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Research article

Assessment on post-harvest losses of tomato (*Lycopersicon esculentem* Mill.) in selected districts of East Shewa Zone of Ethiopia using a commodity system analysis methodology

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ABSTRACT

One of the main challenges facing Ethiopia today is to ensure food security for its rapidly growing population. Although Ethiopia's production is much lower than the national demand, there are high post-harvest food losses. In meeting a country's food demand, increasing production by itself is not enough unless what has been produced is properly managed. In line with this, extensive assessment of post-harvest losses of tomato along the supply chain and the associated factors were evaluated in four purposively selected districts of East Shewa Zone of Ethiopia. The assessment was made using Commodity System Assessment Methodology from "farm-to-fork" to investigate the status of post-harvest losses of tomato along the supply chain and the associated factors in the pursuit of recommending appropriate mitigation strategies. Information was gathered from a total of N = 408 sampled chain actors (producers to consumers) and related institutions. Results revealed that losses of tomato due to improper care and handling of the commodity regardless of its high production in the study area were common problems for all chain actors. A loss of 20.5%, 8.6%, 2.9%, and 7.3% at the producer, wholesalers, retailers, and hotel and café level was recorded respectively with a total loss of 39.3%. Total losses across districts ranged from 17.2-33.3. Field, transportation and market display were major critical loss points identified. Practices such as market fluctuation, lack of temperature management, no/poor sorting and mixed handling of the crop, carelessness on the loss prevention and its impact were identified among the common causes for observed losses. Therefore, creating awareness on the effect of all causes of food loss and minimizing economic loss is recommended. Moreover, affordable and appropriate technology adaptation is needed to reduce observed food losses across the districts.

1. Introduction

Tomato (Solanum lycopersicum) is one of the popular crops in the world, including tropical countries like Ethiopia. Owing to its rich source of vitamins and minerals, particularly as a rich source of lycopene (60–90 mg/kg), tomato is an important component of human diets (Yusufe et al., 2017). It is ranked first among all vegetables in terms of its nutritional contribution with high biological activity in the human diet (Splittstoesser, 1990; Suarez et al., 2008). Tomato, being rich in carotenoids, β-carotene, total polyphenols content and ascorbic acid, is gaining importance as the least expensive source of antioxidants (Slimestad and Verheul, 2009; Veillet et al., 2009). Research indicates that bioactive compounds such as polyphenols have many physiological benefits related to the circulating organ functions; as anti-oxidant, anti-inflammation, blood vessel relaxation, and capillary wall stabilizing agents (Husselund et al., 2013).

In the East Shewa Zone of Ethiopia, the majority of fresh tomatoes are produced by small-scale farmers. These farmers are interested in tomato production more than any other vegetables due to the possibility of multiple harvests, resulting in high economic return per unit area. Moreover in the East Shewa Zone, many farmers are encouraged to produce vegetables for the nearby urban centers (Lemma, 2002). The bulk of tomato production is concentrated in river valleys and lakes, especially in the Awash Valley and around Lake Ziway for their favorable growing conditions, good access to market outlets and better infrastructure and other facilities. Productivity of tomato farms ranged

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from25-40 tonnes per hectare. Approximately 3,300 ha of private holdings were under tomato cultivation, and the total volume of fresh tomato harvested was 347, 27.748 tons (Ethiopian Investment Agency, 2008).

Despite its nutritional, economics and health importance, production of tomato is constrained by post-harvest losses, which limits the volumes of good quality produce reaching consumers. The perishable nature of produce, inferior technology, and lack of awareness among producers as well as market actors resulted in poor handling of the tomato (Bombelli and Wright, 2006). Although increasing production is one aspect of fulfilling food demand, failure to reduce post-harvest loss reduces the availability of food vegetables and income that could be generated by selling the vegetables. The issue of post-harvest losses is of high importance in the efforts to combat hunger, raise revenue and improve food security in the world's poorest countries like Ethiopia. Roughly, one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (Gustavsson et al., 2011). In a study conducted on post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia, the highest post-harvest loss (45.3%) was recorded for tomato (Kasso and Bekele, 2018). In contrary, the global population exceeded seven billion people during 2011 and is predicted to reach 9.3 billion by 2050 (Bond et al., 2013). Alongside more mouths to feed, increasing economic development allows people to consume more, leading to a projected increased food demand of 50–70% by mid-century (Vos and Giovanni Bellù, 2019). Many researchers stated the reduction of post-harvest losses is reported as a critical component of ensuring future global food security (Aulakh et al., 2013; Garikai, 2014; Belik, 2018). Therefore, to device alternative solutions for loss reduction, it is necessary to identify major causes of losses, critical loss points and to quantify the scale of these losses.

To measure postharvest losses for fruits and vegetables, researchers have developed various methods, each focusing on different aspects of the value chain (Kitinoja and Kader, 2015). Among the post-harvest loss measurement approach, commodity system assessment methodology has developed to identify the critical loss points and significant causes of losses, and use local and low-cost technologies/techniques to solve or minimize the problem. It helps the operation within the context of the local, regional or national commodity system. The methodology helps to determine whether any of the practices which are used to produce, handle or market the commodityare the cause of post-harvest losses, quality problems, loss of economic value and nutritional quality (La Gra, 1990).

