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Review Article

Post Harvest Loss of Tomato (*Solanum Lycopersicum* L) in Ethiopia: A Review

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Abstract

Post-harvest loss is one of the concerns of food security and poverty reduction strategies in many developing countries. Post-harvest loss of tomato in developing country like Ethiopia now become big issue, this is due to lack of proper harvesting, packing, storage, transport and handling. The objective of this study was to review the post-harvest loss of tomato both at the grower means farmers and retailers level and to review some points to reduce the loss. The primary sources of data were collected from both farmers and retailers, the secondary source were published from websites, Books, journal and other sources. According to researchers report different recommendation are forwarded, the most important ones are better crop management, proper harvesting, handling, packing, storage and transportation this can improve the quality make more profitable to growers traders to all those involved in the systems of their income earning. Proper Harvesting, handling, packing, storage and transportation this can improve the quality make more profitable to growers traders to all those involved in the systems of their income earning.

Keywords: Post harvest loss, Tomato, Post harvest handling

Introduction

Background

The tomato (*Solanum Lycopersicum* L) belongs to the family Solanaceae. Other useful members of this family include bell or sweet pepper, chili, Cape gooseberry, eggplant and potato. Farmers used to produce tall fresh market tomato varieties within plant support using different locally available material such as bamboo and sticks. Such plant support is an important production practices for crops in which economic yield is highly affected by poor field management and poor handling practices. In Ethiopia staking is most common practices by small farmers and urban gardeners due to excessive vine growth of crop. Currently in some growing area there is high shortage of staking materials and some farmers are facing serious problem in the production of the crop. Bush type tomatoes are becoming important for its early maturing, less need of plant support, easy to manage and so are cheaper to grow (Mac gilliv ray, 1961). In addition they have concentrated fruit set also have shorter duration of growth compared to tall sets. Some farmers are interested for such sets cultivars in the region.

In Ethiopia, the vegetable subsector has a vital role in human nutrition and health, farm income generation, poverty alleviation and foreign currency earnings through export and foreign direct investment. Processed products such as tomato paste and tomato juice are produced for export to Somalia, Djibouti and Saudi Arabia, making a significant contribution to the national economy. Ethiopia's wide range of agro climatic conditions and soil types makes it suitable for the production of both warm and cool season vegetables. Vegetable crops are suitable for production under intensive systems, where some farmers produce two to three times within a calendar year in Ethiopia. However, vegetable production in the country is constrained by several challenges. Among them, postharvest loss of vegetables such as tomato is of critical importance.

Postharvest losses (PHL) refer to the losses that occur along the food supply chain, from the farm gate through till it gets on the table of the final consumer. Losses are encountered along the chain in the handling, storage, transportation and processing, thereby resulting in a reduction in the quantity, quality and market value of agricultural commodities. Within developing countries' context and in Ethiopia particularly, concerns about reduction of quantitative losses (i.e., weight, volume or total wastage of agricultural produce) are of higher priority than qualitative losses such as loss in edibility, nutritional quality, caloric value and consumer acceptability of the produce. It is also known that, in general, qualitative losses are much more difficult to assess than quantitative losses.

The main causes of postharvest losses include mechanical damage, physiological deterioration and biological (i.e., postharvest diseases and insect pests). Rodents and birds also cause postharvest losses, especially in fruits such as tomatoes, although such losses tend to be relatively small for vegetables compared to damages due to rough handling, poor packaging and quality losses caused by temperature stress. In some cases, postharvest losses of vegetables such as tomato are also attributed to socioeconomic and institutional factors, viz. inadequate marketing information and support systems, inappropriate transportation facilities, unfavorable government policies, inability to implement regulations and legislations, lack of appropriate tools and equipment, lack of technical know-how and poor maintenance culture for existing facilities

and infrastructure. In most developing countries such as Ethiopia, roads are not adequate for proper transport of horticultural crops, while transport vehicles and other modes, especially those suited for fresh horticultural perishables, are in short supply. Moreover, the extent of losses is significantly influenced by pre harvest conditions and field operations such as cultivar and soil types, crop management practices, poor weather conditions, insect pest control programs and harvesting as well as packaging and handling practices.

