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The Cause and Extent of Post Harvest Loss of Fruits and Vegetables in Ethiopia - Review

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Abstract
Horticulture is an important sector for economic development and contributes to increased food security and improves the populations' nutrition intake. Horticultural crop production (Fruits and vegetables) is the major farming system in Ethiopia and farmers have willingness to increase the production and productivity of the crops even if it faces many challenges. Post-harvest loss is a global problem but it is more critical in developing countries. Post-harvest losses can be measured both by quality and quantity losses. The major causes of postharvest losses are direct /primary (technical origin) and indirect /secondary (socio economic origin) factors. The extent of post-harvest losses may vary greatly among commodities, production areas, season of production, and ways of handling, management practices and economic status of the country. Postharvest loss as going beyond the loss of the actual crop to include loss in the environment, resources, labor needed to produce the crop and livelihood of the individual involved in the production process. Currently there are limited review on the cause and extent of postharvest losses of fresh fruits and vegetables in Ethiopia due to lack of research works in the sector. It is too early to reach a conclusive recommendation since limited study were conducted in the cause and extent of post harvest loss of horticultural crops. Hence, further studies must be done to tackle the cause of post harvest loss of horticultural crops and minimized the extent of post harvest losses.
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1. INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy (Bezabih and Hadera, 2007). Horticulture can be an important sector for economic development and contribute to increased food security and improve the populations' nutrition intake (Weinberger & Lumpkin, 2007). The country has highly diversified agro-ecological conditions for the production of different horticultural crops (Milaku, 2005). Horticultural crop production (Fruits and vegetables) is the major farming system in Ethiopia. Particularly in the areas where water is available and farmers have access to the market, horticultural production is used as a major source of cash income for households (Bezabih and Hadera, 2007; Milaku, 2005). Food availability and accessibility can be increased by increasing production, improving distribution and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security (Bezabih and Hadera, 2007; Fantahun and Williamson, 2001).

Post-harvest loss of fruit and vegetable is a matter of great economic concern in agriculture. Produce after harvesting undergoes a number of processes including transportation and storage under various environmental conditions. Although time, human force, money and material resources are devoted for planting, irrigation, fertilizer application, 50% of horticultural crops are lost due to post-harvest loss (Alazar, 2007; Olayemi *et al*., 2010). In Ethiopia limited post-harvest improvement studies have been carried out for locally consumed fruits and vegetables (Alazar, 2007). That is why we are initiating to review the causes which accelerated post harvest losses of fruits and vegetables and its extent.

2. POST HARVEST LOSSES

Post-harvest loss is a global problem but it is more critical in developing countries. According to FAO (2015) about 45% of fruits and vegetables are lost or wasted. Post harvest loss of agricultural produce is experienced in Ethiopia, most especially in perishable horticultural commodities like fruits (mango, banana, papaya, avocado, sweet orange etc.) and vegetables (Getachew, 2004). Post-harvest losses can be measured both by quality and quantity losses (FAO, 2016).

2.1. Quantitative Post Harvest Loss

Quantitative post harvest loss as measured by decreased weight or volume of edible horticultural commodity available for human consumption (Buzby and Hyman, 2012; FAO, 2014). The quantitative losses are very easy to measure in developing countries (Humble and Reneby, 2014).

2.2. Qualitative Post Harvest Loss

Qualitative losses such as loss in edibility, nutritional quality, caloric value, wholesomeness and consumer acceptability (unwanted changes to taste, color, texture or cosmetic features of food) of the horticultural commodity and much more difficult to assess and measure (Buzby and Hyman, 2012). The qualitative losses are related directly to nutritional and they are more complicated to measure (FAO, 2014).Standards of quality, consumer preferences and purchasing power varies greatly among countries and cultures (Ladaniya, 2008).

3. CAUSE OF POST HARVEST LOSS

The main causes of post-harvest loss in low-income countries may include improper methods of harvesting, insufficient cooling and unhygienic handling, lack of infrastructure, poor technical and managerial skill in food production and post-harvest (Table 1). According to FAO (2011) factors affecting post-harvest food losses of perishables vary widely from place to place and become more and more complex as systems of marketing become more complex. The causes of postharvest losses can be direct /primary (technical origin) and indirect /secondary (socio economic origin) factors (Sudheer & Indira, 2007).