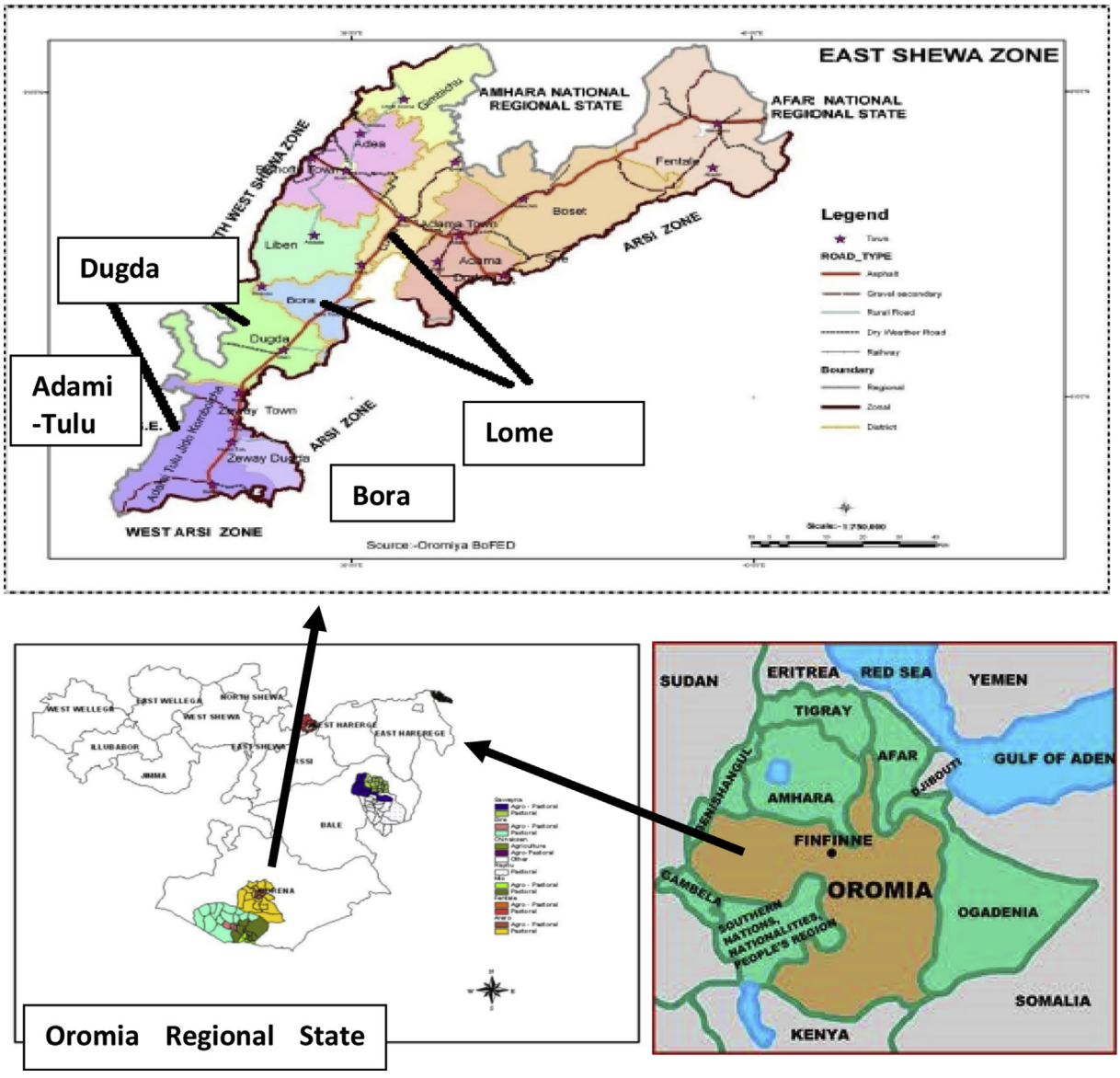

Figure 1. Map of the Study area, East Shewa Zone. Source: OBFED, 2009.

Although tomato is a major agricultural product in Ethiopia, to date, little work has focused on identifying the key constraints and potentials on the system. So far, few studies have been made to address agronomic and pre-harvest management and postharvest treatment (Meaza et al., 2007; Temesgen et al., 2011; Meseret, 2010). Moreover, most research conducted on postharvest losses of tomato focused on market assessment (Abay, 2007; Adugna, 2009; Alemnew, 2010; Birhanu, 2011) and no extensive study has been done to identify post-harvest loss of tomato from farm gate to the point of consumption due to improper harvesting, post-harvest handling, transportation, intermediaries' malpractices, storage and other reasons. Therefore, it becomes inevitable to identify the operations and channels where significant losses occur. In this study, we collected comprehensive data along the value/market chain using a commodity system analysis methodology. A better understanding of where these losses occur, and at what extent, could lead to developing and/or implementing technology or practices to reduce post-harvest losses of tomato.

2. Materials and methods

2.1. Description of the study area

The study was conducted in four districts of East Shewa Zone of the Oromia Region, Ethiopia (Figure 1). The Zone is located east of Addis Ababa. It extends from $7^0 33' 50''$N to $9^0 08' 56''$ N and from $38^0 24' 10''$ to $40^0 05' 34''$E in sub-tropical and tropical climatic zones and a large portion of the zone is located along the Rift Valley. The four study districts were purposely selected for their high tomato production and marketing flow for many major market centers of the country as a whole and its vicinity for nearby major roads of the country, including the Djibouti line. The area lies in the Great Rift Valley system of the Horn crossing Ethiopia and ecologically characterized by dry and arid climatic conditions with an abundant water source, vicinity to center market, relatively suitable road and environment for the production of vegetable relatively than the other areas of the country.

2.2. Sampling and data collections methods

Relevant data were collected using modified questionnaires adopted from La Gra (1990) with semi-structured interviews, formal questionnaires, direct observations, and retrospective method (organizational diagrams). The post-harvest handling related inquiries were prepared, pre-tested with sample respondents, rechecked for its appropriateness for clear understanding and responding, and distributed to the respective selected representative respondents. Then data focusing on factors related to loss and their causes, farmer's practice of handling the tomato from production until they take it to their buyer; their interaction with the respective actors and government and physical flows of produce were gathered.

Yamane (1967) sampling formula with a 90 percent confidence level and population proportional to size (PPS) to each district was applied to get representative households respondents.

$$n = \frac{N}{1 + N(e)^2}$$

where:

n = sample size for research uses.

N = total number of tomato producing household in the target area

e = margin of error at 10%

Accordingly, 99 tomato producers were randomly selected and interviewed. Efforts were made to account for gender representations, and the actual random sampling resulted in 30 female-headed households from the 99 sample producers. Interview of the household heads was conducted in the presence of their spouses.

For complete seller survey, as the exact number of wholesalers in the districts was not known, sufficient and representative respondents were used using purposive sampling. Therefore, 14 (8 from Addis Ababa, three from Meki and three from Ziway) wholesalers were interviewed from the four districts markets including those found in Addis Ababa, most often found in "Atikilt Tera": the biggest central fruit and vegetable market in Addis Ababa. Based on the current availability and number of traders located in the selected areas of each district, representative samples of 70 retailers/traders were interviewed as participants in the tomato commodity chain. Samples were taken from the four districts of the East Shewa Zone, Addis Ababa and Adama town. These retailers included roadside sellers, town market displayers and other small-scale traders. Information on smoothness flow of commodity to the market and consumer were collected from traders. Their know-how and application of their best towards the safety and accessibility, the provision of their services to the customer and their source, farmers/producers; their coordination and communication system with whom they work were gathered.

Sufficient representative consumer respondents were interviewed considering the nearby market and consumers' vicinity to the study area. Randomly selected consumers of 129 were interviewed about their daily experience towards the quality and handling of fresh tomato together with their marketing practice, a social aspect of consumption and perception towards post-harvest loss of the tomato. Under this group, 96 hotel/café owners were also purposively selected and interviewed. The criterion for choosing hotels and cafés was due to their significant use of tomato as a food crop.

Finally, focus group discussions (FGDs) were conducted with significant target groups to get perceptions of different stakeholders along with the commodity chain system and to cross-check the reliability of the information obtained. Accordingly, eight group discussions of producers divided into two subgroups (men and women), each having 5 men and 3 women and a total of 48 people participated for the FGD. Additional and necessary information was also obtained from key informants, like development agents, agricultural officers, and research professionals, MARC (the national fruit and vegetable research-coordinating center) by involving two FGDs with 7 participants. The postharvest management practices were also observed and recorded for the purpose of triangulation.

2.3. Data analysis

The raw data from the survey questionnaire were re-coded, organized and analyzed using SPSS (version 16.0) and Microsoft Excel 2007. Relevant mathematical computations and inferences were made accordingly. Descriptive statistical analysis (means ± standard deviation, percentage and Chi-square) was used in describing socio-demographic, post-harvest handling practices and associated post-harvest loss of tomato. Correlation analysis was used to explore the relationship between post-harvest handling practices and post-harvest losses of tomato. An independent sample t-test was also conducted to examine the significant effect of post-harvest handling practices along with the tomato supply chain on its loss. Matrix ranking was used to describe the relationship between socio-demographic and tomato post-harvest loss and to rank tomato marketing problems.

3. Results and discussion

3.1. Socio-demographic characteristics of the respondents and their correlation with post-harvest loss

Among respondents interviewed, their age and family size (Table 1), their primary means of income (Table 2), gender, marital status, educational levels and their association with post-harvest loss of tomato were quantified (Tables 3 and 4). Age and sex compositions are the primary demographic features used to characterize the working capabilities of the

Table 1. Mean of ages farming households, family size and price of tomato in the East Shewa Zone districts.