Food supply can be induced either by increase in production or reduction of loss. Reducing postharvest loss of produce is key technique in improving food security for people while saving natural resources and energy [1]. Ayandiji., *et al*. (2011) reported that, with the reduction of postharvest losses by 50%, food availability would be increased by 20% without cultivating an additional hectare of land for increasing crop yield. Furthermore, there have not been many researches undertaken on the impacts of food loss in developing countries (Ayandiji., *et al.* 2011). Furthermore, well organized documents that indicated post harvest loss of tomato ' were not existed. Thereby producers and marches could not got adequate information about causes of losses its control mechanisms. Little information is available regarding postharvest loss of perishable produces. Inefficient pre and postharvest handling practices, postharvest losses and major issues of food quality are becoming major challenges in food security [2]. However, for applying any loss reduction techniques, major causes, extent and general postharvest system has to be identified at initial stage. To organized this review I was follow the primary sources of data were collected from both farmers and retailers, the secondary source were published from websites, books, journal and other sources Thus the objectives of this review was to compiled different research report about extent of causes of post-harvest loss and mitigation measure of tomato at the farmers, wholesalers and retailers level.

Literature Review

Tomato and its origin

The word tomato (*Solanum Lycopersicum* L) introduced into Spanish language come from nahuatal word tomato was applied to plant bearing spherical fruit or berries. Tomato is fruit that is almost universally treated as vegetable and perennial plant that is almost universally cultivated as annual. The center of origin of genus *solanum* section *lycopersicum* (formerly genus *Lycopersicon*) is the Andean region that includes parts of Colombia Ecuador Peru Bolivia and Chile all tomato wild relatives are native to this area [3,4].

The tomato was cultivated in small vegetable orchards of meso American areas. World tomato production in 2001 was about 105 million tons of fresh fruit from an estimated 3.9 million ha. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily. Tomato belongs to the Solanaceae family. This family also includes other well-known species, such as potato, tobacco, peppers and eggplant (Auvergne). Tomato has its origin in the South American Andes. The cultivated tomato was brought to Europe by the Spanish conquistadors in the sixteenth century and later introduced from Europe to southern and Eastern Asia, Africa and the Middle East. More recently, wild tomato has been distributed into other parts of South America and Mexico. Common names for the tomato are: tomato (Spain, France), tomato (Indonesia), Fawn keep (China), tomato (West Africa), tomatl (Nahuatl), jitomate (Mexico), pomodoro (Italy), Nyanja (Swahili). Tomatoes contributes to a healthy, well-balanced diet. They are rich in Minerals, vitamins, essential amino acids, sugars and dietary fibers. Tomato contains much vitamin B and C, iron and phosphorus. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. They can be processed into purées, juices and ketchup. Canned and dried tomatoes are economically important processed in and domestication of the cultivated tomato [3].

Ecology of tomato

Soil and climate

Tomatoes should ideally be grown in deep, fertile, humus-rich, free-draining, but moisture retentive. It grows well on most mineral soils that have proper water holding capacity and aeration, and are free of salt. It prefers deep, well drained, sandy loam soils. The upper layer needs to be permeable. Soil depth of 15 to 20 cm is needed to grow a healthy crop. In heavy clay soils, deep ploughing allows better root penetration.

Tomato is moderately tolerant to a wide range of pH level of acidity, but grows well in soils with pH of 5.5 to 6.8 with adequate nutrient supply and availability. Addition of organic matter is, in general, favorable for good growth. Soils with very high organic matter content, like peat soils, are less suitable due to their high water holding capacity and nutrient deficiencies.

In entirely unrestricted soils, a few tomato roots may penetrate to a depth of over 2m, but the greatest concentration of roots occurs in the top 600 mm of soil, which is considered to be the effective rooting depth of this plant. Soils with a minimum depth of 600 mm should thus be selected, with even deeper soils receiving preference. The tomato does well in humus rich soils and will respond well if grown after a green manure or soil-improving crop.

