will cause serious difficulties for even ripening and subsequently high level of post harvest losses be borne by wholesalers/ripeners. Producers invariably use bushman knives (locally called “gejera”) to harvest banana bunches and except for Dwarf Cavendish, they girdle first the pseudo-stems (Annex Figure 1) and then cut the bunches as they touch the ground. Subsequently, they carry them lose on the shoulders to intermediate collection points near the farm where they pile or put them side by side for a few hours to about one day long. Then, depending of the distance and available labor, they transport them to the central farm gate collection centers either similarly by human carriage or using donkey driven carts (Annex Figures 2 & 3) where they pile them without cushioning under natural shade trees or in the open sun covered with banana leaves (Annex Firure 4). Various physical and mechanical damages like impact, direct fruit breakage and spillage, bruising, abrasion, puncturing and compression damages are incurred in the process that cause huge post harvest losses farm, farm gate as well as subsequent handling stages along the supply chain.

Farm-gate collectors

These are sometimes referred to as farm gate level “assemblers” or “forwarders”. They are often village based licensed middlemen or intermediaries who purchase the newly harvested banana at farm gate from the direct producers and forward it to wholesalers that are found in the major regional and central markets. As stated above, farmers get the harvested banana bunches to nearby farm gate collection centers where they often pile them under natural tree shades or in the open covered with banana leaves. The farm gate collectors then hire trucks and purchase and forward the bananas to the regional or central market wholesalers often on contractual agreement basis. In this case, the wholesalers send them the money through their bank accounts. At times, the wholesalers send their own hired trucks to the farm gate and purchase the bananas either directly from the producers or through the brokers. In both cases, the farm gate collectors operate as brokers in between the producers and wholesalers and gain their profit margins for their facilitation services from the wholesalers. Bananas are transported on piled lose bunches either by open ISUZU (5 to 5.5 tons load capacity) or FSR (8 to 9 tons load capacity) trucks (Annex Figure 5). In addition to the rough loading and unloading practices, such transportation system makes the banana bunches along the way heavily liable for impact, vibration, compression, abrasion, bruising and direct breakage damages. Such officially licensed middlemen are found only in the banana producing villages of the Gamo-Gofa zone and there were 104 of them at the time of the survey work; of which 76 were in Arba-Mich Zuria district and 28in Mirab-Abaya district (Arba-Munch Zuria and Mirab-Abaya District Agricultural Product Marketing Offices, 2014).

Farmer cooperatives/unions

These are a group of village level farmers formally organized into farmer cooperatives or unions in order to market their banana and access or purchase inputs. The majority of farmers in the banana growing villages in Gamo-Gofa zone are organized into village level farmer cooperatives, with the cooperatives further organized as members of the Gamo-Gofa Farmers Vegetable and Fruit Marketing Cooperative Union PLC. This union is so far the only cooperatives’ union engaged in banana business in Ethiopia. It is a strong union that, on behalf of its

member cooperatives, at times enters directly into agreement with input suppliers, service providers, donors and export outlets such as Saudi Arabia. It has so far 28 member cooperatives that are engaged in the production of different vegetable and fruit crops in addition to banana (Annex Table 3). Such collective action of farmers in the Gamo-Gofa zone has empowered and enabled them overcome various barriers, own their own storage and transportation facilities, build up their production skills, get access to extension and information services, and at large become part of the market economy compared to those in Bench-Maji and Sheka zones. The union collects the bananas from its member farmer cooperatives at central farm gate collection centers by weighing and registering the amount received from each farmer. In so doing, it sorts the bunches for their maturity and various defects and removes the extra basal and apical portion of the bunch stem. It then loads them onto its own or hired trucks similarly on piled loose bunches cushioned only from the bottom end and sides with banana leaves (Annex Figure 5). In this case too, although better attention is given to the handling of the banana fruits, some levels of post harvest losses related impact, bruising, abrasion, and compression damages owing to similar modes of loading, unloading, and transportation.