Indicators	Lume (n = 15)	Bora (n = 20)	Dugda (n = 31)	A/Tulu (n = 33)	Overall (N = 99)	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Means ± SD	
Age of HHH	35.3 ± 5.8	35.0 ± 5.2	34.8 ± 4.9	34.0 ± 3.2	34.7 ± 4.6	0.785^{ns}
Family size	5.6 ± 1.8	5.9 ± 1.9	5.2 ± 2.7	5.40 ± 2.2	5.5 ± 2.2	0.796^{ns}
Price, birr/box	166.7 ± 24.4	177.5 ± 25.5	177.4 ± 25.3	175.8 ± 25.4	175.3 ± 25.1	0.547^{ns}

ns = no significant difference at $p < 0.05$ using independent t test; HHH = head of household.

Table 2. Ranking matrix of significant means of income of the respondents.

	Prime income sources						Rank
	Components	1	2	3	4	Value	
1	Vegetable production only	X	1	3	1	2	2nd
2	Livestock production		X	3	2	1	3rd
3	Mixed type farming			X	3	3	1st
4	Other sources				X	0	4th
	Superlative income sources among vegetables						
1	Tomato	X	1	1	1	3	1st
2	Onion		X	2	2	2	2nd
3	Cabbage			X	3	1	3rd
4	Pepper				X	0	4th

respondents. Sex distribution among the respondents was 69.7% men and 30.3% women. The proportion of females in the present study was observed to be better than the reports of Adugna (2009) and Alemnew (2010), whose sample of farmers was 97.5% male. The higher proportion of women that we observed during sampling was possible due to the presence of a sufficient number of women producers in the study area. The result shows that, there is a favorable condition to encourage women participation in tomato production and handling in the area. In the study area, men were found to be often responsible for farm work, and the women have the primary responsibility in the reproductive roles, marketing of smaller quantities of farm products and purchase of food and non-food items for consumption.

There is no significant difference ($p > 0.05$) among respondents in terms of age, and the mean age of respondents was 34.7 years and ranged from 26 and 50 years and it is lower than what was reported by Adugna (2009); Alemnew (2010)who found 42.7 and 42 years mean age, respectively in their works. The result clearly showed that the age range of the household remained within productive age (15 and 64 years) (Birhanu, 2011). As depicted in Table 3, family size ranged from 1 to 10 with a mean of 5.5 (~6) family members per household. Larger family size could be considered as an advantage in the small-scale horticulture business. For instance, Birhanu (2011) mentioned that increase in family size was directly proportional to the productive labour force for avocado production, which might result in the lower dependency ratio, affects the

Table 3. Relationship of demographic characteristics and loss of tomato in the study districts.

Variables		Mean (±SD) percentage loss	t-test
Sex of respondents	Male	21.70 (±5.84)	2.886**
	Female	17.60 (±7.86)	
Marital status	Married	20.60 (±4.84)	0.177^{ns}
	Unmarried	21.36 (±7.78)	
Education	Literate	20.59 (±6.74)	1.572^{ns}
	Illiterate	13.58 (±1.20)	

**significant difference; ns = non-significant difference.

Table 4. Correlation of tomato loss versus age of respondents and family size.

		Total Loss	Age of Respondents
Pearson Correlation	Total Loss	1.000	0.248
	Age of Respondents	0.248	1.000
Sig. (1-tailed)	Total Loss	.	0.007
	Age of Respondents	0.007	.
		Total Loss	Family size
Pearson Correlation	Total Loss	1.000	-0.052
	Family size	-0.052	1.000
Sig. (1-tailed)	Total Loss	-	0.304
	Family size	0.304	-

supply of avocado positively and thereby leading to better participation in markets. Besides, Bezabih and Hadera (2007) have witnessed different labour sources are employed in horticultural production of eastern Ethiopia, where family labour takes the majority share of work.

Among the respondents of the study districts 39.4, 30.3 and 30.3 % were married, unmarried and widowed, respectively. Most of the widowed respondents were women who are responsible for caring for their children and their farming activities. Of the entire population of respondents 97% were literate. The majority of respondents (50.5%) attended primary school, 35.4% attended secondary school, 7.1% with the ability to read and write, 4% with a certificate and above, and the remaining respondents (3%) were illiterate. Especially in the rural areas, the literacy rate is much lower. The 3% illiteracy rate of the farmers could be due to involvement of farmers in livelihood activities, prevailing poverty in the area and fewer opportunities for education as explained by Rehman et al. (2007) for tomato farmers in Pakistan.

In the study districts, there are diversified sources of income to the household, but the major one was found to be mixed type farming (Table 2). These farms produce vegetables, maize and other crops as well as rear animals and participate in small scale trading of what they produced. Tomato, onion, head cabbage, melon, papaya, and others represent the significant vegetables and fruits grown in the study districts (Table 2).

The best income source among vegetables was rated to be tomato followed by onion, cabbage and green pepper. The proportion of growers in respect of the crop type they grow showed that 65.65% were noted to be involved in growing tomato and onion; 19.2% in tomato, onion and maize and 15.15% in tomato only (Table 2).

The social, economic, cultural and other demographic characteristics of producers may lead to a different role in practicingproper management required by the agricultural produces. From the observed field and other points of the chain in tomato, the result (Table 3) showed that gender plays a significant role ($p < 0.01$) in the loss, that higher losses were recorded for men (21.70%) than for women (17.60%). This result is in contrast with the idea of Mequanent (2009), who explained males are better than female farmers regarding farming experience and access to technologies. Females are more attached to giving care/management and mostly settle than males. Due to their expertise, they try to handle their products and reduce loss. With the fact that agricultural activities are seen aslabour-intensive, and therefore male-dominated, females hire labour, even paying an extra cost.

The marital status could imply post-harvest losses in tomato production since; married farmers are likely to have access to more family labour, especially for harvesting. The time taken to do the harvesting may be longer, and in an attempt to rush the works fruits are poorly handled due to poor skill in handling as compared with hired labourers (Ayandiji and Omidiji, 2011). With this fact, there was a high loss recorded even though it is not significantly different from the unmarried producers.

There was no statistically significant difference in post-harvest tomato losses between literate and illiterate participants. Level of education showed a negative relationship with the extent of loss of tomatoes that relatively higher loss from literate participants (20.59%) than the illiterate ones (13.58%). The reason could be due to the presence of other option as a source of income for those educated farmers/producers. Basavaraja et al. (2007) revealed the education level of farmers influences the post-harvest losses significantly at farm level. Literacy is a contributory factor to high post-harvest 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 (Ayandiji and Omidiji, 2011). But it was observed, in the contradictory, that those producers with higher education do not care much after they pick the amount they want it to cover their cost with enough profit. But those with least education seemed to give relatively good care and fighting problems to pick as frequent as possible. The difference appears it is the matter of having another source of income or not.

There was a positive relationship between the age of producers and significant loss of tomato (Table 6). As the age of producer's increases, the loss recorded at different points of the chain is relatively higher. The possible reason might be the young are more aggressive with marketing or better use of technology than the older ones. Moreover, the involvement of the older ones in another business, social interaction and related issues can also play a role in the less care given to the tomato, which in turn results in loss. We observed a negative, but statistically non-significant, relationship between tomato loses and family size. Logically, the size of HH does not matter, but the number of active work force play a role in post-harvest loss reduction through involving into different postharvest activities.

3.2. Influence of post-harvest activities on tomato loss

3.2.1. Harvesting

The harvest time of tomato is considered as the most crucial factor in postharvest losses. In the research area, harvest time is determined by the commitments of farmers with the transporters, for long-distance transportation. Result of this study showed that all respondents do not have a specific time of harvesting but do it at any time of the day as long as they get market demand. Harvesting is done at any time of the day (mostly after 10 AM). A contrasting result was reported from Pakistan where farmers pick tomato crop early in the morning (79%) to bring their produce to the local and nearby markets. Farmers who transport their produce to distant markets pick their fruits in the afternoon (5%) and evening time (16%) (Saeed and Khan, 2010).