Temperature and light

Tomato requires a relatively cool, dry climate for high yield and best quality. However, it is adapted to a wide range of climatic conditions from temperate to hot and humid tropical. The optimum temperature for most varieties lies between 21 and 24°C. The plants can survive a range of temperatures, but the plant tissues are damaged below 10°C and above 38°C.

Tomato plants react to temperature variation during the growth cycle for seed germination, seedling growth, flower and fruit set and fruit quality. If cool or hot weather spells persist during flowering, pollen production will be low. This will influence fruit formation. Frost will kill the plants. To avoid frost damage, it is best to wait until the winter is definitely over before sowing. It is possible to sow indoors earlier (in pots or trays). Light intensity affects the color of the leaves, fruit set and fruit coloring tropical lowlands; the minimum temperature at night is also important [5].

Water and humidity

A simple rule of thumb can be used to determine whether local water supplies are sufficient for growing tomato. If there are herbaceous plants (plants with many thin leaves) growing in the natu-

ral environment, it will be possible to grow tomato. You should be able to count on at least three months of rain. Water stress and long dry periods will cause buds and flowers to drop off, and the fruits to split. However, if rains are too heavy and humidity is too high, the growth of mould will increase and the fruit will rot. Cloudy skies will slow down the ripening of tomatoes. However, adapted cultivars are available.

Vegetative growth and development

In strict sense vegetative phase is usually short since the floral transition occurs for most cultivars when the third leave is expanding this within three weeks of cotyledon expansion [6] usually only six to 11 leaves are produced below the first inflorescence they are alternate with two to five phylotaxy if too few leaves are produced before flower initiation, assimilate supply may be in sufficient to support flower and fruit development. In determinate tomato only two to three inflorescences separated by one or more leaves are usually produced on the main stem while indeterminate types inflorescence are continuously initiated at leaf interval varying with cultivars environmental condition. Three being the most frequent [3] cause the development of leafy inflorescences prevent the formation of the flower pedicels abscission layer [3].

In determinate tomato vegetative growth and reproductive development are thus proceeding during the greatest part of the plant life as strong competition between developing leaves and apical meristem influences and condition both the earliness of harvest and the total yield. High assimilate availability under high light condition stimulates both meristem activity and leaf growth [7] but when plant are source of limited under high temperature or low light. The yield per unit of time is often greater than from indeterminate types (a more concentrated yield over a shorter period), which may be a disadvantage if prices drop to low levels at peak harvest. It also means that, where continuity of supply is important, follow-up plantings need to be made at shorter intervals than with indeterminate cultivars. Growing tomato seedlings indoors is an easy, cost effective and healthy method. So one seed in a (banana leaf) pot with a diameter of 7.5 cm or in as tray. Cover the seeds lightly with potting compost.

The seedlings will emerge in 7-10 days. After germination the plants need light, but keep them out of direct sunlight to avoid the leaves burning. Thin out the seedlings, leaving the healthiest seedling in the pot. When the roots come through the base of the pot (about 4 weeks after sowing), transfer the plants to a larger pot (12.5 cm). The plants will be ready for transplanting outside 7weeks after sowing the seeds. Support the plants by staking. Potted plants can be kept indoors. Young leaves growth favored at expense of apical development. This effect is counteracted by the removal of young leaves [8].

Diseases on tomato

Tomatoes can be affected by many diseases, several of which cause serious losses. Before planting, each grower should be aware of which diseases are most likely to occur locally in any specific planting, so that control measures may be implemented. Select those cultivars or cultural practices that reduce the impact of key diseases.

One should know from where a pathogen originates, how it disperses and infects the plant, and what environmental conditions favor disease development. It is most important to be able to identify the various diseases, particularly in the initial stages of the infection, and to know which methods of control are most likely to be successful.