Wholesalers

These are banana traders that operate mostly at major regional and central market outlets. They buy the bananas in bulk either directly from producers or through the licensed farm gate collectors and ripen and sell them to individual and institutional retailing business operators (green grocers, supermarkets, street and open market vendor, etc.). After the bananas are unloaded upon arrival, they are sorted, weighed and treated for ripening initiation for 2 to 3 days, depending on the locality or prevailing temperature (Annex Figures 6). The ripening process is done through the traditional kerosene smoking system inside airtight and non-ventilated chambers commonly called “chela” or “muket” houses (Annex Figures 7 & 8). Ripening is most commonly done on piled bunches of 5 to 10 layers (only ETFRUIT and a few whole sellers perform the ripening process in hands). After ripening, bunches are dehanding and sold to various retailers in their respective localities either in green-ripen or yellow-ripen forms. Here again, as a result of the rough unloading, weighing, ripening, and dehanding practices, bananas are heavily liable for impact, compression, bruising, abrasion, puncturing, direct breakage and over-heating damages. Nearly all wholesalers/ripeners also explained both immature and over matured fruits as regularly being part of the post harvest loss they incur. While the immature fruits either completely fail to ripe or ripe unevenly, the over mature ones often tend to be caked due to over ripening and cracked during the prescribed ripening treatment period. Some wholesalers located close to the export outlets (Dire-Dawa, Harar and Jijjiga; sometimes ETFRUIT as well) are engaged in green banana exports to neighboring Djibouti and Somaliland.

Retailers

These are traders that purchase either green-ripe or yellow-ripe bananas after dehanding from wholesalers/ripeners and sell them to consumers (Annex Figure 9). When they buy the green-ripe bananas, they often cover them with newspapers for another 2-4 days (depending on the prevailing temperature) and keep them until they develop the ultimate yellow color before they sell them to the ultimate consumers (Annex Figure 10). Here again, some losses due to physical, mechanical and physiological damages are variously incurred when they transport and handle them in open trucks, wooden boxes, and woven baskets as well as display them in the open sun and dusty places.

Consumers

Consumers are categorized into individuals, households, and public and private institutional types. Households form the bulk of the consumers in the market. Institutional consumers include, juice houses, cafeterias, hotels, restaurants, hospitals, universities, etc.

Export buyers

These are foreign traders often in the neighboring countries of Djibouti and Somaliland, and at times Saudi Arabia, which purchase fresh bananas from Ethiopia and do the subsequent business within the market channels in their respective countries.

3.1.2. Descriptive and econometric results of factors of banana post-harvest losses and its determinants

Assessment of post-harvest losses of banana at the various chains before it reaches to the final consumers were assessed and results identified for the major determinants of post-harvest losses are also presented on Table 1 below. Results were estimated as percentage of total production or amount handled at different stages of the supply chain.

Table 1. Estimated postharvest loss of banana at different stages of the supply chain

Levels /stages of product handling	Mean (%) (std.dev)
Farm level losses	
<i>Harvesting</i>	6.53 (1.32)
<i>Transport and storage</i>	9.15 (1.22)
Total loss at the farm level	15.68
Ripeners (wholesale) level losses	
<i>transport</i>	8.68 (2.32)
<i>unloading</i>	3.73 (2.53)
Ripening	2.86 (1.37)
<i>Selling</i>	6.78 (2.42)
Total loss at the wholesale level	22.05
Retailers' level loss	
From purchase to sale (total)	8.05 (3.93)
Total loss at retail level	8.05

Source: Calculated from own survey result, 2014/15

3.4.1. Farm level losses

The result on Table 7 revealed that the average total farm level loss of banana was 15.6 percent of the total production. From this total loss, the loss incurred due to improper transport and storage is much larger. Important post-harvest factors that contributed to transport and storage losses at the farm level include impact, compression, breakage, and bruising damages. Farm level loss during harvesting was estimated to be 6.53 percent of the total production. Losses at harvest were mainly due to bunch and finger breakage, and impact and bruising damages.