There was tomato loss during harvesting due to mismanagement of the time, criteria to harvest the tomato. Though non-significant differences exist between the points, the higher loss was recorded (Table 5). The result shows that loss exists whether the producers use their criteria to harvest and whoever harvests.

All respondents agreed that harvesting at any time of the day is just for the sake of making it ready for transportation/delivery and be available for sale in the open markets. This is in line with Saeed and Khan (2010) concerning the maturity index used to decide the time of harvest. Almost half of the respondent's benchmarked market demand while the rest said bothcoloursof the fruit and market demand being their reference to harvesting their produce. Other researches indicated standard tomato quality is primarily based on uniform shape and freedom from growth or handling defects (Suslow and Cantwell, 2012).

For home consumption, the majority of the respondents used entirely red tomatoes. At the same time, the rest mentioned that they had used tomatoes at any ripening stage as long as it is mature. Those who preferred fully red tomatoes reasoned out that such kinds of fruits are not meant to be marketed due to their perishable nature somewhat better used for home consumption than earlier stages of maturity. Those who said any stage of the fruit is used reasoned out that, they use fruit from the stage of turning to red ripe and after this stage, because they did not recognize what they use for home consumption is not a significant amount. It was not considered as that much influencing in reducing the amount of tomato to be marketed.

In most cases, hired labour was used to harvest the produce while some of them harvested their produce by themselves, including family members. Growers said there is mishandling of their produce by hired labour while harvesting due to carelessness, which leads to a loss in the field and subsequently in the market owing to the mechanical injury inflicted due to careless handling by hired labourers. These injuries include harvesting and placing overripe and damaged tomato fruits with healthy ripe fruits. The majority of hired labourers were illiterate.

From the total respondents, 73.73% respondents do not harvest their tomatoes at the appropriate maturity stage but practice mixed picking while the rest did not respond.

Table 5. Loss of tomatoes (%) as influenced by harvesting components.

Characteristics	Response	Means ± SD	p
Point of criteria to harvest	Market demand	20.42 ± 6.46	0.962^{ns}
	Colour of the fruit and market demand	20.49 ± 7.10	
Maturity for home consumption	Fully red	20.55 ± 6.90	0.753^{ns}
	Any stage as long as it is mature	19.95 ± 6.06	
Who harvests the tomato	Family of the householder	20.21 ± 5.25	0.883^{ns}
	Hired labour	20.49 ± 7.00	
The difference in maturity for home and market	Red-ripe for home and mature half red for market	21.63 ± 6.87	0.011^{ns}
	No difference for all	17.99 ± .84	

ns = non-significance.

3.2.1.1. Grading and sorting. During the assessment, the respondents replied that they do practice sorting. Mostly they sort out damaged and diseased from healthy as well as ripe from unripe & mature from immature. This finding might have similarity with the practice depicted by Suslow and Cantwell (2012) who mentioned distinction among grades is based predominantly on external appearances, bruising and firmness. The produce is sorted right in the field. Practically it was observed that there was also an attempt of sorting out those unfit and with externally visible damage and diseased fruits in the boxes in the market during the merchandising process. The final cull is often sold at a lower price and otherwise just used for animal feed on site.

The respondents seem to have graded products while selling their tomatoes based on the presence of damage and related defects and determine price differences. Though respondents were found to try to grade their produces, they, however, do not want to lose much because of the amount of tomato to be left unsold would be higher that they do not want to happen. Tomatoes with Mediocre quality are sold mostly to the nearby café/small restaurant owners and to be used immediately for sauce making for daily use in "Wet".

Most respondents replied that any size but the mixed colour and healthy, to be their first grade for local market while more prominent and half red to be for the distant market as first grade. Respondents often faced price change due to the difference in the quality of their produce. Some respondents indicated that there should be a voluntary or mandatory body for inspection of their produce and training provision. They further mentioned that they do not grade because they do not want to reduce the amount of their produce to be sold. They did not realize economic loss they could face due to cross contamination of deteriorated fruit with healthy ones.

3.2.1.2. Post-harvest treatment. All producers responded that they apply post-harvest treatment before marketing their tomatoes, which is cleaning from debris. Their practice is vital to the fruits, which otherwise leads to an additional cause of damage, disease, or another defect of the harvested produce. These practices lead to the reduction of the price due to poor appearance. However, there is a considerable amount of chemical applied for the sake of controlling and preventing diseases and pests while it is in the field, left as a visible residue after harvest (Figure 2).

However, there are no other standard technological treatments like washing and coatings because of the lack of know-how or due to expenses associated with such types of procedures. Regarding training concerning post-harvest treatments of the produce, 62.6% of them have attended training provided by the agricultural office of the districts. In contrast, the rest 37.4% did not train for unknown reasons. Those trained producers found the training helpful that they start to follow their produce while still in the field and also recognize the value of having good fruit to the market to get a reasonable price (see Figure 3).

3.2.2. Packaging of tomato

Packaging systems play an essential part in the logistic chain for protecting, labelling and stacking of valuable or fragile contents (Department Life Cycle Engineering and Febe-Ecologic. 2007). Methods of packing can affect the stability of products in the container during shipping, and influence how much the container protects their quality. Prepackaging or consumer packaging generally provides additional protection for the products (Rehman et al., 2007).

Wooden boxes are the packaging materials being used in the four districts. Rehman et al. (2007) reported similar practices from Pakistan. 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. When filling in the field, boxes are relatively bigger and overfilled. On the other hand, to bring it to the market, there is a relatively different box used, which is to be filled with less quantity of tomatoes than the previous one. The surface of the wood is rough such that it results in mechanical damage and other deterioration. There is a practice of using a previously used box due to cost and of course, limited awareness about possible cross-contamination. Those boxes are mostly placed in the house regardless of their piling or protection from rain and sun. The cost is one major factor for not to using new boxes or managing the bulk amount of the box, though the second can be related to carelessness.

Producers also predict the size and other criteria of the wooden box. They mostly know the effect of size and roughness of the surface of the box, but do not have an alternative option because of financial problem. The absence or poor packaging material in the major marketing systems of Ethiopia can be one massive problem for the horticulture industry.

Figure 2. Tomatoes in the market with a visible residue of unidentified chemical (a) and quality tomato fruits without any visible chemical residue (b).

Figure 3. Tomato boxes differ in their fill, which proves the weight of tomato is different among producers (Figure 3a and 3b) and final market holders (Figure 3c).

Birhanu (2011) pointed out that unavailability of standardized packing material has forced exporters in Ethiopia to import packing material from the Netherlands and Israel.

Boxes alone have different weight, but on average a boxes was found to weigh 7.1 kg (~7 kg). New ones can weigh up to 10 kg or more while those used for a more extended period might weigh as low as ~5 kg due to continued drying and damage considering the thickness of the wood used in general (Table 6).

There was also an argument in having the approximate weight of one box of tomato alone. Regardless of the information from most of the producers and traders, based on a sample of measurements, the average box of tomato weight was found to be 60.1 kg (60 kg). The gross weight of boxes (fruits plus box) was found to be 70 kg (with a mean total weight of 65.1 ± 1.7 kg) or more (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.

The results of the present study indicated that packing is the most critical factor damaging the tomatoes at a quite early phase of post-harvest handling. Loss of tomatoes due to packaging problem in Pakistan reaches up to 27% (23–27%) in different market places of the leading business point where tomatoes are brought from all over producing areas (Saeed and Khan, 2010).

