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Research Article

Assessment on Post-Harvest Losses of Tomato (*Lycopersicon esculentem mill.*) in Selected Districts of Sidama Zone-Ethiopia

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ABSTRACT

The study aims to identify and explore the causes and extent of tomato post-harvest losses through the value chain of three purposively selected districts of Sidama zone located in South Nation Nationalities People Region of Ethiopia along with their market destination. The study was conducted through survey and sampling of 95 producers, 78 wholesalers/retailers, 80 Consumers and weight loss analysis were conducted at the field and markets levels as a case study. In addition, 28 Key Informants and Focused Groups were discussed. The collected data were subjected to SPSS computer software programs; version 19, 2013 and Microsoft Excel 2007 database system. Accordingly, the results revealed that losses of 24%, 9%, 3%, and 6% at producer, wholesalers, retailers, and Consumers level respectively with a total loss of 42% from harvesting to consumer. Significant losses of 50% of the total loss were recorded from Wondogenet district ($p<0.01$) which attributed to the absence of stacking of plants in the field together with the market problem. Field, transportation and market display were major points of losses of tomato; significant losses being observed right from the field ($p<0.01$). It can be concluded that post-harvest losses in tomatoes occur during each practice of the above chain actors. However, the maximum losses were noticed at the production stage of the produces. The reasons were poor harvest techniques, packaging materials and absence of cold storage and transportation systems. The interference of egocentric brokers, lack of awareness, carelessness on the loss and its impact are major factors.

Keywords: Tomato; Post-harvest loss; Fresh fruit; Vegetable

INTRODUCTION

Tomato (*Lycospersicon esculentum*) is one of the most important and widely cultivated vegetable in the world. It is the main component of the daily diet of most Ethiopian societies [1]. Tomato is widely used in many parts of the world using countless recipes in food processing and service industries. The estimated world production of tomatoes is about 109.44 million tons from an area of 4.04 million hectares [1]. The first record of commercial tomato cultivation is from 1980 with a production area of 80 ha and the upper Awash by Merti Agro-industry for both domestic as well as export markets. From 1994 up to 2011, tomato acreage increased to 5338 ha with a total production of 55,635 Mg (CSA, 2011) [2].

Nowadays the increasing of agricultural production in the world is in progress but much of the population do not have access to adequate food supplies. There are many reasons; One of which is there are a huge amount of horticultural product losses occurring in the post-harvest and marketing system. Since tomato is highly perishable it encounters several problems during transportation, storage, and marketing [3]. Owing to lack of information on appropriate technologies like post-harvest treatments, packaging, storage etc. The fruits are not only losing their quality but also encounter substantial post-harvest loss. In tropical countries loss of 20%-50% between harvesting, transportation and consumption of fresh tomato [4]. This is due to shortage of recommended package of information, poor quality seeds, poor irrigation systems, lack of information on soil fertility, disease and insect pest, high postharvest loss, lack of awareness of existing improved technology and poor marketing systems are the major production constraints of tomato production in Ethiopia [5].

There is no adequate information on the postharvest loss and causes of tomatoes. Besides, there is no clear evidence precaution of high losses of such products may occur at which point . Tomato is highly a seasonal crop, and hence there is a surplus at a particular season of the year, the physiological nature of tomato (high moisture content, high respiration rate, soft texture) may subject it to microbiological, mechanical, physiological damages unless measures are taken. The produce is mishandled from

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the farm gate to the point of consumption due to improper harvesting, post-harvest handling, transportation, intermediaries' malpractices, storage and other reasons. In addition, the scholar heard that most farmers sell their tomatoes at a throwaway price due to unforeseen reasons. Options to reduce and or control post-harvest losses are limited, and thus the need to design research studies that are geared to developing such strategies. Assessing and determining the specific causes of the problem at which point and by what reasons will help devise appropriate technology. If the threats are not addressed and corrected, poverty reduction and other economic development will not go as planned.

Therefore, this research assessed and addressed the status, type, extent, cause/constraints and possible solutions of post-harvest losses of tomatoes in the specified areas of Sidama Zone districts along the value chain provides a starting point on the loss reduction recommended methods for the future. It will also indicate the points where the loss occurs and basic information on producers' practice to either be improved or modified for the future.

MATERIAL AND METHODS

The study areas

The study was conducted in three systematically selected tomato production districts of Sidama zone of SNNPR, Ethiopia and their respective markets of tomato. These areas were Shebedino, Wondogenet and Hawassa zuria located about 18 km, 25 km and 15 kilometres from the head town of SNNPR, Hawassa respectively. The soil type of these areas is convenient for tropical horticultural crop production with the mean seasonal temperature of 180°C to 270°C, and mean annual rainfall, 1000 mm. The study areas have an altitude range up from 2000 meters-2200 meters above sea level (Sidama zone agricultural office, 2012).

Even though most of Sidama zone districts were producing 'kocho', corn and some other fruits, the three study districts were purposively selected for their relatively high vegetable production in general and tomato in particular with good water source especially for irrigation, neighbourhood to centre market of Hawassa, suitable road and environment for the production of vegetable (Sidama zone Agricultural Sector).

Methods of data collection

The required data were collected at producers, transportation, traders' and Consumers' levels in the post-harvest chains of the commodity. Field data were collected on the post-harvest practices of tomato fruits at different stages of handling through survey methods using questionnaires, informal interviews, direct observations and weight loss measures. Focus group discussions with stakeholders/agricultural officers, producers and key informants and other actors were used at different stages of the analysis.

Sample size

Based on the selected tomato producing areas, the determination of sample size during the selection of respondents from a total of producers was resolved using Slovin's sampling formula with 90% confidence level [6]. Using the formula, a total of 95 farmers/producers respondents were interviewed; 26, 37 and 32 from Shebedino, Wondogenet and Hawassa zuria districts respectively were interviewed where 28 were females.

Where:

n=Sample size for Research Use (RS)

N=Total number of producers in three tomato producing areas.

e=Margin of error at 10%

As the selected respondents may not be available during the interview time due to several unforeseen reasons, in such a sampling technique, it is difficult to control such error occurrence so it is better to have a correction point, margin of error (e). It is also applicable with a 10% margin of error while determining our sample size with 90% confidence level (Table 1).

Sampling technique

Purposive sampling techniques were used for the study area selection and systematic random sampling for respondent's selection. Within each district, potential areas were purposively selected in the same manner as above taking into account the existing total tomato production status and potential. The questionnaire was pre-tested and rechecked for its appropriateness and ease of understanding by the respondents before distribution. Focus Group Discussion (FGD) and interviews with Key Informants (KIs) were conducted with SWOT analysis. With this, data were collected and analyzed. During the assessment, critical observation of the real situation was also used as a crosscheck method to have reliable data.

From the traders' perspective, 18 wholesalers were taken purposively for interview. These were purchase tomatoes from those districts frequently. Based on the current availability and number of traders found in the selected districts and city administrations market, a representative sample of 60 retailers were interviewed as participants in the chain of the commodity. These retailers were those who sell tomatoes as small-scale traders in vast markets.