3.4.2. Wholesale level losses

The average total post-harvest losses at the wholesale level were estimated to be 22.05 percent of the total produce handled/purchased for sale. This amount is the largest of all post-harvest losses at the different stages of handling and is mainly attributed to the losses incurred while transporting the produce all the way through from the place of farm gate purchase. The possible transportation problems that contribute for the loss include impact, compression, vibration, bruising, and breakage damages. Losses at the wholesale level also occur during unloading, ripening and selling, which also include various physical, mechanical and physiological damages. Of the causes of postharvest losses accounted during banana transport from the farm gate to regional and central markets, 20 percent of wholesalers purely reported impact and fruit breakage as cause of post-harvest loss while the rest (80%) responded the cause to include physiological and other mechanical damages like compression, abrasion, bruising and puncturing as well (Figure 2)

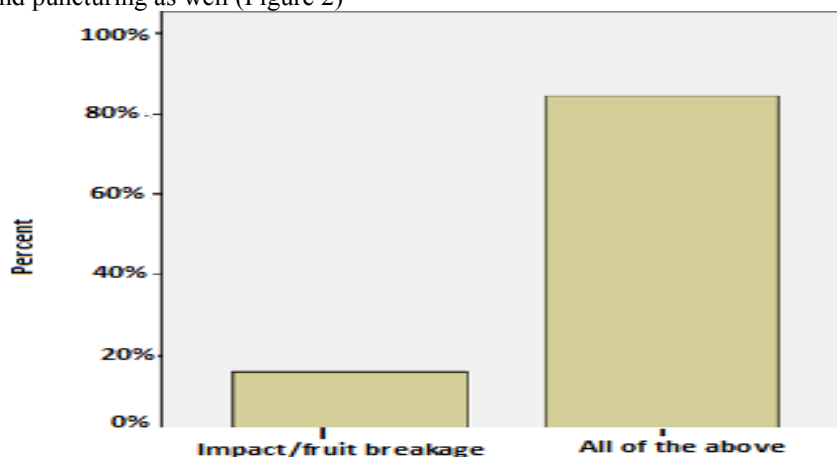


Figure 2. Major causes of post harvest loss during banana transport from farm-gate collection centers to regional and central wholesale markets

3.4.3. Retail level losses

The average total post-harvest loss at retailing level (wholesale purchase to consumer sale) was estimated to be 8.05 percent. This amount is small as compared with the other handling stages stated above primarily due to the relatively rapid turnover of the produce in between the retailers and final consumers. The main causes of post-harvest losses at the retail level include inappropriate display conditions (temperature, dust, etc.) and handling facilities (final ripening and handling boxes, shelves, etc.)

3.4.4. Determinants of post-harvest loss of banana at the farm level

Based on literatures and available data, attempts were made to identify the determinants of post-harvest loss of banana at the farm level using a multiple linear regression model. The results of the analysis are presented on Table 2.

Table 2. Multiple linear regression results on the effect of factors affecting farm-level post-harvest loss of banana

Variables	Coefficients (Std. error)	T-values (P-values)
Age	0.011 (0.028)	0.404 (0.687)
HH size within productive age group (15<age<65)	-0.092 (0.101)	0.918 (0.360)
HH experience in banana production (years)	-0.064 (0.030)	-2.12** (0.036)
Area of banana land (ha)	-1.127 (0.313)	-3.60*** (0.000)
Market distance (Km)	0.683 (0.114)	6.01*** (0.000)
No. of days of storage	0.364 (0.174)	2.09** (0.038)
Means of bunch transport1 (1=human labor)	0.689 (0.609)	1.131 (0.260)
Means of bunch transport 2 (1= Pack animal)	0.463 (0.455)	1.02 (0.311)
Means of bunch transport 3 (1=carts)	0.544 (0.602)	0.903 (0.368)
Storage 1 (1= Under natural open shade)	-0.529 (0.462)	-1.15 (0.254)
Storage 2 (1= In open covered with banana leaves)	-0.19 (0.467)	-0.407 (0.684)
Storage 3 (1= under ventilated shade house)	-0.557 (0.534)	-1.042 (0.299)
Storage 4 (1= On the open sun without cover)	0.062 (0.728)	0.085 (0.933)
No. of observation	150	
R-square	0.585	
Adjusted R-square	0.546	
F-value	14.76***	

Source: Calculated from own survey result, 2014/15, ** and *** denote significance at 0.05 and 0.01 level

Where: HH=Household; No.=Number; ha= hectare; km=kilometer

The summary of the overall model suggests that the model is good enough to explain the relation between the dependent and the independent variables. The R-square values indicate that more than 50 percent of the variation in post-harvest loss is explain by the selected independent variables. The significant F-value also reveals that the coefficients of the selected independent variables are significantly different from zero, indicating the goodness of fit of the model.