The benefit of the producer is not only affected due to price fluctuation but also to the loss of saleable weight individual boxes between producers and the local retailers and the final market points or near consumer traders. Approximately, on average, the weight of a boxful tomato is recorded to be 60 kg (ranging up to more than 70 kg) at producers and nearby market. Still, there was a noticeable difference of approximately 10 kg less on the final exchange. This difference was not fortunate for one specific location and time but repetitive regarding time and place. There was an indirect check-up in cities and towns, like Jimma, Hawassa and others every time there was a chance to do so.

Reasons for this discrepancy in mass could include: the weight loss due to water loss on the long journey of the crop, and (2) on the suspect, due to mistreating of both the producer and the final user/consumer by the middlemen. One way or the other, the ones who suffer by price are the producers and consumers, of course, the latter being affected not only by price but also not getting quality products due to the time spent in between and the poor handling together with the perishable nature the crop.

There was a significant box weight difference between districts (Table 6), and the largest average being found in Dugda. Owing to the presence of high production and trading activity that might lead to giving attention to have new boxes, which are often relatively more massive than the frequently used ones that dried and worn out due to frequent use.

3.2.3. *Cooling and storage of tomato fruit*

Cooling produces to remove field heat is scientifically recommended by many researchers. Nevertheless, almost no practice of cooling tomatoes is done at any stage of the chain in the studied districts. There is no management of temperature. It was observed that fruits 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.

There was an observation that some producers who transport their produce to the local market with their donkey cart cover the fruit with the available materials, net-like covers (Figure 4a and 4d) and fresh and dried leaves (Figure 4b and 4c) to reduce exposure to the sun. This practice is one of the best practices observed at the producers' level.

A case study was conducted by taking a sample of six farms to know the damage of tomato due to overfilling of the box and rough nature of the wooden box together with the mishandling of the labour (Figure 5). There was considerable damage to tomato. Assuming that ten fruits weigh one kg and taking three average piles of boxes, fruits damaged by the box during filling and marketing both in the field and local market were counted. There were different ranges of damaged fruits with a range of 15–17 fruits per one box from the bottom box and 9 to 11 fruits per box from the middle box. There was a mean loss of 3.44 kg (5.7%), and 2.18 kg (3.6%) tomato from the bottom and middle piled boxes respectively. From the result, it is clear that the pile size affects the amount of fruit loss. There was a high loss in all the six farms. Using least significant difference mean separation test for injury, there was a significant difference ($p < 0.05$) between the bottom and the middle piled box and even among the farms due to the apparent difference in their handling practice.

The impact of mechanical damage (Figure 5b), though its degree differs based on the stage of ripeness, later on, results in deterioration of quality of the fruit (Figure 5c). Impact energy and stage of maturity had a significant effect on all types of mechanical damage. Severity and rate of latent damage increase progressively in fruits through time in natural conditions. This opinion is following that of Mohammadi-Aylar et al.

Table 6. Mean weight of packaging materials for tomato in the study districts.

Weight (kg)	Lume	Bora	Dugda	A/Tulu	Overall	p
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Weight of box alone	6.2 ± 0.8	6.7 ± 1.2	7.6 ± 0.8	7.2 ± 1.3	7.1 ± 1.2	0.001**
Mass of Tomato	58.8 ± 1.9	59.5 ± 1.8	60.9 ± 1.3	60.2 ± 1.6	60.1 ± 1.7	0.001**
Total weight	63.8 ± 1.9	64.5 ± 1.8	65.9 ± 1.3	65.2 ± 1.6	65.1 ± 1.7	0.001**

** significant difference.

Figure 4. Tomato covered with available materials; net-like covers (Figure a and d) and dried leaves (Figure b and c) for protection from sun exposure.

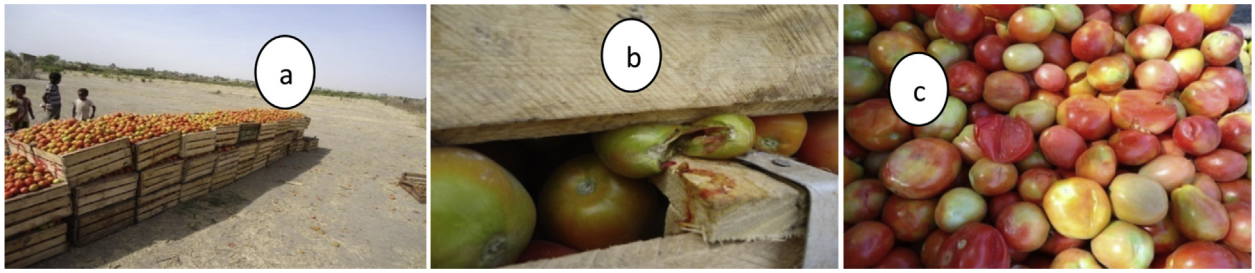

Figure 5. Tomato boxes piled right in the field (a) during transportation (b) and market places(c) depicting damages that cause loss.

(2010) who stated the different ruptures caused to the tomato fruits depend on the stage of the ripeness-occurred in 30% of the samples through 24–72 h storage.

In this study, we found no evidence of producers storing tomatoes: storage was practiced by traders and roadside markets only. In Pakistan, losses at storage, grading and distribution across the supply chain in Pakistan do not show many differences in occurrence and remain 3%, 1% and 1% only respectively (Saeed and Khan, 2010). The primary reason why the producers do not store tomato is; due to less production, perishable nature of the produce, and there is no modern technology knowledge to store and finance problem. Even sometimes, in case there is a misunderstanding with buyers, though happen rarely, they use wooden boxes placed piled.

3.2.4. Mode of transportation of tomato

In this study, there were different modes of transportation used by the farmers for tomato marketing. There was a significant difference ($P < 0.05$) among the mode of transport used. Majority of the tomato growers (60.6%) bring their produce to the local market used cart with pack animals as a mode of transportation while the remaining farmers (39.4%) use a truck (Table 7). Rehman et al. (2007) clarified that during transportation the produce should be moved by proper packaging and stacking, to avoid excessive movement or vibration because vibration during transport may cause severe bruising or other types of mechanical injury.

Rehman et al. (2007) reported that tomato producer of Pakistan (59%) who brought their produce to other than the local market used a pickup truck as a mode of transportation, while the remaining 41% farmers used a cart and other means to bring their produce to the local market for sale. Animals play, same as transporting of other goods, a significant role in tomato production too. Regarding the use of transportation, donkeys attached with carts are used to transport tomatoes from farm gate to access roads and markets. This finding is in line with Birhanu (2011) who affirmed that donkeys and horses are principally used for transport of avocado.

Produce is loaded and unloaded within wooden boxes. There was no observed activity of dumping of the product on the truck during the assessment. Although containers were used, there was Spillage during loading and unloading of the fruit while transferring from producers' box to trader/buyer box and loading to the truck. There was poor handling of tomato together with the rough wooden container. Besides, 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 tomato.

Table 7. Means and frequency of transportation of tomato in the study districts.

Characteristics	Response	Percents	X^2
Type of transportation used	Truck	39.4	4.455*
	Pack animals	60.6	
Frequency of transportation	Twice	7.1	31.273**
	Three times	49.5	
	>3 times	43.4	

**significant difference at $p < 0.01$; *significant at $P < 0.05$.

The tomatoes pass through different transportation points as it is transported from the field until it reaches to consumer. There was a significant difference ($p < 0.01$) on the frequency of transporting the produce from farm to consumer. There was an observation from the majority of the respondents that tomato is transported three times, field to the retailer, and retailer to wholesaler, and wholesaler to major cities' market (Table 7). In some cases, there was more than three times the transportation of the produce when intermediary involvement is seeking additional profit, which is one of the major post-harvest loss problems observed during the assessment. There is also transporting the tomatoes twice, from field to wholesaler and then to major cities of the country.