Cafes and restaurants as representative of consumer respondents were interviewed in the districts of Shebedino, Wondogenet

Table 1: Sample distribution of respondents in selected Sidama Zone districts.

	Respondents	Shebedino		Wondogenet		Hawassa Zuria		Hawassa		Total actors	
S.No		NP	RS	NP	RS	NP	RS		RS		RS
1	Producers	17378	26	65271	37	21110	32	-	-	-	95
2	Wholesalers	-	2	-	1	-	1	-	14	-	18
3	Retailers	-	15	-	10	-	10	-	25	-	60
4	Consumers	-	5	-	10	-	5	-	60	-	80
	Total Samples	-	-	-	-	-	-	-	-	-	331

Source: Woreda Agricultural Offices, Kebele administrations, and Sidama Zone Trade, Industry and Transport Office; February 2013.

and Hawassa zuria. Considering cafes and restaurants, enough representative consumer respondents were taken. Thus, 80 consumers were purposively selected for the interview from the study districts. Among these numbers, 50 cafeterias and Hotel owners were purposively selected and interviewed. The criteria for selecting the hotels and cafés was just the service they provide related to food using tomatoes more often.

Purposive sampling method was employed to collect data from Key Informants (KI) (purposively selected producers) and FGD (agricultural officers of the districts, agricultural officers of the zone and agricultural research professionals who were food science and technology, postharvest technology, plant science and horticultural science in profession) was conducted to get different perceptions and reliability information from different stakeholders about the commodity. Accordingly, three group discussions of stakeholders in the production areas were participated for the KI and FGD by having a total of 22 men and 6 women. The first and second group discussions were held at the farm and Wondogenet Agricultural office by having 18 producers and 5 agricultural officers respectively. Separately, FGD was conducted by involving 5 food science and technology professionals who were purposely selected from the Institute of Nutrition, Food Science and Technology at the Hawassa University of Agriculture.

Sampling techniques for weight loss analysis

A representative sample of two local boxes (60 kg of tomato each) from the two systematically selected (farms) were collected purposively and packed in a marked farmers local piled box, loaded on an open truck (Isuzu) at the bottom and one in the middle and transported to Addis Ababa Vegetables Market ('Atikilit tera'). Assuming that 10 fruits weigh one kg and taking the above two average piles of marked boxes from farms of the district, fruits damaged in the box during filling and marketing both in the field and at the end of transportation were counted in triplicates for its weight loss. This duty was accomplished three times and measuring weight loss due to damage, defects and overripe in the three successive market days at the retail level (as a case study). The initial weight of tomato at the farm and weight at the retailers were taken to determine the weight loss of tomato as shown below as described by [7].

Where: Wi=Initial Weight, Wf=Final Weight, WL (%)=percentage of Weight Loss.

Data collection

Data were collected with a questioner from the field observation, Producers, traders, consumers' interviews and discussion with key informants and focused groups; the status, type, extent and causes of post-harvest losses of tomato in the specified areas along the value chain were recorded. 1: knowledge/skills and experiences towards tomato production and handling practices, 2: Harvesting time and maturity, 3: Harvesting methods, 4: Packaging materials used and ways of storage handling 5: Ways of transportation and marketing. The estimated percentage losses of tomatoes at the producers, transportation, traders' and consumers levels were recorded.

Statistical data analysis

The raw data generated from a semi-structured questionnaire for individual interviews of producers, wholesalers, retailers and consumers and weight loss measures were re-coded and organized on Microsoft Excel 2007 database system before being subjected to a computer software program called SPSS (version 19, 2013). Results of the SPSS analysis were used as tabulated reports and descriptive statistics; sum, mean, frequency distribution and percentages were again presented in tables to enable easy interpretation. Strength, Weakness, Opportunity and Challenges (SWOC) analysis was duly considered in the interview schedule for producers to complement data and realize the objectives of the study. Data obtained from Key Informants and Focused Groups were described in SWOC table form.

RESULT AND DISCUSSION

Tomato loss at the producers' level

The cumulative loss of tomatoes at producers' level in the study area was found to be approximately 24% (Table 2). The percent losses of tomatoes were calculated through estimating by averaging losses reported by the respondents during different processes of assessment, which is the same trend [8]. The high loss, found at the producer level was loss left on the field due to lack of stacking and diseases and pests (85% of the 24% loss). While 15% of the 24% loss was due to miss handling, lack of sorting, field transportation, handling types of equipment and loss due to improper loading and unloading activities. The tomato loss from Wondogent (33%) district was higher followed by Shebedino and Hawassa Zuria districts. The reason for the high loss was found in Wondogenet districts due to poor harvesting and handling practices (picking, grading, packaging, storage, loading and unloading the overloading of the field packaging materials, lack of stacking), demographic factors, seasonal and perishable in nature of tomato.

The picking time, field diseases and pests, knowledge and skill in harvesting and handling of vegetables contributes to the estimation

Table 2: Loss of tomato (mean ± SD) at producers' level of the three districts of Sidama zone, Ethiopia.

Factors	Shebedino	Wondogenet	Hawwassa Zuria	Overall	p-Value
Miss handling	1.41 ± 0.3	1.02 ± 0.3	0.93 ± 0.2	1.12 ± 0.3^{c}	0.000**B
Luck of sorting	0.70 ± 0.0	0.42 ± 0.0	0.48 ± 0.0	0.53 ± 0.0^{b}	
Field transport	0.65 ± 0.1	0.77 ± 0.0	0.77 ± 0.0	0.73 ± 0.0^{b}	
Handling equipments	0.74 ± 0.1	0.62 ± 0.1	0.66 ± 0.0	0.67 ± 0.1^{b}	
Loading and unloading in the field	0.80 ± 0.1	0.46 ± 0.0	0.45 ± 0.0	0.57 ± 0.0^{b}	
Disease and Pests	5.98 ± 1.7	12.78 ± 1.7	5.80 ± 1.5	8.19 ± 1.6^{a}	
Loss left on field	10.05 ± 2.7	17.20 ± 1.9	8.63 ± 2.1	11.96 ± 2.2^{a}	
Total	20.33 ± 5.0^{a}	33.27 ± 4.0^{b}	17.72 ± 3.8*	23.77 ± 4.2	

**are significant difference, means with the same letter (superscript) vertically are not significantly different

and loss of commodities. The sorting and grading of tomatoes based on the colour, size and shape and stressed tomato believed in reduction of losses. In the study area, no proper sorting was carried out that plays a significant role to increases the expressed losses (0.53%). The quality of the packaging material (rough wooden material, sacks, on the field without handling material) in the field was poor leads to stress (0.67% of mean loss) (Table 3).

The loss left on the field at Wondogenet was higher than the rest due to the absence of stacking materials due to economic barriers (the wooden stacking material are expensive). In the case of loss due to miss handling, field transportation, during loading and unloading and market delay in Shebedino districts were relatively higher than the rest due to less awareness on harvesting and handling practices. The maturity indices of tomatoes were found to be important in minimizing losses. In the study areas, 75% of the producers were harvested when the tomatoes were red (ripen and overripen). The tomato that got overripe was susceptible to mechanical injury easily.