Thirteen independent variables (6 continuous and 7 dummies) were inserted in the model to assess their quantitative effect on proportion of post-harvest loss of banana out of which four were found to have a statistically significant impact. As expected, household experience in banana production was found to have a negative and significant impact on proportion of post-harvest losses. As experience increases by 1 year, the proportion of post-harvest loss of banana was found to decrease by 0.064 percent. This can be related with the fact that as experience increases, producers get more awareness and knowledge on how to manage their operation so as to reduce post-harvest losses and other operational costs. Area of land was introduced to measure the impact of scale of operation on post-harvest losses. The result depicted that a one unit increment in banana

land area could result in the reduction of post-harvest loss by 1.13 percent. This result may contradict with the expectation that more can be lost when there is large production. On the other hand, it indicates how farms can be more efficient in reducing losses through improved techniques as their level of operation increases. Market distance and number of days of storage were found to have a significant and expected relation with the proportion of post-harvest losses. As market distance increases by a unit, the proportion of post-harvest losses was estimated to increase by 0.68 units. Increasing the number of storage days by a unit could also result in the increment of proportion of post-harvest loss by 0.36 percent.

Despite its insignificant impact, the positive coefficients of all types of transport indicate that the existing means of transportation used by the producers in the area contribute for post-harvest loss of banana. The positive sign of the coefficient on storage type on an open sun is also an indicator for using shade in storing banana to reduce its possible post-harvest loss.

3.4.5. Determinants of post-harvest losses at the wholesale and retail level

While assessing the determinants of post-harvest losses at the wholesale and retail level, similar household and market characteristics have also been hypothesized. Out of the selected variables, ripening technique, transportation mechanism and type of banana cultivar purchased were excluded from the analysis as the responses were uniform throughout the sample. Table 3 presents the results of the regression analysis for determinants of post-harvest loss at the wholesale and retail level.

Table 3. Multiple linear regression analysis results for determinants of post-harvest loss at wholesale and retail levels

Variables	Wholesale level		Retail level	
	Coefficients (Std.error)	T-values (P-values)	Coefficients (Std.error)	T-values (P-values)
Age	-0.01 (0.098)	-0.105 (0.917)	-0.043 (0.093)	-0.463 (0.646)
Experience in banana marketing	-0.333 (0.116)	2.879*** (0.006)	-0.149 (0.071)	-2.111** (0.040)
No. of hours required to transport banana from purchase site to base town	0.132 (0.049)	2.719*** (0.009)	-	-
No. of hours of storage before ripening	0.181 (0.169)	1.068 (0.290)	-	-
Duration of ripening (hours)	0.154 (0.083)	1.846* (0.071)	3.947 (1.033)	3.822*** (0.000)
Room type 1 for ripening (1=sealed masonry warehouse)	4.945 (3.098)	1.596 (0.117)	-	-
Room type 2 for ripening (1=basement of masonry apartment)	6.47 (3.20)	2.022** (0.048)	-	-
Constant	16.25 (5.42)	2.998 (0.004)	-1.729 (5.341)	-0.324 (0.748)
No. of observations	59		53	
R-square	0.305		0.245	
Adjusted R-square	0.210		0.199	
F-value	3.199***		5.30***	

Source: Calculated from own survey result, 2014/15, *, ** and *** denote significance at 0.1, 0.05 and 0.01 levels.

Where: No.=number; Std.=standard

The result on table 9 indicates that experience in marketing have a significant impact in reducing post-harvest losses at both the wholesale and retail level as increased experience helps to acquire more awareness and knowledge on the possible techniques of reducing losses. As the number of hours to transport banana from purchase site to a base town increases by 1 unit, the proportion of post-harvest loss is estimated to increase by 0.13 percent at the wholesale level. Similarly, for a one hour increment in the duration of ripening, the proportion of post-harvest loss is expected to increase by 0.154 and 3.94 percent at the wholesale and retail level respectively. Finally, ripening of banana at the basement of masonry house was found to increase post-harvest loss by 6.47 percent at the wholesale level. This could be attributed to the possible buildup of temperature and carbon-dioxide under such conditions as a result of the absence of air circulation facilities under the traditional kerosene smoking ripening system invariably employed across the market outlets in Ethiopia.