Disease avoidance is one of the major factors to consider. Here one may consider the selection of cultivars showing resistance or tolerance to specific diseases. Site selection, disease-free seed or transplants, crop rotation, planting times, irrigation practices, good general sanitation, good nutrition, and many other cultural practices, which encourage strong, active growth, should all be taken into account. They lessen the chances of disease infection, and may reduce the impact of diseases, should these occur.

Chemical control of many diseases often becomes essential. Most of these chemicals have a preventative action only, and cannot cure infected plants. They are used by regularly depositing a layer of chemical on the plant parts to prevent initial infection or, where light infections have occurred, to prevent or reduce the spread of the disease from infected to healthy tissue. A routine preventative spray programmed to control early and late blights, as well as other diseases [9].

Tomato production pattern

In Ethiopia tomato production is practiced using irrigation of water pumped from ground and nearby rivers as the area has potential river water crossing most of production fields. However, majority of crop production in the country is mainly rain fed dependent. Several rivers are existed. These rivers are mainly used for irrigating horticultural crops, during the dry season. From the total, only 13.4% of producers in the area produce tomato by both rain feed and irrigation. The focus group discussion results also showed that tomato is preferably produced during the dry season under irrigation mainly to reduce risks of diseases and pests, which enforces seasonal production. (More than half of the producers (53.60%) in the study area were able to extract their own tomato seed, while others (43.20%) buy seeds from local market. However, majority of the producers (61.60%), were not using new improved tomato varieties [10].

Crop categories	Production (Quintal)	Share of crop category (%)	Yield (q/ha)
Cereals	236,076,624	69.8	23.2
Pulses	26,718,345	7.9	15.5
Oils seed	7,600,993	2.2	11.8
Vegetables and root crops	60,569,544	18	Vegetable, 62.1 Root crops 175.1
Fruits crops	54,615,540	2.1	171.9

Table 1: Production and yield of major food crops in Ethiopia in the year 2014/2015 (CSA).

Causes of postharvest loss	Wholesalers %	Rank
Poor packaging material	20	7
Absence of road for trucks	40	6
Harvesting damage	40	6
Poor quality of produce	50	5
Price fall/low price	50	5
Delayed harvesting	70	4
Absence of market	70	4
Climatic condition	80	3
Storage damage	90	2
Damage during transportation	100	1

Table 2: Proportion of wholesalers stating reasons for loss of tomato.

Causes of postharvest loss at traders level

As identified by wholesalers and retailers, poor marketing access, reduced price of produce, damage during transport, damage during storage, low quality of produce, climatic condition, physical damage during harvesting, late harvesting and poor packaging material were listed as major causes of tomato postharvest loss. These all causes of postharvest loss are not single or separate factors, rather they were interrelated and complex in nature. For example harvesting damage at producer's level could be reason for low quality of produce and storage loss when produce reaches wholesaler and retail market. Hidden damage during harvesting and transportation was also stated as reason for postharvest loss by 16.70% of retailers and 40% of wholesalers. Harvesting and transportation damage at producer level causes rotting and further spoilage of produce at retailers (60%) than wholesalers (40%) as they store for more time for retailing. Wholesalers transfer produce to next chain within average of 3.90 days, while retailers store average of 5.40 days up to finishing all purchased. Kiaya (2014) reported that food losses are mainly due to poor infrastructure and logistics, lack of technology, insufficient skill, knowledge and management capacity of supply chain actors and lack to markets.

Causes of postharvest loss	Retailers %	Rank
Poor packaging material	30	8
Absence of road for trucks	20	9
Harvesting damage	60	4
Poor quality of produce	40	7
Price fall/low price	53	5
Delayed harvesting	63	3
Absence of market	50	6
Climatic condition	53	5
Storage damage	90	2
Damage during transportation	100	1

Table 3: Proportion of retailers stating reasons for loss of tomato.