The associated factors identified for the harvesting, handling and tracking losses of tomatoes were market delay (72.8%), climatic fluctuations (27.2%) like heavy rain and flood in farms found next to rivers, like that of 'Shamanto' river in Wondogenet. There was no significant difference between districts on the agreement of those causes. The market delay was a huge problem; because it was the base for the other consecutive causes of loss of tomato and result of other cases of loss. The market delay was mostly related to price fluctuation created by the intermediaries especially the brokers who hinder the information flow and communication and blocking of producers and wholesalers contact and their free-open deal on price without considering the perishable nature of the crop.

Tomato loss during transportation

Transportation is one of the chains where losses occur due to different factors (Table 3). Based on the producers' response together with observation of the existing practice and handling condition, the cumulative percent loss of tomato at producers' chain point of the study districts found during this assessment was 4.2%. One of the major reasons was the distance where the produces transported with the inconvenient (rocky) road which leads to shaking the product and creating stress thereby physical damage and nutrient loss had occurred. Eighty-seven producers which were 91.5% responded with this regard.

Mode of transportation

Different modes of transportation used by the farmers for tomato marketing were observed in the study. There was a significant difference ($p<0.01$) among the mode of transport used. 68% of the tomato growers bring their produce to the nearby local market and/or for the area of the collection were used a cart with pack animals as a mode of transportation while the remaining farmers use small truck takes the produce from field based on their deal and road access to the vehicle though not always (Table 4). But for long transportation almost all producers and wholesalers use medium tracks like Isuzu and FSR. Regarding the use of transportation, animals especially donkeys attached with carts are used to transport tomatoes from the farm gate to access roads and markets. This is in line. He affirmed that donkeys and horses are principally used for the transport of fruits and vegetables in Ethiopia. Khan also clarified that during transportation the produce should be immobilized by proper packaging, stacking and type of transportation system, to avoid excessive movement or vibration because vibration during transportation may cause severe bruising or other types of mechanical injury thereby, mean loss of 0.3% occurred due to the mode of transportation used [6-7].

Almost all tomato growers and wholesalers in Sidama zone are involved in transporting their products to the local and regional markets using non-cooling medium trucks and carts. Therefore, losses had been occurred during transportation due to the remoteness of local and regional markets, bad conditions of roads (rocky roads) besides the non-cooling medium transportation system. Cooling produces to remove field heat is scientifically recommended. There is no management of temperature. It was observed that tomatoes were put in a box right in the field without any protection from the scorching sun while waiting for the trucks to come and pick them up.

In the case study, there was an observation though that some wholesalers who transport their produce to the nearby local market with their donkey cart cover the product with the available materials, plastic-like covers and fresh leaves to reduce exposure to the sun. This practice is one of the best practices observed at the producers' level. But some wholesalers were transported their produce without covering any materials [8].

Loading and unloading

All produce was loaded and unloaded the tomatoes with wooden boxes during transportation. There were no observed activities

Table 3: Factors of transportation loss of tomato in the study districts (frequency and percentage).

Variables	Response	Frequency	Percentage
Type of transportation used by wholesalers n=18	Medium truck (Isuzu)	17	94.5
	Other	1	5.6
Type of transportation used by farmers n=95	Truck	34	32
	Pack Animals	61	68
Frequency of transportation n=95	Twice	6	5.5
	Three times	54	51.5
	three times	35	43
Delaying of tomatoes on the farm after harvest n=95	Half-day	62	65
	A whole day and more	33	35
Distance and inconvenient roads n=18	Long-distance	-	-
	Inconvenient roads	5	28
	Both	13	72

of dumping of produce on the truck during the assessment. But during unloading, there were damaged fruits in some boxes. Though wooden containers were used, there was a loss 0.8% during loading and unloading of the products while transferring the products from producers' box to trader/buyer box and loading to the truck (Table 4). There was poor handling of tomato together with the rough wooden container. In addition, loading and unloading of the over-filled box of mixed mature tomato lead to mechanical damage. It needs proper care during loading and unloading plus sorting the over-ripe and damaged ones from properly matured tomatoes.

Distance

The product passes through different transportation points as it is transported from the field until it reaches to consumer. There was a significant difference ($p<0.01$) in the losses among the districts regard with the transportation and there was an average percentage mean loss of 1.6% due to distance and inconvenient roads, which was high as compared to other causes of loss during transportation (Table 5). Loss due to Distance and inconvenient roads in Wondogent was higher than that of Shebedino and Hawassa Zuria districts. During the assessment, 51.5% of the produces transported their produce three times; field to wholesalers, wholesalers to retailers and retailers to consumers (Table 4). In the case of studies, there was more than three times transportation of the produce when intermediary involvement is seeking additional profit, which is one of the major postharvest loss problems observed during the assessment. There was also transporting the produce twice, from field to wholesaler and then to major cities of the country.

Type of packaging materials

The other main reason for loss during the assessment was the type of packaging materials used in the chain. Wooden boxes are the packaging materials being used in the three districts. Similar practices were reported in Pakistan [8]. The type and size of boxes used for harvesting and transporting tomatoes to the nearby market and those used for long-distance transportation are somewhat different. To bring it to the market there is relatively different weight boxes were used but on average, a box was found to weigh 6.8 kg (~7 kg) (Table 6).

A mean average percentage loss of 1.5% was recorded in the districts due to the improper packaging materials like a rough wooden container which was nailed and fixed with sharp-edged pieces of irons for packing and transporting tomatoes results in mechanical damage and other deterioration. There is a practice of using previously used boxes due to cost and of course limited awareness about possible cross-contamination. Those boxes are mostly placed in the home yard regardless of how they are piled one over the other and not shaded from rain and sun. The cost is one major factor for not using new boxes or managing the bulk amount of the box, though the second can be related to carelessness. The results of the present study indicated that packing is the most important factor damaging the tomatoes at quite an early phase of postharvest handling. Loss of tomatoes due to packaging problems in Pakistan reaches up to 27% (23% to 27%) in different market places of the main business point where tomatoes are brought from all over producing areas [9].

Producers also predict the size and other criteria of the wooden

Table 4: Loss due to transportation of tomato (mean ± SD) in the study districts of Sidama Zone.

Variables	Mean (SD) loss in %			Overall	p-value
	Shebedino	Wondogenet	Hawassa Zuria		
Distance from field to local market, Hawassa (km)	18 ± 5.6	25 ± 6.1^{a}	15 ± 4.3^{a}	19 ± 4.5	0.001**
Loss due to Distance and inconvenient roads	0.4 ± 0.0^{a}	1.0 ± 0.05^{a}	0.2 ± 0.0^{a}	1.6 ± 0.5	0.003**
Loss due to the type of transportation used by farmers	0.1 ± 0.0^{a}	0.1 ± 0.0^{b}	0.1 ± 0.0^{b}	0.3 ± 0.0	0.000**
Loss during loading and unloading	0.3 ± 0.0^{a}	0.4 ± 0.0^{c}	0.1 ± 0.0^{c}	0.8 ± 0.0	0.002**
Loss due to the type of packaging materials	0.5 ± 0.0^{a}	0.6 ± 0.1^{ab}	0.4 ± 0.0^{ab}	1.5 ± 0.1	0.004**
Transportation Loss	1.3 ± 0.0^{ac}	2.1 ± 0.15^{ac}	0.8 ± 0.0^{ac}	4.2 ± 0.15	0.002**

**significant difference at $p<0.01$, means of the same letter are not a significant difference.

Table 5: Weight of packaging materials (mean ± SD) for tomatoes in the study districts.