3.1. Primary Causes of Post Harvest Loss

Physiological (wilting, shriveling and chilling injury, etc), microbiological (decay due to fungi and Bacteria) biological, physical and mechanical injury are the primary causes of post harvest losses (Etebu *et al.,* 2013). Causes of post harvest loss can complement each other. Damage caused by microorganisms is nearly always preceded by mechanical, chemical and physical damage, thereby weakening the products natural defenses, and facilitating attacks by fungi, bacteria or moulds (Sudheer & Indira, 2007). Pathological rots are the most serious which is followed by mechanical injury which causes serious damage to the perishable products (Elias *et al,* 2010; FAO, 2011).

3.1.1. Mechanical

All fresh horticultural crops are high in water content and are subject to desiccation (wilting, shriveling) and mechanical injury (Kader, 2013). Mechanical damage can arise from careless and rough handling of vegetables during harvesting, packaging, transportation and storage. There are three main mechanisms of mechanical damage, namely vibration, compression and impact damage (**fig1**). These cause mechanical damage in the form of cuts, cracks, punctures, abrasion, scuffing and scratches with the predominant form being bruising of vegetables and fruits (Atanda *et al.,* 2011).

3.1.2. Microbiological

Fruits and vegetable are susceptible to attack by bacteria and fungi, with pathological breakdown. All living material is subject to attack by parasites (**fig2**). Some disease is able to penetrate the unbroken skin of produce; others require an injury in order to cause infection. The succulent nature of fruits and vegetables makes them easily invaded by these organisms and cause of loss of fresh produce (Elias *et al.,* 2010; Kader, 2013). Horticultural crops can be contaminated with different microbial contaminants during handling and processing and become source for infectious microorganisms (Moy, 2005). Postharvest diseases destroy more than 30% of the perishable crop yields especially in developing countries (Agrios, 2005). Fruits and vegetables contain very high moisture, have large size, exhibit higher respiration rate and usually have soft texture, which favour the growth and development of several diseases by the microorganisms between harvest and consumption (Sharma *et al*., 2009).

3.1.3. Physiological

Natural respiratory losses which occur in all living organisms account for a significant level of weight loss through generates heat. Physiological changes which occur during ripening, senescence, including wilting and termination of dormancy (e.g., sprouting) may increase the susceptibility of the commodity to mechanical damage or infection by pathogens (**fig2**). A reduction in nutritional level and consumer acceptance may also arise with these change (Babita & Kiranmayi, 2010; Nunes, 2008).

3.1.4. Biological

Consumption of food by rodents, birds, monkeys and other large animals causes direct disappearance of food. Sometimes the level of contamination of food by the excreta, hair and feathers of animals and birds is so high that the food is condemned for human consumption (**fig 2**). Insects cause both weight losses through consumption of the food and quality losses because of their frass, webbing, excreta, heating and unpleasant odours that they can impart to food (Atanda *et al*., 2011).

3.1.5. Chemical

The chemical constituents in stored agricultural produce undergo spontaneous reaction that causes loss in their sensory qualities such as colour, flavor, texture and nutritional value (Kiaya, 2014). “Maillard reaction’’ that causes browning and decolouration in dried fruits and vegetables (**fig 2**). Application of high chemical fertilizers and chemical pesticides also cause postharvest losses. There are also be accidental or deliberate contamination of food with harmful chemicals such as pesticides or obnoxious chemicals such as lubricating oil cause for post

harvest loss (Atanda *et al*., 2011). Horticulture product deterioration caused by chemical or biochemical agents can lead to significant losses in nutritional value and production of undesirable components of e.g. rancidity in fats and oils and Maillard reactions of sugars (Kader, 2002).

3.1.6. Biochemical reactions

A number of enzyme-activated reactions can occur in foods in storage giving rise to off-flavors, discoloration and softening which causes losses of horticultural products (Atanda *et al*., 2011).