According to [10] research output, due to the price fluctuation in the market, sometimes retailers have to hold back their produce and some of them also sale with reduced price or even discard when no more buyers come. This is commonly case for these who participate in small scale retailing of fully matured and low quality produce at open market. Banjaw [11] also reported that different containers such as wooden box, baskets, plastic materials and sacks used in handling of produce with inadequate handling that enhances level of produce damage. Price deduction was major problem for all production and distribution actors in tomato marketing. At wholesale and retailers market, average of 35.5% and 28.33% price discount was estimated respectively depending on degree of quality losses of produce.

Tomato traders also experienced huge loss during transportation, storage and marketing. As per their estimation, average of 11.60% and 12.13% of tomato was lost at wholesalers and retailers level, respectively This result showed that about quarter of tomato purchased from producers was not able to reach consumers. Similarly, according to Kasso and Bekele (2016), post-harvest loss ranging from 20% to 50% was recorded for fruits and vegetables in between marketing and consumption due to lack of appropriate management during harvesting, packaging, storage, grading and transportation.

Farmers level sample analysis showed relatively higher postharvest loss (24.17%) than respondent's estimation (21.24%) which might be due to some farmers practiced household consumption, seed extraction and animal feed when tomato was mechanically damaged and over ripened. However, in case of wholesalers extent of loss was reduced by half in sample analysis than their actual respondent's estimation which might be due to exaggeration of their loss estimation.

As many researchers found, extent of postharvest loss for tomato was found to be almost half, which is too huge and it would be also above this if consumer level loss is considered. Kitinoja and AlHassen (2012) reported that with postharvest losses at the farm, wholesale and retail markets commonly reaching 30% to 50% for many of the horticultural crops, and physical damage measuring as high as 50% to 89% of loss for vegetable crops in the markets of Africa and India. This represents an enormous waste especially at farmers' level. Kasso and Bekele (2016) also reported that the highest post-harvest loss was recorded in tomato (45.32%) than other vegetables and fruits.

Practice to reduce spoilage	Producers (N = 60)	Wholesaler (N = 29)	Retailer (N = 22)
Collect during cool weather	23.3	10.3	0
Careful handling during harvest	48.3	34.5	18.75
Store under shade	10.0	3.4	37.5
Store in a cool place	1.7	17.2	12.5
Take care during transport	31.0	31.0	6.25
Use padding/cushion-material during transport		-	0
Harvest after buyers identified	23.3		
Sell at lower price		6.25	6.25
Nothing	8.3	3.4	12.5

Table 4: Proportion of value actors using different means to reduce spoilage (%).

Several studies have reported high postharvest losses due to poor packaging, inadequate storage facilities and poor means of transportation using human labor, donkeys and mules, public transport and rented trucks Such losses can be reduced by harvesting produce at optimal maturity, through grading, packaging and careful handling of the produce, maintaining higher sanitation standards, decreasing injury incidence and maintaining good storage and environmental condition. Moreover, treatment combinations such as low temperature, waxing, low oxygen and high carbon dioxide storage and ethylene inhibitor such as calcium chloride treatment have been reported to have the potential to extend the storage life of fresh produce such as tomatoes. Moreover, some literature also claims that tomatoes could be marketed at premium quality if lower storage temperatures were accessible and encouraged private sector to provide such facilities particularly in urban markets where retail prices will merit such investments. In general, maintaining appropriate storage of vegetables can minimize moisture loss and wilting, slow down respiration rate, prolong shelf life and inhibit development of decay-causing pathogens (Bezabih Emana., *et al*. 2017).

Crop	Total production (Million quintal)	Post harvest losses (%)
Potato	36.6	37.15
Tomato	12.58	45.32
Mango	1.003	43.53
Avocado	0.60	40.00
Banana	4.40	45.78

Table 5: Production and postharvest loss of selected fruits and vegetables in Ethiopia (2015/2016).

According to researcher finding [12] production of tomato is 25.58 quintal per annual and its post harvest share is 45.32.15 percent, which was higher as compare to post harvest losses of other crops. There are several causes that responsible for the deterioration physical and chemical quality of tomato. Among these infestation of diseases, rough handling, lack of storage and transportation facilities, physiological disorder due to un optimal pre and post harvest management.