Weight(kg)	Shebedino	Wondogenet	Hawassa Zuria	Overall	P-value
Weight of box	6.6 ± 0.4	6.7 ± 0.4	7.1 ± 0.1	6.8 ± 0.3	0.000**
Weight of Tomato	58.4 ± 1.1	58.2 ± 1.3	58.6 ± 2.4	58.6 ± 1.6	0.000**
Total (W of box plus tomato)	64.9 ± 0.9	64.9 ± 1.2	65.2 ± 1.5	65.7 ± 1.5	0.000**

** no significant difference.

Table 6: Retailers packaging materials frequency and percentage results for the three districts.

Packaging materials	Frequency	Percentage
Wooden crates	28	46
Jute bags	16	27
Sacks	16	27
Total	60	100

box. They mostly know the effect of size and roughness of the surface of the box, but do not have the alternative option because of financial problems. The absence or poor packaging material in the major marketing systems of Ethiopia can be one huge problem for the horticulture industry. Birhanu (2011) [6] pointed out that the unavailability of standardized packing material has forced exporters in Ethiopia to import packing material from Netherlands and Israel.

The average box of tomato weight was found to be 58.38 kg (~58 kg). The gross weight of boxes (fruits plus box) was found to be 65.19 kg (~65kg) (Table 6). In calculating the production and amount of loss, only 60 kg was used as an average weight of tomato per box in the study areas.

To gain an average price for the different quality of tomatoes some farmers and most traders (especially retailers) simply put the tomatoes into wooden crates and/or jute bags, and held those together by rope in such a way that the big size, good coloured and high appearance tomatoes are in the top of the crates and/or Jute bags. While low-quality tomatoes (small size and immature) are putting in the middle of the crates and/or jute bags were presented to the markets.

Most farmers who are selling their products in bulk to wholesalers are not packing their products rather they leave them on the bare floor. All wholesalers, who sold their tomatoes to the retailers in the markets were using wooden crates for packing which contain an average of 56 kg to 60 kg., but retailers who are selling tomatoes to the consumers are using all of the packaging materials wooden crates, jute bags and sacks respectively in their local markets (Table 5).

Due to the lack of sorting, grading, cleaning and proper packaging materials of tomatoes, it was observed that all the respondents were facing the problems of mechanical damages (bruising of the fruits). According to the observation, the improper harvesting and packaging materials such as re-used wooden crates and Jute were highly contributory factors of loss 1.5% (Table 6).

Delaying

One of the contributory losses during transportation was delays of tomatoes on the farm after harvest. This was due to market problems while the product was on producers hands after being harvested in the study districts farms. Mostly, the delays happened when taking it from field to market. According to the farmers, the product waits to a maximum of half-day (65%). In some cases, there were delays of one whole day and more (35%). The reason for these delays in collecting from the field was when the truck does not come on time (Table 4). On the other hand, there was also picking ahead of time. There was also a case when the deal is broken between the producer and the one who takes the produce due to misunderstanding or cheating by brokers/middlemen.

Tomato loss at the market level

Sidama zone hosts a huge number of longer staying, in and out traders of fruits and vegetables. The traders in purposively selected markets of Sidama zone and Hawassa who purchase and sell tomato as a major income were interviewed. For this study, 78 traders (60 retailers and 18 wholesalers) were used purposively from the study district towns.

Wholesalers: It was difficult to identify and find wholesalers due to the informal movement of the system; fortunately, 14 were found from Hawassa but they have frequently purchased tomatoes from the target districts considered as wholesalers based on the volume of tomatoes they handle frequently on the chain. Most wholesalers were men while the majority of retailers were women which are in line with what found in their assessment result in Nigeria. Their destination is different from short distance Hawassa to a different part of the country [10].

Even though, it was difficult to evaluate the exact value of the loss at the market level, from the survey it was estimated as 9% and 3% at wholesalers and retailers respectively. One of the major reasons was the lack of market information. From the assessment result, we found that 95% of producers and 50% of marketers have no access to current prices or volumes to plan their marketing strategies. They are just practising what was on practice before. Whether the price goes down or up, the main way of knowing or getting information was through person-to-person communication. The tomato production and market information can be found in the agricultural office. The respondents doubt the accuracy of the available information. On the contrary, none of the actors in the tomato value chain seems to practice record keeping. About 18% of the wholesalers were not willing to give a response about the information dissemination.

Different contributory factors were encountered for the loss of tomatoes at the market level (Table 7). These were ranked based on the response priority given by farmers. Brokers, who used to act as an intermediate body, were the major contributory factors for tomato loss at market levels. Many intermediaries participate in the passage of the produce from the field to consumers' plates. There was a significant difference ($p<0.01$) in whom tomato is sold. As the study indicated, the majority of the producers (95%) sold through brokers (Table 8). But some producers directly sold to the local markets. For instance, most of the producers from Wondogenet have been selling through brokers while the majority of produce from Shebedino and Hawassa Zuria selling directly to the local markets.

Brokers were majorly (75.5%) involved in price determination while the rest responded that they are not sure as brokers determine the price (Table 8). Practically, these brokers were the major bodies who handle the crop between farmers and wholesalers. These intermediaries are not supposed to buy the product but who control the buying-selling deal between the producers and the buyers. They hide information from both parties and set their invisible existence in between.

It is believed by the respondents and another part of the community in the chain that they can control the movement of the product until the price gets high and the price agreement is done. There was less awareness of postharvest handling technologies and knowledge to reduce the losses due to delays with no special care. The method that existed was pushing the producer to sell their produce at the determined price otherwise, it will be lost. The producers will have no other option. All agreed that all actors in the chain are responsible for losses. Producers and consumers are the two most affected parties. Producers are affected financially whereas consumers are affected both financially and in getting quality and enough quantity of safe produce.

Most of the produce was displayed on the farm gate to be sold to whoever takes it, be it wholesaler or retailer (Table 8). It was the

Table 7: Rank matrix of marketing problems of tomato in the study districts and vicinity markets (KI and FGD).

S.no	Components	Frequency	Rank
1	Brokers hinder fair sales	10	1
2	Perishable nature of the crop	7	2
3	Lack of market information	5	3
4	Lack of market place	3	4
5	Low price	2	5
6	Storage problem	1	6

Table 8: Market price determination and role of intermediaries at the study districts.

S/n	Characteristics	Responses	Frequency n=95	Percent	p-value
1	How to sell the produce	Through Collectors/ Brokers	95	95[a]	0.001**
		Directly local market	5	5.0[b]	
2	Price determiner	Brokers	72	75.5[a]	0.001**
		Producers and wholesalers	23	24.5[b]	
3	Place to sell the produce	Farmgate	93	98.0[a]	0.001**
		Roadsides	2	2.0[b]	

**significance difference

place where dealing takes place. There was a significant difference (P<0.01) in respect of the location where the product was sold.