There is also a loss between harvesting till sold in the market due to any reasons, mishandling, dumping from producers' box to buyers', exposure to sun and others. There was an average tomato loss of ~3.79 boxes/ha according to the respondents estimates. The causes of these mentioned included: theft and spillage.

A study in Pakistan by Saeed and Khan (2010) indicated transport is one cause of post-harvest losses and found up to 12% loss of tomato from three selected marketplaces. In contrast to what is usually expected, the results of this study showed that loss was relatively lower for produce transported along a longer distance, showing a negative relationship between distance and loss (Table 8).

As previously mentioned, there was a negative relationship between the volume of produce and loss. But considering market movement, it seems that the loss was high in areas where production and marketing activity are higher in the respective districts, where selling of tomato was tried at fresh and with a higher price to the wholesalers. Loss of tomato was found in the three other districts. With an overall mean distance of 8.02 km distance from farm to market (local market) of the study districts, there was a mean loss of 2.80 boxes/ha during transportation.

3.2.5. Delays/waiting

Due to the market problem, there is a delay of tomato shipping during handling in the study districts. Mostly the delay is when taking from field to market. According to the respondents, when it happened, the product waits to a maximum of half-day (71.7%). In some cases, there is a delay of one whole day (28.3%). The reason for this delay in collecting from the field is when the truck does not come on time.

On the other hand, there is also picking ahead of time. There are also cases where the deal is broken between the producer and the buyer. This breach can be due to misunderstanding or cheating by brokers/intermediaries.

If in case delay of the fruit occurred, fruit often remains under full sun in piled wooden boxes. Producers understand the side effect of exposing the fruit to the sun. They can tell quality and quantity reduction/loss, reduction in price and reduction on their encouragement to produce will result. Their primary reason for not doing a shading or other managements is the financial problem they experience and lack of knowledge on small-scale post-harvest practices on how to make shade using locally available materials with less cost.

3.2.6. Processing

To know the farmers' knowledge of tomato processing producers were interviewed whether they process and deliver tomato products to the best of their knowledge and experience. Though most of them know processed products (like ketchup and sauce like that of Merti product), they do not precisely practice delivering the required type of tomato type. They only have an experience of selling what they have produced on time to the existing market air as fresh.

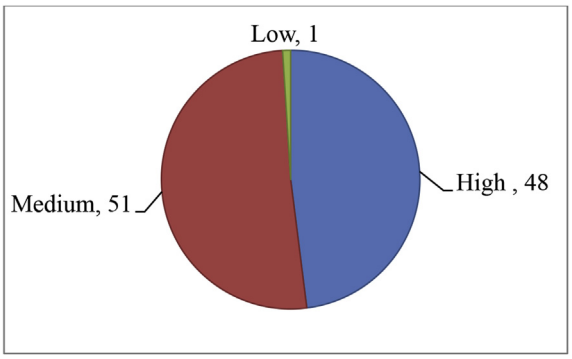

Figure 6. Extent of tomato loss at the producer level in East Shewa Zone districts.

There is also an activity of using over-ripe and unsold (together with the damaged one) tomato for juice and using it as a sauce for "Wet" by the local and nearby small hotel service providers. Rehman et al. (2007) explained that for reducing the post-harvest losses and gluts supply to the markets, the surplus or overripe produce is processed; this might have some public health consequences. Most of the tomato left behind because of inferior quality was used in the small cafés for daily food services.

The responses indicated that respondents directly or indirectly confirm the presence of the loss. The extent of tomato loss was found to be highly significant ($P < 0.01$). Figure 6 shows the response to the extent of loss of tomato that 99% of the respondents put the loss from medium to high. Tomato losses at or below 10% were classified "low", between 10-20% as "medium", and losses greater than 20% were classified as "high".

Table 9 shows, the significant points of the chain where losses occur are indicated. Based on the respondents' response together with an observation of the existing practice and handling condition, assumed a loss of tomato in the major areas of the study districts was recorded. From those, field loss (10.14% per ha) was the major contributor to the total loss recorded (20.45% per ha) in the study districts during this assessment. This loss was because of market fluctuation and interference of many intermediaries, crop sensitivity to damage during handling on the field and during harvesting, less knowledge on maturity indices of the crop and other reasons. Ayandiji and Omidiji (2011) reported that the more the days the tomato fruit spent on the farm after maturity, the more the loss.

The relatively huge loss was recorded from Lume district followed by Bora, Dugda and A/Tulu districts. There was a significant difference ($P < 0.01$) of loss within the different chain points and between districts (Table 9).

The reason for the high loss recorded in Lume districts could be not practicing of staking/support sticks for the crop by the majority of the producer; less care to the field due to proximity town doing other activities and others. It can lead to the weakening of the plant to carry the heavy load of the foliage. As a result, the fruit falls on the ground which leads to damage and spoilage of the fruit. Other reasons like the poor post-harvest practice of the harvested fruit by the actors in the chain might be almost the same between districts, but still reasonably contributing to the loss.

Table 8. Mean result of transportations of tomato in the study districts of East Shewa Zone.

Variables	Lume	Bora	Dugda	A/Tulu	Overall	p
	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD	
Distance from field to the local market, km	14.5 ± 5.5	6.6 ± 2.3	6.5 ± 2.1	7.4 ± 3.1	8.0 ± 4.2	0.001**
Transportation Loss, box/ha	1.9 ± 0.4	3.1 ± 0.6	2.7 ± 0.5	3.1 ± 0.6	2.8 ± 0.7	0.001**

** = significant difference.

Table 9. Mean weight Loss of tomato (Kg) per box at different point of producers in the four districts of East Shewa Zone, Ethiopia.

Variables	Lume	Bora	Dugda	A/Tulu	Overall	p-value
	Means ± SD	Means ± SD	Means ± SD	Means ± SD	Means ± SD	
Loss- mishandling (damping, sun exposure, etc)	1.46 ± 0.4	1.07 ± 0.4	0.98 ± 0.3	0.72 ± 0.3	0.99 ± 0.4[a]	<0.001**
Loss-field sorting	0.75 ± 0.1	0.47 ± 0.1	0.53 ± 0.1	0.57 ± 0.1	0.57 ± 0.1[cb]	<0,001**
Loss- to transport	0.70 ± 0.2	0.82 ± 0.1	0.66 ± 0.1	0.82 ± 0.1	0.75 ± 0.2[b]	<0,001**
Loss-market delay	0.79 ± 0.2	0.67 ± 0.2	0.64 ± 0.1	0.71 ± 0.1	0.69 ± 0.2[b]	<.0.001**
Loss- loading/unload	0.85 ± 0.2	0.51 ± 0.1	0.49 ± 0.1	0.50 ± 0.1	0.55 ± 0.2[b]	<0,001**
Loss- left on the field	17.25 ± 2.8	10.10 ± 2.0	8.68 ± 2.2	8.30 ± 1.5	10.14 ± 3.7[a]	
Total Loss	33.32 ± 5.1	20.38 ± 3.9	17.77 ± 4.1	17.16 ± 2.79	20.45 ± 6.7	

Means with the same letter vertically are not significantly different.
** = significant difference.

The cumulative percent loss of producers at the study districts found during this assessment was 20.45% of 6.7%) in the study districts during the assessment work period of 2011. The percent losses of tomato were calculated through estimating by averaging losses reported by the respondents during different processes of assessment, which is the same trend to what was said by Rehman et al. (2007).