4. Conclusion

Market distance, duration of transport, storage condition, storage duration, duration of ripening, type of ripening rooms, means of bunch transport, experience in banana marketing, etc. were found to be important determinants of the post-harvest loss of banana in Ethiopia.

Despite the availability of favorable policy and production conditions, the current situation of banana handling and marketing in Ethiopia is generally inefficient. It is affected by several factors including unregulated marketing practices and inappropriate marketing facilities (transportation, packaging, storage, and ripening) largely on account of the absence of strong marketing institutions such as the Ethiopian Commodity Exchange Authority. This coupled with the bulky and highly perishable nature of the produce has rendered the produce to be more liable for various postharvest losses across the supply chain. At times, this situation is in turn pressurizing some traditional banana producing localities and farmers switch to other less perishable crops such as cereals, coffee and spices as observed during the survey in Bench-Maji and Sheka zones.

Another worry stated by farmers was the absence of deliberate extension service and market information on banana to help them improve their banana productivity and market their produce at fair prices.

5. Recommendations

In order to improve the post harvest management system of banana in Ethiopia, minimize losses and thereby improve the income of all along the supply chain, the present study has identified and recommended the following activities as major areas of intervention into the future.

- Traditionally banana is transported and ripened on loose bunches that are excessively stacked over each other. Sometimes, additional items like charcoal, small ruminants, chickens, and human beings are also added to the top of the banana loads. As indicated in the survey results, such practices are the main causes of banana post-harvest losses incurred as result of various physical, mechanical and physiological damages. To overcome the situation, due emphasis should be given towards introducing such improved practices like commercial level preparation and washing of banana hands at farm-gate levels and transporting and ripening them in hands inside standard perforated plastic crates or boxes. Possible regulatory mechanisms may also be devised along all the banana marketing channels in Ethiopia.
- Although the traditional kerosene gas smoking banana ripening system is generally known to accelerate the banana ripening process due to the presence of both acetylene (C_2H_2) and ethylene (C_2H_4) in the smoke, it is often liable for lower consumer attraction and has long been disregarded in many countries. This is on the one hand because of the resultant burnt scars, bruises, microbial infections, poor appearances on the peel, and displacement of the natural aroma of the fruits by the gas smoke, and on the other due to the absolute difficulty to regulate the level and uniform distribution of temperature, relative humidity, and air-circulation within the ripening rooms. Thus, the introduction and promotion of modern commercial banana ripening techniques, using automated ethylene generators with calculated concentrations and exposure time, should be thought of into the future.
- Banana in Ethiopia is almost entirely marketed and consumed in the fresh fruit form. In order to minimize the level of post harvest losses, maximize the diversity of its consumption as well as extend its availability by extending its shelf-life, the development of various value-added products such banana juice, cakes, biscuits, powder, beer, soft drinks, pasta, chips, and baby foods should be given due attention.
- Distance and poor access roads to farm-gate collection centers, absence of shade houses at farm-gate collection centers, and lack of transportation facilities to nearby market centers, have negatively impact the potential of farmers to increase banana production and minimize subsequent post harvest losses. Strengthening Interventions that help curve such problems need to be given due attention as well
- Supply of improved and disease free tissue culture plantlets or suckers from regulated central nurseries, and control of farmer-to-farmer exchange of suckers in order to minimize the possible risk of pest and disease transmissions, provision of extension services to producers including post harvest handling systems, and regular training of all banana supply chain actors should be planned and implemented in good time to optimize the functioning of the banana industry in Ethiopia.