Wholesalers' responses showed as they know the cause of loss and way of handling the crop as 65% of wholesalers have more than five years of experience in the tomato trade. However, they load 85 to 90 boxes of tomato per truck/Isuzu and do not usually cover it from the sun. Their positive side is that they mostly travel at the coolest time of the day and night. They face the same problem of brokers' hindrance from information on quality and price of the fruit, though not much affected as the farmer does because of the profit they get by increasing price as compensation on their destination.

After receiving from wholesalers, retailers were found in a loss of up to 4 or 6 boxes per truck at the final destination market due to many reasons. The causes mentioned were market fluctuations being the major one, temperature, poor filling and sorting and others. In addition, about 2 boxes of loss were found during loading and unloading. Based on the season, market fluctuation condition, there could be almost 8 boxes loss of the fruit after long-distance travel. 9% loss found from wholesalers starting from field loading up to unloading on the final destination considering the transportation, handling issues in between.

Retailers: A sample of 60 retailers, including roadside, shops and town traders were purposively interviewed. Among them, 80% of women reported a similar trend of more women involved in retailing than men did in Nigeria. The age of most retailers lay in the range of 15 to 40, which is in line with who reported most (74%) women hawkers of the respondents in South Africa were in the middle age category. The involvement of women in the production and marketing of vegetables, specifically tomatoes is encouraging in the study area. Further involvement in wider production and marketing, like involving in wholesale is crucial.

These chain actors are with many options, either buying the available tomato if demand is high or choose and deal any type of tomato available on the market, considering themselves as temporary traders who can shift to other crops or other commodities. They, of course, face the ripe tomato which is susceptible to damage and loss if demand is less together with the poor handling management and no storage facility. As a result, they sell at a higher price to the final user to compensate for the loss.

The major problems observed on the retail market were: No sorting of diseased and damaged one while displaying for sale, damping on the ground and mixing with other vegetables and unrelated commodities. They believed that they could get enough profit from displaying more tomatoes so that they do not worry about the remaining. After they get more than what it costs them, either they sell it at a low price or leave it for the animal.

There was an assessment of tomatoes run by retailers to know the loss and related factors in possibly reachable retailers in the study areas. One retailer runs an average of 8 boxes though ranges up to 12 boxes [10-11] (Table 9).

There was no significant difference (p=0.01) in weight of retailers box, the weight of tomato alone and weight of retailers box with tomato among the districts' final destination of "Guilt" or mini-Et fruit (Table 10).

There was no significant difference in the loss of tomatoes among the districts. There was a difference (p<0.01) between retailers at different market locations. Based on the assessment result, there was a total mean loss of 4.34% recorded at Hawassa Zuria district during the assessment. As a consequence, high mishandling and poor loading and unloading activities were relative to the other districts (Table 11). Therefore; approximately 3.0% total loss at retailers' level was recorded. Regarding the absence of tomato sorting and other tomato caring activities, this result was smaller than the loss observed from other levels. The more box of tomatoes run, the less proper handling given the more the fruit exposed to damages and consequently, more loss would happen.

Tomato loss at consumers' level: Eighty (80) consumers were taken for the analysis of loss at the consumers' level. Regarding the awareness of consumers on post-harvest related issues, most of them did not have any reaction at all. The post-harvest issues are not given due attention. While the rest had no preference to buy produce poorly handled and with less quality (Table 12).

This reaction showed a significant difference ($p<0.01$) among consumers.

The response from the consumers shows almost the same trend. They depend on their preference. Size and colour are frequently observed in consumers' preference for the produce. Of course, all consumers in all districts prefer to purchase tomatoes at lower prices. There was a significant difference ($p<0.01$) among consumers concerning the cost of tomatoes. The majority of them react negatively while the rest of the respondents face no reaction towards the cost of the produce.

All respondents mentioned that there is a daily sign of unmet preference or demand of the consumers. The feedback from a consumer is that the price goes up due to the many intermediaries involved in the chain. They do not buy tomatoes at a fair price because all intermediaries add their additional costs, which adds up to the final price that consumers have to cover.

The national per annual availability and consumption of fruit and vegetables in Ethiopia is less than 21.7 kg per year which is much less than the minimum recommended level of i.e. >146 kg per year (400 gram per day [12,13]. Extremely small quantities of horticultural crops are daily consumed in Ethiopia.

Besides the above-mentioned response of producers about consumption, samples of 80 consumers were also randomly interviewed for their attitude towards what they are consuming. Almost all had the same response that they do not even think of the issue of postharvest handling. Almost all consumers responded that their concern is on the availability and accessibility of the fruit but not on the quality and the safety part of it. This does not mean that there is no preference for a quality tomato to a poorly handled one. Consumers from the main town/city mostly raise the reaction towards the cost of tomatoes. This cost issue is not observed much from consumers nearby the source because of many options to choose and as a result, cost does not go further from the affordability to the average consumer. They very often buy small amounts, maybe one or two kg of tomato for daily use per HH and due to that they do not give attention to quality, loss or other health issues. Few had an answer that they think of it, but never bring it to the stage for discussion due to many reasons.

Café and Hotels: From the districts, 50 café and hotels including small houses serving food as a business were assessed and interviewed for their view on tomato consumption and handling issues. An average hotel buys a box of tomatoes for a maximum of two days (frequently on the market days). Table 13 shows there was a mean loss of 1 % to 5 % in each district. It happened due to the mix filling of overripe and damaged tomato with the healthy one on the farm or retail market that initiates perishing the other too at consumers' level.

The price of one box of tomatoes by the hotel/café showed a price difference of average of 127.66 Birr and 49 Birr additional from farmer and trader respectively. Even though, it was difficult

Table 9: Weight of tomatoes and Boxes at retailers' points in the study districts.

Variables	Shebedino	Wondogenet	Hawassa Zuria	Overall	p-value
Weight of box alone, kg	7.0 ± 1.4^{b}	6.1 ± 0.9^{b}	5.7 ± 0.9^{b}	5.9 ± 1.0^{b}	0.002^{**}
Weight of tomato, kg	57.2 ± 2.0^{ab}	58.3 ± 1.3^{ab}	57.0 ± 1.4^{ab}	57.2 ± 2.0^{ab}	0.005^{**}
Total Weight, kg	64.2 ± 2.7^{a}	64.4 ± 1.8^{a}	64.2 ± 2.7^{a}	63.4 ± 2.3	0.004^{**}

Mean values bearing the same superscript letters horizontally are not significantly different ($p<0.01$)

Table 10: Loss of tomato (mean ± SD) at retailers' points in the study districts.

Variables	Shebedino	Wondogenet	Hawassa Zuria	Overall	p-value
Loss during loading and unloading, %	1.55 ± 1.5^{a}	1.33 ± 0.6^{a}	2.94 ± 0.1^{a}	1.94 ± 0.7^{b}	0.543^{ns}
Loss during handling, %	1.60 ± 0.8^{ab}	1.50 ± 0.5^{a}	1.40 ± 0.3^{b}	1.50 ± 1.5^{ab}	0.135^{ns}
Total loss at retailers level, %	3.15 ± 2.3^{c}	2.83 ± 1.1^{c}	4.34 ± 0.4^{c}	3.44 ± 2.3	0.642^{ns}

Mean values bearing the same superscript letters horizontally are not significantly different ($p<0.01$)

Table 11: Consumer demands differences of the study districts, Sidama Zone.