Horticulture	Type of major losses	Estimated loss (%)
Tomato	Abrasion, bruise, rupture, softening, shrivel, bleach, crash, over ripe	45.32
Mango	Wound, scratch, rotting, bleaching puncture	43.53
Potatoes	Scratch, flaccid, decay, bleach spot, compression, wound, crush, sprouting	37.15
Orange	Abrasion, discolor, sour, decomposition, shrinkage, rough and thick peal	35.58
Onion	Decay, wilt, shrink, flaccid, sprouting	25.21
Green pepper	Flaccid, decay, wilting, color change	22.54
Banana	Decay, softening, bruising, chilling, peal split, breakage,	19.87

Table 6: Type and estimated post - harvest losses and quantity deterioration of the dominantly cultivated horticultural crops.

AS the above compiled information revealed (Table 6) that post losses of horticultural crops are higher as compare to cereal and pluses crops. The extent of losses ranges from 19.87% in Banana to 45.32% in tomato. The major causes of damage were mechanical damage during harvesting, transportation, harvesting at out of optimum maturity time and pathogen problems. In order to minimize Post-harvest losses appropriate and feasible agricultural techniques such as the general principles of extending shelf-life of these crops must be put in place. The importance of agricultural practice such as selection of planting materials, cultural practice including harvesting method and handling practice on the quality of harvested produce was reported [10].

Harvesting should be carried out as carefully as possible to minimize mechanical injury such as scratches, cuts, puncture sand bruises to the crop. This should be carried out during the cool part of the day, which is early morning and late evening harvest crop at appropriate stage. Farmers or producers have not harvest immature crops and have not wait too long before harvesting [13].

Researchers reported estimate of average total post-harvest losses of 22.05 percent of the total banana produce handled/purchased for sale at wholesale. This has impacts on the economies of all involved in the chain. Hence, there could proper handling, good sorting and cleaning, good packaging, adequate transportation and good storage facilities so as to reduce Post-harvest losses of horticultural crops. Good handling enables reduction in mechanical injuries that otherwise affect produces, separation of damaged produces from the normal once minimizes chance of damage, crop specific packaging supports in reducing damages to products during storage and transportation. During transport crop compatibility has to be identified to reduce damage that can resulted on the other crop, appropriate means of transport has to be selected, during loading and unloading care has to betaken not to damage crops [11,14-21].

Summary and Conclusion

In Ethiopia, the fruit and vegetable sub-sector has seen over 17% average growth over the last 10 years, and the government aims to increase production by an additional 47% from 2015-2020. During this review it has been clearly observed that collectors and wholesalers play an important role in the distribution of tomato, both of whom obtain the produce from farmers or growers. Growers or farmers identify disease infection and damage during harvest as the main reasons for post-harvest Loss. For wholesalers and retailers, it was damage during harvest and transport, poor quality of purchased tomato and poor packaging which are considered as the main causes of loss. Wooden crate is the most common packaging material for tomato from the farmer to wholesaler, other packaging materials used less frequently.

Farmers usually transport the harvested tomato to the farmhouse in baskets or crates carried usually on the shoulder. And at the retailer level product mix up with other type of commodities or with ripens or damaged tomatoes have been observed quite frequently.

Finally, it was found that about yield loss of tomatoes is incurred by the farmers, and this is mainly as a result of the aforementioned causes because of disease and pests such as: late blight and bacterial blight and ball worm, because of damage during harvesting storage, transport and poor pre harvest agronomic activities, The wooden crates are often overfilled, resulting in the crushing of fruit when they are stacked. On The other hand on the retailer side they incurred a total loss even if it was a bit hard to determine the figure because the price component was found to be less reliable, on the retailer's hand tomatoes are exposed to direct sunlight left sitting in the sun, but the most damage is occurred in growers level other than retailers due to lack of awareness regarding to post harvest handling of vegetables particularly tomato crop.

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