As mentioned before, higher contribution of loss from left on the field in Lume district put the top in higher significant percent loss followed by Bora, Dugda and Adami-Tulu districts. The causes may be almost the same as that of Rehman et al. (2007) who listed the reasons as picking, grading, packaging, storage, transportation and poor marketing, though the loss was higher on the field in this case.

The significant causes of loss pointed out by the sampled respondents showed that the major one was a market delay (74.7%) followed by climatic fluctuations (25.3%) like heavy rain and flooding in farms adjacent to rivers, like that of Modjo River. There was no significant difference between districts on the agreement of those causes. The market delay being a considerable problem, field loss after harvest precedes all points of the chain as a point where high loss is recorded. This response was a general one. The first cause was the base for the other consecutive causes of loss of tomato and the result of different reasons. The market delay was mostly related to price fluctuation created by the intermediaries. Especially the brokers who hinder the information flow & communication and blocking of producer and buyer/wholesaler contact and their free-open deal on price and other means vis-à-vis the perishable nature of the crop.

3.3. Marketing components

Marketing is not merely the last step of handling fresh produce but must be part of the overall plan to provide products that best meets the needs of the consumer. La Gra (1990) described that consumer preferences play a significant role in determining the economic value of the fruit being sold. Madrid (2011) strengthens the need for assessing market-related factors with post-harvest loss that in the European Union, an estimated 4 billion Euro was lost due to post-harvest losses and reduced quality of fruit.

3.3.1. Market information

Assessment result indicated that fruit handlers and marketers have no access to current prices or volumes to plan their marketing strategies. The only ways getting information whether the price goes down or up, is through person-to-person communication. Although tomato production and market information is available in the agricultural office, the respondents doubt the accuracy of the available data. Moreover, none of the actors in the tomato value chain seems to practice record keeping. About 20% of the respondents were not willing to give a response to the information dissemination.

3.3.2. Market intermediaries

Many intermediaries participate in the passage of the produce from field to consumers' plate. There was a significant difference ($P < 0.01$) to whom tomato is sold. Accordingly, the majority of the producers sell to collectors or brokers while the rest sell to Unions, especially those members of the Union from Dugda and Adami-Tulu (Table 10). Some producers directly sell to the local market (4%). For instance, most of the producers from Meki and Ziway sell to Unions while brokers collect the majority of produce from Lume and Bora.

Brokers are majorly involved in price determination while the rest of respondents responded that they are not sure (technically fooled by brokers) who determine the price (Table 10). Sometimes they think the major market participant whoever starts it decides the market. Practically, these brokers/collectors are the significant bodies who handle the crop between producers and consumers. These intermediaries are not supposed to buy the fruit but control the buying-selling deal between the producers and the buyers. They hid 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 price agreement is made. There is no special attention/care and with ignorance in handling the produce. There is no/less

Table 10. Market price determination and role of intermediaries in determining marketing of tomatoes in the study districts.

Characteristics	Responses	Percent	X^2
To whom to sell the produce	Collectors/Brokers	72.7[a]	74.606**
	To Local market	4.0[c]	
	To Unions	23.3[b]	
Price determiner	Brokers	77.8[a]	30.556**
	Others	22.2[b]	
The Place to sell the produce	Farmgate	97.0[a]	87.364**
	Roadsides	3.0[b]	

**significant difference.
Superscript letter means with the same letter vertically are not significantly different.

Table 11. Rank matrix of marketing problems of tomato in the study districts and vicinity markets.

	Components	Rank
1	Brokers hinder fair sales	1
2	Perishable nature of the crop	2
3	Lack of market information	3
4	Lack of marketplace	4
5	Low price	5
6	Storage problem	6

awareness of what would happen to the product due to waiting/delaying with no special care. The method 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 the respondents agreed that all actors in the chain are responsible for losses. Producers and consumers are the two most affected parties. Producers are losing money, whereas consumers are affected both financially and in getting quality and enough quantity of safe produce.

There is a significant difference ($P < 0.01$) in the place where the product is sold. Most of the produce is displayed on the farm gate, including on-farm site to be sold whoever takes it, be it wholesaler or retailer (Table 10). It is the place where dealing takes place. Some producers sell their produce on the roadside for passerby.

The primary marketing problems of the producers are ranked based on the response priority given by the respondents (Table 11). Brokers who used to act as intermediaries serve both as a buyer and seller get benefit from both sides.

3.4. Tomato traders

As a significant source of tomato, Eastern Shewa hosts a considerable number of longer staying, in, and out traders of vegetables, mostly tomato and onion. The traders in selected markets of Eastern Shewa and Addis Ababa handle the average concentration of vegetables and fruits crops (Dawit and Hailemariam, 2006). For this study, 84 traders (70 retailers and 14 wholesalers) were used randomly from the study district towns and vicinity cities, including Addis Ababa.

3.4.1. Wholesalers and retailers

It was challenging to identify and find wholesalers due to the informal movement of the system. Fortunately, 14 were found from Addis Ababa, eight from Adama, three from Adami-*Tulu andthree* from Mekiwho were considered as wholesalers based on the volume of tomato they frequently handle on the chain. Their destination is different from a short distance, Adama, longer distance Tigray and other parts of the country.

From the total wholesalers, 71% of them started their establishments before five years ago, and the rest of them within the last five years. Almost all the establishments were launched from the "Atikilt tera", Addis Ababa. Their response showed they know the cause of loss and way of handling the crop. However, they load 84 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 coldest 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.

Wholesalers replied that they face a loss of up to 5 or 6 boxes per truck at the final destination market due to any reason. Causes mentioned were market fluctuations being the major one, temperature, poor filling and sorting and others. Besides, about 1.5–2 boxes of loss found during loading and unloading. Based on the season, market fluctuation condition, there could be almost half loss of the fruit after long-distance travel. 8.63% loss found from wholesalers starting from field loading up to unloading on the final destination considering the transportation, handling issues in between.

A sample of 70 retail respondents, including roadside, shops and town traders were randomly interviewed. Among them, 77% were women. Adeoye et al. (2009) reported a similar trend for more women involved in retailing than men did in Nigeria. Age of most the retailers lay in the range of 15–40, which is in line with Mashau et al. (2012) who reported most (74%) women hawkers of the respondents in South Africa were in the middle age category. Involvement of women in the production and marketing of vegetables, specifically tomato and onion, are encouraging in the study area.

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 crop 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. Majority of them were with knowledge about crop behavior and the consequence. For that reason, they indulge in the market after studying the market condition, which helps them to escape from losing much.

A case study was conducted to evaluate the extent of loss at retailer levels. Three boxes of tomato were taken as a sample to observe the degree of loss and related causes of damages, including its shelf life. One box was taken to Addis Ababa, "Atikilt tera" market and then taken/bought by retailer. The other two boxes to Ziway and data was just taken as rough estimation due to market rash. The retailer gave an estimate of 6 kg of thrown tomato after the second day while the other was sold to a consumer and another second retailer. Amount of tomato from the box sold was recorded, and the number of defected and perished ones due to overripe was quantified. The following trend was found from a specific box weight of 55 kg. Defect in this context includes damaged by insect-pest or diseased. Technically, 24.75 kg (45%) of tomato loss from the sampled box was considerably found. However, the reality showed those considered losses like overripe, mechanically damaged and some of the other defects were sold mixed to low income households. There was an assessment of tomato run by retailers to know the loss and related factors in possibly reachable retailers in the study areas. One trader/retailer runs an average of 8 boxes though ranges up to 12 boxes.