S/n	Characteristics	Response	Frequency /n=80/	Percent	P-value
1	Consumers' reaction to the practice of postharvest handling and quality	No preference to buy	24	30^{b}	0.005 **
		No reaction	56	70^{a}	
2	How do consumers react to the cost of tomato?	Negative/less satisfaction/	62	78^{a}	0.003 **
		No reaction	18	22^{b}	

**Significant difference at P<0.01

Table 12: Tomato price and loss at consumers' level (mean ± SD) in Sidama Zone in the surplus season during the assessment.

Variables	Shebedino	Wondogenet	Hawassa Zuria	Overall
Loss due to poor handling	3.4 ± 0.60^{a}	5.0 ± 0.00^{a}	4.0 ± 0.00^{a}	4.1 ± 0.60
Loss due to over ripening	2.9 ± 0.10^{b}	1.3 ± 1.20^{c}	1.3 ± 0.60^{c}	1.8 ± 0.63^{ab}
Mean Loss, %	6.3 ± 0.70^{c}	6.3 ± 1.20^{c}	5.3 ± 0.60^{c}	5.9 ± 1.23

Means of the same letters are not significantly different

to estimate the percentage loss at consumers' level due to lack of knowledge of what loss means. But from the assessment of the sampled consumers, a proximate mean total loss of 6% was found. From the three districts, cafes and hotels from Wondogenet districts recorded higher losses relative to the rest. The reason could be due to the extent of damage, the more time spent till it reaches through long-distance and sun exposure together with the perishable nature of the tomato. Not to mention the poor handling given through the value chain, the loss was higher. The weight of tomato loss due to mechanical injury was not statistically significantly different between locations of the hotels/cafés. There was also no statistically significant difference in price and loss of tomatoes among the districts (Table 13).

Socio-economic characteristics of farmers and its relation with loss: Age, sex, educational level and means of income are the major demographic features used to characterize the working experience of producers and their contribution to the loss. These contribute to the pre-production, production, post-harvest handling and marketing as discussed below.

Sex and age of farmers: Results according to Table 14 showed that there was high gender inequality in tomato farming. This indicated that women played a somehow significant role in vegetable production in Sidama areas. The proportion of females 30.5% in the present study was observed to be much better than who took 2.5% female producers. This shows that there is a favourable condition to encourage women participation in postharvest loss reduction in the study area [14].

Age is a very important demographic characteristic because it determines the size and quality of the labour force. The majority of the farmers were between 21 and 41 years (65.5%). This indicated a good supply of agile workforce in tomato production in the study areas. The mean age of respondents in the study area is lower than what was reported by who found 42.7 and 42 years respectively. The result clearly showed that the age range of the household remained within productive age (15 and 64 years) [6,14,15].

Educational level and Farming experience: Literacy is one of the important characteristics that influence farmers' decisions on the adoption of new technologies. Most of the farmers were illiterate and had insufficient educational levels (Table 14). This could be a contributory factor to high post-harvest losses in tomato production because only farmers with post-primary education can appreciate and use most post-harvest technology available. Coupled with this, the fact is the majority of the farmers had below 10 years' experience in tomato production. This could affect post-harvest losses in tomato production. Their years of experience in tomato production might also preclude poor knowledge and adoption of preservation technology among the farmers [8].

Relationship between demographic characteristics and loss of tomato: The demographic characteristics of producers have their contributions to the different roles in practising good management required by the agricultural produces. The means were computed by independent samples t-test. Based on the observed field of study and other points of the chain in tomatoes, the result showed that gender plays a significant role ($p<0.01$) in the loss, that higher losses were recorded for men than for women (Table 15). This result is in contrast with the idea who explained males are better than female farmers regarding farming experience and access

Table 13: Characteristics of producers and demographic features of farmers (mean ± SD).

Variables	Category	Frequency	Percentage	Shebedino n=26	Wondogent n=37	Hawassa Zuria n=32	Overall n=95	P-value
Gender	Male	66	69.5	-	-	-	-	-
	Female	29	30.5					
Age (years)	≤20	1	1.1	37.81 ± 10.9a	36.54 ± 8.17a	35.53 ± 9.93a	36.55 ± 9.54	0.795ns
	21-41	62	65.5					
	>41	32	33.4					
Experience In growing /years/	01-Oct	68	71.5	11.35 ± 7.83b	8.73 ± 5.15c	6.47 ± 3.82d	8.68 ± 5.9	0.002ns
	Nov-20	23	24.2					
	>20	4	4.3					
Educational Level	No education	55	57.9	-	-	-	-	-
	01-Aug	29	30.7					
	09-Dec	8	8.2					
	Diploma	3	3.2					

Source: Survey result, 2013, ns=Non-significant difference, **=Significant difference

Table 14: Relationship of demographic characteristics & loss of tomato (mean ± SD) in the study districts.

Variables (Demographic characteristics)	Description	Percentage loss	t-test
Sex	Male	20.60 ± 5.53	2.663**
	Female	18.70 ± 6.75	
Educational level	Literate	13.25 ± 3.83	2.23**
	Illiterate	22.69 ± 5.84	
Farm experience	≤ 10 years	19.95 ± 3.95	0.72ns
	≥ 10 years	11.56 ± 6.35	

**significant difference; ns=non-significant difference

to technologies. Females are more attached to giving care and practices better management and mostly settle than males. They have good experience to handle their produce in the districts of Sidama zone and hence reduce loss [16].

There was a statistically significant difference between the literate and illiterate. Besides, numerically education showed a negative relationship with the extent of loss of tomatoes that relatively higher loss was recorded (22.69%) from those illiterate than the literate ones revealed education level of farmers influences the post-harvest losses significantly at farm level. Literacy is a contributory factor to high postharvest losses in tomato production because only farmers with the knowledge to read and write can appreciate and use most of the post-harvest technologies available [17]. Besides, it was observed, that those producers with higher education do care much about they pick the amount they want to cover their cost with enough profit. However, those with the least education seemed to give relatively less care and do not fight problems to pick as frequent as possible. There was no statistically significant difference between producers who have farming experience less than or equal to ten and greater than ten years [18].

There was a positive relationship between the age of producers and the loss of tomatoes. As the age of producers increase, the loss recorded at different points of the chain is relatively higher. This could be due to less management and handling provided at the field and after harvest as busy with social affairs and exhaustiveness. A negative correlation was observed between the loss of tomatoes and the educational level of respondents. As the educational level of producers increase, their management of the production of tomatoes and adoption of new technology increased. Hereby, the total loss of tomatoes was reduced. Negative relation was also observed between loss of tomato and farming experiences. As the farming experience on tomato production increases, their knowledge of tomato production maximizes. Hence, the loss was reduced.