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8. Annexes

Annex Table 1. Banana grower small-scale farmer households and large-scale (commercial) farms and other stakeholders consulted across the survey areas

No.	Zone	Woreda (District)	Kebele (Village)	No. of small-scale farmer households		No. of Large-scale/commercial farms	Other stakeholders
				MH	FH		
1	Gamo-Gofa	Arba-Minch Zuria	Sile-Kanchama	11	4	8	-Zonal, woreda & kebele agric. Offices -Mirab-Abaya & Arba-Minch Zuria Woreda Revenue Authority Branch Offices -NGOs (<i>Vita, SNV & LIVES</i>) -AMARC -GFVFCU -Respective kebele farmer cooperatives
			Ocholo-Lante	12	3		
			Omo-Lante Ankober	9	6		
2	Bench-Maji	North-Bench	Fakatin	9	6	1*	-Zone, woreda & kebele admin. & agric. Offices - *BCESC
			Gorit-ena-Mag	12	3		
			Kitte Fanika	10	5		
3	Sheka	Yeki	Addis Birhan	11	4	1*	-TARC - *TGCESC
			Fide	10	5		
4	Keffa	Gimbo	-	-	-	1*	-*Gojeb Agric. Dev't Ent.
5	NWTigray	T/Adiabo	-	-	-	1*	-*Tekeze Fruit Growers Ass.
6	North-Wollo	Raya-Kobo	-	-	-	1*	-*Kobo-Girana Banana Farm
Tota	6	8	10	100	50	14	-

Where:

MH=male-headed household; FH=Female-headed household; TARC=Tepi Agric. Research Center; AMARC=Arba-Minch Agricultural Research Center; GFVFCU= *Gamo-Gofa Farmers Vegetable and Fruit Marketing Cooperative Union PLC*; NGOs=Non-government Organizations (*Vita, SNV & LIVES*); TGCESC= Tepi Green Coffee Estate Share Company; BCESC= Bebekka Coffee Estate Share Company.

Annex Table 2. Banana supply chain actors and other stakeholders consulted across the survey areas

No.	Market outlets	Banana Market-Chain Actors					Other stakeholders
		No. of farmer cooperatives/unions	No. of licensed farm gate collectors (forwarders)	No. of wholesalers/ Ripeners	No. of retailers	No. of consumers	
1	Arba-Minch	5	12	1*	3	3	Gamo-Gofa Zone Customs & Revenue Branch Office
2	Hawassa	-	-	5**	3	3	-
3	Addis Ababa	-	-	13***	6	6	-Ethiopian Customs & Revenue Authority -Central Statistics Agency
4	Adama	-	-	3	3	3	-
5	Assela	-	-	1	2	2	-
6	Harar	-	-	3	3	3	-
7	Dire-Dawa	-	-	2	3	3	Dire-Dawa Customs & Revenue Office
8	Jigjiga	-	-	3	3	3	Jigjiga Customs & Revenue Office
9	Tog-Wajaale	-	-	1	2	2	-
10	Mekelle	1	-	4****	3	3	-
11	Woldiya	-	-	6	2	2	-
12	Dessie	-	-	5	3	3	-
13	Debre-Markos	-	-	2	2	2	-
14	Bahir-Dar	-	-	3	3	3	-
15	Gondor	-	-	2	3	3	-
16	Metema Yohannes	-	-	-	2	2	Metema Woreda & Metema-Yohannes Kebele Agric. Offices
17	Jimma	-	-	5	3	3	-
18	Mizan	-	-	-	2	2	-
19	Tepi	-	-	-	2	2	-
Total	19	6	12	59	53	53	-

Source: own survey result, 2014/15

*Refers to the Gamo-Gofa Farmers Vegetable and Fruit Marketing Cooperative Union PLC (GFVFMCU)

**Includes the Ocholo Lante Kebele (Village) Famers' Cooperative in Gamo-Gofa zone

***Includes ETRUIT (public commercial enterprise)

****Includes the Shiraro-Tekeze Banana Growers Association in Tigray Regional State

Annex Table 3. List of primary farmer cooperatives that are members of the Gamo-Gofa Farmers Vegetable and Fruit Marketing Cooperative Union PLC, 2014/2015