According to the retailers' response, there was a significant difference ($P < 0.01$) in distance that tomato travels with an overall mean of 15.6 km from field to the local market within the study districts and from its selling place to the final destination of "Gulit" or mini-fruit and vegetable market in a village for those town and city traders.

There was significant difference in terms of price of tomato between producer and retailers or traders. Even there was a difference ($P < 0.01$) between retailers at different market locations. Boxes of tomato located at a different position were significantly different between producers. Based on the assessment found, there was a total mean loss of 1.53% loss recorded during the 15.6 km mean distance coverage transport and 1.40% loss due to mishandling and others which is a 2.93% total loss at retailers' level.

Regarding loss of tomato vis-à-vis distance between farm and local market, there was a positive expressive correlation ($R^2 = 0.89$) result found indicated in Figure 7. The higher the number of the box of tomato transported and the less proper handling given, the more the fruit exposed to damages and lost.

3.4.2. Consumer

Regarding the awareness of consumers on post-harvest related issues, most of them (66.7%) do not have any reaction at all. The post-harvest problems are not given due attention. While some react (33.3%) showing no preference to buy produce poorly handled and with less quality (Table 12). This reaction of consumer 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 color are frequently observed in

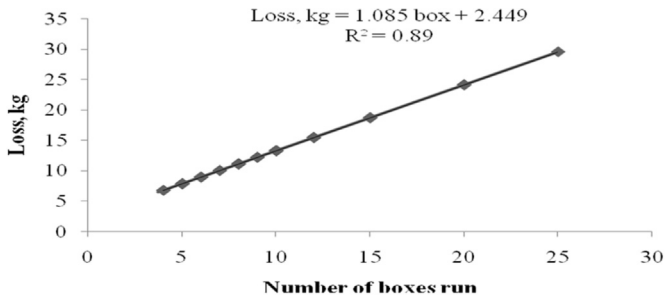

Figure 7. Relationship between numbers of boxes run by one trader Vs loss (kg).

Table 12. Consumer demands differences of the study districts, East Shewa Zone.

Characteristics	Response	Percent	X^2
Consumers' reaction to the practice of post-harvest handling & quality	No preference to buy	33.3[b]	11.00**
	No reaction	66.7[a]	
How do consumers react to the cost of tomato?	Negative	78.8[a]	32.818**
	No reaction	21.2[b]	

**Significant difference at $P < 0.01$.
Superscript letter means with the same letter vertically are not significantly different.

consumers' preference for the produce. Of course, all consumers in all districts prefer to purchase tomatoes at lower prices. There is a significant difference ($P < 0.01$) among consumers concerning the cost of tomato. Majority of them react negatively while the rest of the respondents face no reaction towards the value of the produce.

All respondents mentioned that there is a daily sign of unmet preference or demand of the consumers. The feedback from the consumer is that the price goes up due to 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 capita annual availability and consumption of fruit and vegetables in Ethiopia is less than 21.7 Kg per year (Ganry, 2009; WHO, 2011) which is much less than the minimum recommended level of, i.e. >146Kg per year (400 g per capita per day (Ruel et al., 2005). Minimal quantities of horticultural crops are daily consumed in Ethiopia.

Almost all of the consumers do not even think of the issue of post-harvest handling. Nearly all consumers responded that their concern is on the availability and accessibility of the fruit, not on the quality and the safety part of it. However, this does not mean that there is no preference for a quality tomato to poorly handled one. Consumers from the central town/city mostly raise the reaction towards the cost of tomato. This cost issue is not observed much from consumers nearby the source because of many options to choose. As a result, the price 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 household 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 any reason. This result showed that, everybody is feeling the post-harvest issue is not theirs but someone else's, but do not exactly know who.

3.4.3. Cafe and hotels

From the main town and city, 96 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 tomato for a maximum of two days use for customer service as salad, sauce with pasta-macaroni or "wet". Table 13 shows there was a loss of 2–7 kg from each box. It happened due to the mix filling of overripe and damaged tomato with the healthy one on-farm or retail market that initiates perishing the other too.

A price of one box of tomato by the hotel/café showed a price difference of 188.5 ETB and 86.7 ETB additional from farmer and trader, respectively (Table 13). The weight of one box of tomato on the point of café and hotels is with a mean of 60.3 Kg. From the assessment of the sampled hotels and cafes serving tomato in finished form, a mean total loss of 7.3% per box was found. From the sample areas, cafe and hotel from Addis Ababa and Adama recorded higher loss relative to the district towns. 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 the box was significantly different between locations of the hotels/cafés but not the number of boxes. There was also a statistically significant difference in price and loss of tomato.

4. Summary and conclusion

The study was conducted to assess the post-harvest losses in tomato in selected districts of East Shewa zone, Ethiopia. Tomato is one of the major vegetable crops in the Eastern Shewa Zone; it is produced widely in many places of the Rift Valley Region and serves as an essential means of income for the livelihood of vegetable farming local households. Despite the favorable climatic conditions and the high production of tomato supplying to the majority of the country's market, the management system on delivering the crop to local and export consumption is not up to standard. Post-harvest loss of the crop is one setback problem on the production and supplying sufficient amount in reducing food shortage and attaining food sustainability.

A total sample respondent of 408 was used for this assessment, from producers to consumers, based on the questionnaires and discussions. Significant samples of women were involved relatively. The estimated post-harvest loss of tomato in the study area at different chain actors/points was 39.31% (20.45% producers, 8.63% wholesalers, 2.93% retailers, and 7.3% from hotels and cafes) of the total production starting from producers to hotels and cafes. The significant factors thatcontribute to tomato quality defect and loss were market fluctuation, perishable nature of the crop, interference of many middlemen, lack of awareness on post-harvest handling practices and less consideration on the cumulative effect of every single cause of loss. Mixing ripened, overripe and green tomato, large crates and delays during transport and marketing: appear to be the primary sources of losses in the study. Reducing observed loss require working in linkage with each other for mutual benefit, producers

Table 13. Tomato price, the weight of the box of tomato and loss at hotels and cafes in East Shewa Zone and vicinity town/city.

Variables	Mojo/Koka	Alemtena	Meki	Ziway	A.A./Adam	Overall
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Price, birr/box, H&C	342.0 ± 62.2[bc]	305.8 ± 23.8[c]	294.3 ± 44.5[c]	367.0 ± 91.6[b]	449.6 ± 42.1[a]	363.8 ± 84.2
Wgt of box tomato, Kg	60.6 ± 1.9[b]	61.8 ± 0.8[ab]	62.3 ± 2.1[a]	62.7 ± 1.6[a]	54.0 ± 1.4[c]	60.3 ± 3.7
Loss, %	6.5 ± 0.9[c]	6.1 ± 1.0[c]	5.5 ± 0.8[c]	7.4 ± 0.9[b]	10.2 ± 0.9[b]	7.3 ± 1.1

H & C = hotels and cafés.
Superscript letter means with the same letter vertically are not significantly different.

to traders to processors to consumers. Tomato handlers with higher levels of formal education had lower post-harvest losses than those with lower education levels and indicating better post-harvest handling practices by professional handlers because of their ability to understand and adopt new technologies quickly. Therefore, tomato fruit handlers need to be trained on the latest appropriate and affordable technologies starting from those small and medium scale techniques of packaging, transporting and advanced techniques and methods of post-harvest handling. Moreover, working on post-harvest handling practices and marketing system through cooperation within Unions, and with NGOs and other governmental institutions is needed. Thus, strong flow chain is required to help producers and traders create and adopt technologies and skills.

Declarations

Author contribution statement

Gazai Abera: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Ali M. Ibrahim, Sirawdink F. Forsido, Chala G. Kuyu: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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