Post-harvest Knowledge and practices of different actors: Knowledge, attitude and practices of different actors along the product chain concerning post-harvest losses and their solution were assessed because of devising mitigation strategies by concerned bodies. It was assumed before assessment that they did not have enough knowledge of the major causes of losses and growers had limited exposure of experience about the basic post-harvest handling practices of reducing the loss. However, most of the actors responded that they know, through experience, that they face several factors of pre-and post-harvest. Some producers stated that they practice covering their tomatoes during transporting with donkey cart from field to the local market. They knew exposure to the sun affects their tomato badly and result in monetary loss. In addition, they were not fully aware of the summative effect of every cause of postharvest losses on the final qualitative and quantitative loss.

Some solutions practised by producers for frequently occurring problems on-field and after harvest was forwarded. Besides the financial problem, they try to practice routine activities on the field to the best possible as long as they can manage with what they have (money, knowledge, experience, etc.). For example, they harvest after they get a buyer which guarantees their selling confidence regardless of the argument on quality, price depreciation and filling boxes over; covering the boxes of tomato with available materials on the cart while taking to local market practised by some producers.

The roadside market is open to any trader so that there is no interference from intermediaries. Producers nearby the major roads can also sell their produce freely other than retailers who mostly are not producers. Most cultural practices previously being done are now becoming better through training from agricultural offices. What is left to improve is working on post-harvest handling practices and marketing systems through cooperation within and with others, working with Unions, NGOs and other governmental institutions?

Major Production and post-harvest handling constraints of tomato: Based on the field survey, FGD and KI discussions, the major constraint in the production of tomatoes was a shortage of affordable and reliable input chemicals. Unlike other agricultural inputs like seeds, chemicals were not found in local markets. Hence, its less variability and high price was reported to affect the use of chemicals in tomato production in the study areas. Usually, the quality of chemicals was subject to adulteration, as there is no mechanism in place especially quality assurance in the retail of chemicals. The recent increase in the price of fertilizer and some cases shortage and/or late arrival in the market has considerably affected the use of fertilizer in the production of horticultural crops especially vegetable crops [19].

Problem ranking matrix indicates the major cause of tomato loss for producers was identified to be due to market delay (Table 17). This was due to the involvement of brokers/middlemen interference, though functioning as communicator bidirectional. The majority of the respondent mentioned the post-harvest loss of tomatoes was associated with market problems followed by unprecedented climatic fluctuation like heavy rainfall and flooding in farms next to rivers. Market delay and market fluctuation being a serious

Table 15: Correlation of tomato loss versus age, educational level, family size and farming experience.

Pearson correlation Sig.(2-tailed)	Age of respondents	Total loss
Age of respondents	1	0.752**
Total loss	0.752**	1
	Educational level	Total loss
Educational level	1	-0.782**
Total loss	-0.782**	1
	Farming experience	Total loss
Farming experience	1	-0.814**
Total loss	-0.814	1

**Correlation is significant at the 0.01 level (2-tailed)

problem, field loss after harvest precedes all points of the chain and accounts for the high loss recorded and reported physiological, pathological and mechanical damages as major causes of economic losses of tomatoes. Secondly, it was also the perishable nature of the crop and cost of the production inputs like fertilizer, pesticide, motor-pump and seed [10].

The 3rd was the sum of transportation problem, packaging material problem which is wooden rough surface and frequently used poor handled, and the problem of proper training on critical farming operations and as per they mentioned and the credit problem too. The respondent's response implies not the absence but fears they have on how they are going to pay it back when they face a problem of the natural problem and market fluctuation. The fourth rank was the problem of disease and pest problem.

According to the assessment result (FGD and KID), the general major constraints can be seen as production and market constraints. In addition, the following constraints were observed:

- Lack (poor) of improved seeds, well-planned operation, input supply and timely supply of inorganic fertilizers through government channel;
- Poor preparation of seed, management of soil fertility, cultural practices, post-harvest handling and the ignorance of the extent and causes of loss;
- Lack of awareness on the construction and utilization of improved storage and due to its high amount of harvest farmers face construction capital that can accommodate a huge amount of produce.

The market constraints observed were poor knowledge on cost-benefit analysis of production system (when to produce, what to

Table 16: Problem Ranking Matrix of major problems of tomato.

	Components	1	2	3	4	5	6	7	8	9	Value	Rank
1	Perishable nature of tomato	X	1	3	1	1	1	7	1	9	5	2nd
2	Lack of transport		X	3	2	2	6	2	8	9	3	3rd
3	Market problem/ Brokers/middlemen			X	3	3	3	3	3	9	7	1st
4	Disease and pest					X	5	7	8	9	2	4th
5	Packaging problem						X	7	6	9	3	3rd
6	Cost of input							X	7	9	5	2nd
7	Training and credit access problem								X	9	3	3rd
8	Climate change									9	5	2nd

Table 17: SWOC Analysis Matrix of FGD and KID.

Strength	Weakness
Appropriateness of the land for production and vicinity to major markets	No/Poor value addition activities
High yield potential of the crop	Shortage of improved pre-& post-harvest technologies
Humiliate of Investors and private producers with best practice	Absence of awareness on post-harvest technology
Self-preparation of seedlings	Low productive cultural practices
Access of Labor	Lack of practised training implementation of training on practice
Increasing demand of consumers towards vegetables (tomato)	Poor Market information
Training, financial services are available	Inability to be organized in marketing groups
-	Lack of organized information flow
-	Absence of cold storage transporting truck
-	Poor quality packaging materials
-	Overloading (unit per box, truck)
-	Lack of flourishing of linkage between cooperatives, unions and farmers
Opportunities	**Challenges**
Potential to increase area and productivity	Market problem/fluctuation
Organized cooperative in input supply (as loan and support) and technical support	Chemical and fertilizer use (dose, time, frequency and appropriateness); chemical adaptation with the diseases
Area with flat land and high water source	Disease problem but lack of know-how on protection
Improving road access	Lack of information and blocked by brokers (with hiding of information) on price...leads to loss
Short season, high-value crop and high returning crop in small size land for low-income household	Lack of capital by the major small scale but highly involved tomato producers
The shining of newly established farmer unions	Lack of coordination within and b/n farmers and buyers
Involvement of women (gender balance)	Poor Technology dissemination in country level
-	Lack of implementation of training on practice
-	Poor record-keeping on production and loss of the crop vis-à-vis the major causes

produce, how to produce and for whom to produce and price-setting) by most producers; and high perishable of the crop brings market limits. There was poor knowledge of farmers on crop diversification about market demand which resulted in surplus production of tomato and less demand in return leads to selling with low price otherwise loss of the crop. There is a frequently observed practice on farmers that they prefer to produce a crop that can give high economic returns like a tomato at the same time as others do. In times like this surplus production of the same crop is high throughout the market, which cannot be related to market demand, which in turn results in a high loss.

Lack of competent cooperatives of farmers on market issues (i.e. lack of awareness creation for their respective members, production supply, information dissemination systems and strategies); there was no visibly observed attention given by the government to this product as other exportable agricultural products; lack of cold chain/storage for high way transport and lack of awareness on pre-and post-harvest technologies were market constraints. Many pulling back factors hinder the improvement of the production, quality, handling and delivery of sufficient tomatoes to the end consumer. These include the limited market share of the produce and less/no know-how of consumers towards the consumption of tomato together with the careless handling of the crop by involved actors in between and of course the poor expansion of agro-processing industries in the country.