3.1.7. Physical

Postharvest losses of fruits and vegetables is enhanced by physical damage, extended storage duration, high temperatures, excessive or insufficient heat or cold , improper relative humidity and chilling injury (Atanda *et al*., 2011; Kader, 2013).

3.2. Secondary Causes of Post Harvest Loss

Secondary causes of post harvest losses that encourage a primary cause of loss. They are usually the result of inadequate or non-assistant capital expenditures, technology and quality control Excessive or insufficient heat or cold and improper atmosphere (Zenebe *et al.*, 2015).

3.2.1. Improper harvesting

Improper harvesting practices result in loss due to spoilage of the produce before reaching to consumers along with the loss in quality of the produce such as deterioration in appearance, taste and nutritional value (Devkota *et al*., 2014). Inadequate harvesting equipments and rough handling results bruising and increase possibilities of contact of the produce with the soil which may leads to contamination with micro-organisms subsequently causes faster senescence and reduces shelf life (Kasso & Bekele, 2016).

3.2.2. Inappropriate environmental factors

Climatic or environmental factors are seen as the most influential and important element that affects post-harvest losses (Antunes *et al.,* 2007).

3.2.2.1. Improper temperature management

Temperature in both extremes is the main causative agent in affecting the postharvest period of horticultural products. Temperatures either above or below the optimal range for fresh produce can cause rapid deterioration (Kader, 2002).

3.2.2.1. 1. High temperature

High temperatures are increased rates of respiration, deterioration and water loss in fresh produce, leading to reduced market value and decreased nutritional value.The higher the temperature, the shorter the storage life of agricultural produce and the greater post-harvest loss (Kiaya, 2014). The rate of fresh produce deterioration increases by 2-3 folds with for every 10°C increase in temperature (Kader, 2002).

3.2.2.1.2. Low temperature

Low temperature injury occurs at different temperatures (from 0 to 18°C) depending on the type of crop, maturity stage and storage duration. Various physiological and biochemical alterations as well as cellular disfunction occur due to chilling injury (Yahia, 2004). Horticultural commodity exposed below 10 ^{o}C will give rise to a physiological disorder known as chilling injury (Sargent *et a*l., 2000). Chilling injury is manifested in a variety of symptoms including surface and internal discoloration, pitting, water soaking, failure to ripen, uneven ripening, development of off flavors and heightened susceptibility to pathogen attack (Toivonen and Hodges, 2011; Kader, 2013). According to Kader (2002) the freezing point of their tissues is relatively high (ranging from -3 °C to -0.5 °C), and disruption caused by freezing generally results in immediate collapse of their tissues and a total loss of cellular integrity.

3.2.2.2. Improper relative humidity

Relative humidity can influence water loss, decay development, the incidence and severity of some physiological disorders and uniformity of fruit ripening (Kader, 2013). High relative humidity favour growth of microorganisms which cause extensive damage to the produce. Excess moisture promotes the growth of fungi and other spoilage micro-organisms which increases susceptibility of produce to moulds and insect pests (Perez *et al.,* 2003; Nunes, 2008).

3.2.3. Ethylene cause

Ethylene causes several problems such as accelerates chlorophyll degradation, induces yellowing of green tissues, abscission of leaves and flowers and tissue softening of fruit and vegetable products and several physiological disorders (Abeles, 1992; Yahia, 2004).

3.2.4. Lack of knowledge/skill

Fruit production activity is at infant stage in Ethiopia and both small scale fruit producers and traders have very limited knowledge and skill on fruit production and postharvest handling practices. High amount of fruits and vegetables is expected to be wasted due to several inappropriate postharvest handling practices (Kader, 2005). High postharvest losses can be as a result of ignorance in scientific and technological techniques associated with the conservation of food products. Loading and unloading operations are carried out in these countries by

unskilled and uneducated workers who generally do not carry products carefully which causes post harvest loss (Kitinoja, 2010; Hodges *et al*., 2011).

3.2.5. Unavailability of tools and limited facilities

Limited access exists to facilities such as aids, containers, equipment, stores, cold rooms, drying and curing rooms increase post harvest losses of horticultural commodity (Kader, 2004).