	Name of cooperative	No. of members			Woreda	Kebele	Major commodity
		Male	Female	Total			
1	Kolla-Shelle F/V/F/P/Cooperative	92	2	94	A/Zuria	Kolla-Shelle	Banana & mango
2	Genta-Sira Sile Kanchama F/V/F/P/Cooperative	160	6	166	"	Sile Kanchama	Banana
3	Dega-Ochole Dega Firafire F/V/F/P/Cooperative	16	-	16	"	Dega-Ochole	Applefruit/seedling
4	Abaya-Mille F/V/F/P/Cooperative	48	1	49	"	Chano-Mille	Banana & mango
5	Chano-Chelba Aerze F/V/F/P/Cooperative	43	6	49	"	Chano-Chelba	Banana & mango
6	Chano-Dorga F/V/F/P/Cooperative	26	2	28	"	Chano-Dorga	Banana & mango
7	Gila-Terara F/V/F/P/Cooperative	54	2	56	"	Kolla-Shara	Banana & mango
8	Ochole Lante Tenkir F/V/F/P/Cooperative	245	50	295	"	Ochole Lante	Banana & mango
9	Zeyise Aelgo Luda F/V/F/P/Cooperative	40	-	40	"	Zeyise Aelgo	Banana
10	Kurshato F/V/F/P/Cooperative	13	7	20	"	Ochole Lante	Banana (and mango & moringa processing)
11	Dega-barana Andinet Dega Firafire F/V/F/P/Cooperative	156	3	159	M/Abaya	Dega-Barana	Apple fruit/seedling
12	Ankober F/V/F/P/Cooperative	8	26	34	"	Ankober	Banana & mango
13	Dalbo F/V/F/P/Cooperative	20	-	20	"	Dalbo	Banana & mango
14	Wajifo Raya F/V/F/P/Cooperative	26	-	26	"	Wajifo Raya	Banana & mango
15	Umo-Lante Tigil Fire F/V/F/P/Cooperative	51	-	51	"	Umo-Lante	Banana & mango
16	Molle F/V/F/P/Cooperative	15	3	18	"	Molle	Banana & mango
17	Chencha Dega-Firafire F/V/F/P/Cooperative	406	70	476	Chencha	Chencha Ketema Akababi	Apple fruit/seedling
18	Doko-Kole Derbuse F/V/F/P/Cooperative	198	62	260	"	Doko-Kole	Apple fruit/seedling
19	Doko-Shayo Garo-Atikilt F/V/F/P/Cooperative	308	70	378	"	Doko-Shayo	Apple fruit/seedling
20	Doyo-Yuyra F/V/F/P/Cooperative	227	105	332	"	Doyo-Yuyra	Apple fruit/seedling
21	Ye-Aeze Dega-Firafire F/V/F/P/Cooperative	306	35	341	"	Aeze	Apple fruit/seedling
22	Kogo Dega-Firafire F/V/F/P/Cooperative	157	53	210	"	Kogo	Apple fruit/seedling
23	Doyo-Yuyra Improved Potato Producers F/P/Cooperative	52	10	62	"	Doyo-Yuyra	Potato multipn., apple fruit/seedling
24	Mafona F/V/F/P/Cooperative	61	12	73	"	Mafona	Apple fruit/seedling
25	Chilash Area	109	7	116	Boreda	Chilash Area	Apple fruit/ seedling, Boleke
Total		2837	532	3369	-	-	-



Annex Figure 1



Annex Figure 2



Annex Figure 3



Annex Figure 1. Banana harvesting with a bushman knife (“gejera”)
 Annex Figures 2 & 3. Banana bunches being carried transported from farm to farm gate collection centers by people & donkey carts



Annex Figure 4

Annex Figure 4. Farm gate banana collection centers, i.e. roadside (upper left), under tree shade (upper right) and open sun (bottom)



Annex Figure 5

Annex Figure 5. Banana bunches being loaded at farm gate collection centers and transported to regional/central wholesale markets



Annex Figure 6

Annex Figure 6. Banana bunches being unloaded, weighed and placed into ripening treatment chambers at regional/central wholesale markets



Annex Figure 7

Annex Figure 7. Banana bunches (left) and hands (right-ETFRUIT) being treated with kerosene smoking for ripening initiation at regional/central wholesale markets



Annex Figure 8

Annex Figure 8. Banana ripening chambers at regional/central wholesale markets air-tightly sealed (for 2-3 days) after loading and kerosene smoking for ripening initiation



Annex Figure 9

Annex Figure 9. Banana retailing along roadsides (vendors), open markets (bottom right) and green grocers (bottom left)



Annex Figure 10

Annex Figure 10. Banana hands wrapped with newspapers for final consumer level yellow ripening at retailers' level

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