SWOC Analysis: Based on the discussion and observation with a group of producers and basic informants, some basic Strengths, Limitations, Opportunities and Threats (SWOC) were extracted that may help in setting solutions to intervene in the major chain. As a result, general limitations and strengths of actors and available opportunities were pointed out. Issues that were considered as threats to the producers and other economic related issues are also inspected. The main results of the SWOC analysis are listed in Table 18.

Weight losses analysis

Weight loss at the wholesale level (case study one): A sample of two farms Mr. Tariku kia's and Mr. Duko Olango's farm) were taken from the districts for this case study to know the damage of tomatoes due to overfilling of the box and rough nature of the wooden box together with the mishandling of the labour at the final transportation of the wholesale market ('Atkilit tera' market in Addis Ababa). The piled boxes were put in the middle and bottom of the loaded truck. Assuming that 10 fruits weigh one kg and taking two average piles of marked boxes from farms of the district, fruits damaged by the box during filling and marketing both in the field and at the end of transportation were counted. There were different ranges of damaged fruits with a range of 2.5kg-3.7 kg per one box from the bottom box and 1.7 kg-2.3 kg per box from the middlebox.

There was a mean loss of 3.2 kg (5.3%) and 2.2 kg (3.7%) tomato from the bottom and middle piled boxes respectively. From the result, it is clear that the pile size, the type of box the ripened stage of harvesting and the long-distance affects the amount of fruit loss. Using LSD mean separation test for loss, there was a significant difference ($p<0.05$) between the bottom and the middle piled box and even among the farms due to the overload on the bottom boxes and the apparent difference in their handling practice respectively. The improper packaging materials and transportation were found to have a significant effect on the weight loss of tomatoes. The impact from mechanical damage, though its degree differs based on the stage of ripeness, later on, results in deterioration of quality of the fruit. Impact energy and stage of ripeness had a significant effect on all types of mechanical damage. The severity and rate of latent damage increase progressively in fruits through time in natural conditions. This opinion is following that of who stated the different ruptures caused to the tomato fruits depend on the stage of the ripeness-occurred in 30% of the samples through 24 to 72 hours storage [20].

As described, the rate of moisture loss may be increased by as much as 400% by a single bad bruise on tomatoes; they become shrivelled after losing only a small percentage of their original weight due to water loss. Water loss represents salable weight loss and reduced profits.

Weight loss at retail level (case study two): After the end of transportation of the two marked and piled boxes of tomato explained in case study 1, measuring the weight was continued to observe the extent of loss and related causes of damages including its shelf life for the successive three days of the retail market. Due to the cost of tomatoes not being affordable by this conductor, those boxes were owned by favouring traders and just taken as a sample and followed till the best reachable chain points. The two boxes were given to the retailer Miss Wishu Abu who own a mini-Etfruit shop in Addis Ababa, "Atikilt tera" market. The retailer gave an estimation of 6 kg of thrown tomato after the second day while the other was sold to consumers and another second retailer. The number of tomatoes from the box sold was recorded and the number of defected and perished ones due to overripe was quantified. Having that specific average box weight at the retail market is 57 kg, the following trend was found. Defect in this context includes damaged by insect-pest or diseased.

Technically, an average 13.5 kg (25%) of tomato loss from the

Table 18: Tomato loss during selling and factors from case study assessment.

	Days			
Weight factors	**1st**	**2nd**	**3rd**	
Initial Weight, kg	54.3	53	50	
Loss found on the mini-Etfruit due to different reasons				**Average total loss in each factor**
Mechanically damaged, kg	0.5	1.51	2.1	4.1
Overripe and/or perished, kg	0.376	0.7.5	6.2	7.3
Defected, kg	0.5	0.7.39	0.8.25	2.1
Average total loss/kg per box/in each day	1.4	3.0	9.1	-
Average total loss/kg per box/in three days				13.5

Table 19: Summary of tomato loss at different chain actors of the three districts of Sidama Zone, Ethiopia (2012/2013).

Chain actors	Loss (%)
Producers	24
Wholesalers	9
Retailers	3
Hotels and cafés/Consumers/	6
Total	**42**

sampled box was considerably found. The loss due to mechanical damage, over ripen and defects were 4.1 kg, 7.3kg and 2.1 kg respectively after three successive days marketing period. This result indicated that loss due to over ripen was the highest as compared to loss due to mechanical damage and loss due to defects. Besides, loss due to mechanical damage (4.1 kg) was twofold higher than that of loss due to defects. The average total losses /kg per box/ in each day were 1.4 kg, 3.0 kg and 9.1 kg consecutively. As shown in Table 19, the loss increased as the marketing period of tomatoes increased. This was due to improper handling, packaging and storage practices of retailers. However, the reality showed that considered loss like overripe, mechanically damaged and some of the other defects were sold mixed to those HH with small income sources. In that case, the loss found from Miss Wishu retail market was only from the over defected, over perished and some damaged tomatoes, which was 5.5%.

Total Post-harvest losses

The tomato loss in Sidama Zone study districts at different chain points and chain actors is shown in Table 19. The table shows the loss of tomatoes from producers, wholesalers, retailers, hotels and cafés with a total loss of 42%. As described above, these losses occur due to several post-harvest activities during the value chain with the fact that many of the horticultural crops have a relatively short duration after harvest. Through the supply chain points of post-harvest, field loss was the most critical stage with the highest postharvest losses of 24% followed by the wholesale and consumers stages with losses of 9% and 6%, respectively (Table 20). Therefore, the total postharvest losses of fresh tomato fruits from harvesting to consumers stage were 42%.

The postharvest losses of 42% reported in Sidama zone tomatoes are lower than 60% as reported earlier in Tanzania [21-24]. The low postharvest loss observed in this study was possible due to the short transport distance from the production area to the urban market.

Raja and Khokhar, 1993 stated that postharvest losses in fruits and vegetables range from 25%-40% or even greater. The current result is greater than with the Raja and Khokhar statement. Seasonal post-harvest losses of fruits and vegetables are high in the tropics due to hot environmental conditions and moisture levels. The deterioration of fruits and vegetables starts right after their harvest, if not properly harvested [25-32].

CONCLUSION

Generally, the result showed that all handling practices employed in the field to consumers' level are not satisfactory. Therefore, each level actor should be required to involve in the postharvest loss reduction of tomatoes in the study areas. There is also a good opportunity for agro-processing (production of tomato paste and ketchup) in the study area through the application of both modern and traditional processing technologies. Taking advantage of these opportunities, every actor will require working in linkage with each other for mutual benefit, producers to traders to processors to consumers, and that strong flow chain be developed to help producers and traders create and adopt technologies and skills.

Therefore, there is a wide range of post-harvest losses encountered that need attention to reduce losses throughout the process of pre-harvest handling, harvesting condition (pre-maturity, over maturity, harvesting tools, harvesting skills), post-harvest handling (pre-cooling, sorting, grading, curing, packaging, temporary storage, transport, and market distribution/linkage).

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