3.2.6. Inappropriate packaging

Poor packing design is reduces efficiency and increases the risk of mechanical and biological hazards. Avoid improper packing (lack of ventilation, low material resistance, sharp and wrinkled surfaces, etc.), inappropriate pile up during packing, packing products with different degree of maturity and mechanical damages caused by personnel or improper design of mechanical grading machines which causes post harvest loss (Sparks, 2013; Zenebe *et al.* ,2015). Unfortunately, low-quality packaging materials are widely used in many parts of the world due to their low cost (**fig 3**). The use of sharp-edged packaging containers often leads to puncturing and bruising of agricultural products (Arah *et al*., 2016).

3.2.7. Inadequate storage

Inadequate storage facilities at the producing or marketing centers, exposes the produce to the natural causes of losses i.e damage by micro-organisms, respiration, transpiration and other biochemical reactions (SATNET, 2014). To mix high quality agricultural produce with damage produce from bruises and skin cracks in the storage increase post harvest loss (Atanda *et al.,* 2011).

3.2.8. Inadequate transportation facilities

The physical and mechanical damage occur during transportation and distribution (**fig 3**). Losses during transportation can be high, particularly in developing countries due to lack of sophisticated means of transportation (Cortez *et al.,* 2002). Inappropriate means of transporting agricultural produce such as human labour, donkeys, public transports leads to both primary and secondary post-harvest losses (Arah *et al.,* 2016). High speed on rough and bad road networks by vehicular drivers transporting agricultural produce results in post-harvest losses. The use of dirty and poorly ventilated vehicles exposes the agricultural produce to pathogenic, biological and microbial attacks (Dudi, 2014; Sparks, 2013).

3.2.9. Inadequate marketing systems

Growers can produce large quantities of good-quality fruits and vegetables but if they do not have a dependable, fast and equitable means of getting such commodities to the consumer, losses will be extensive (Kader, 2005; Seid *et al*, 2013). Lack of market to absorb the production, absence (weakness) of marketing institutions safeguarding farmers' interest and rights over their marketable produces, lack of coordination among producers to increase their bargaining power and imperfect pricing system of traders as major problems to producers (Faris, 2016). In post-harvest loss assessment at Jimma zone elaborated presence of highest percentage loss was sold in the open space being exposed to sun (Adugna *et al*., 2011) (**fig 3**).

Horticulture production is often hindered by lack of market access and market information (Abay, 2007). (Bezabih and Hadera, 2007) also argued seasonal production to be inversely related to price. Under developed infrastructure (roads, harbor facilities), lack of training and awareness (product price, product demand, product supply) among people involved in the marketing system may cause postharvest loss.

3.2.10. Government Regulations and Legislations

The degree of governmental controls especially on wholesale and retail prices of fresh fruits and vegetables varies from one country to another. Price controls are counter-productive. Regulations covering proper handling procedures and public health aspects (food safety issues) during marketing are, very important to the consumer if it is implemented well. Policy changes (e.g. agricultural diversification, quality standards, price policy may cause postharvest loss of horticultural products (Kader, 2005).

3.2.11. Poor Maintenance

Some good facilities that were built a few years ago are currently not functioning properly in developing countries, because of lack of maintenance and spare parts (Kader, 2005).

3.2.12. Economy status

Food losses in the low-income countries including Ethiopia are the result of 'poor' state of their supply chains (Hodges *et al.*, 2011).

3.2.13. Social and cultural factors

Social and cultural factors such as urbanisation, education and population growth can influence the quantity and quality of produce available. Fresh vegetable losses can also be a direct result of human psychology whereby a fresh commodity is not eaten and is thrown away because the end user did not fancy eating it or for religious taboos (Parfitt *et al.,* 2010).

3.2.14. Consumers' waste

Consumption stage lasts from the moment of purchase by consumers of fruit and vegetable to the moment of consumption in the food supply chain. Fresh fruit and vegetables contribute almost 50% of food wasted by households (FAO, 2011). In developing countries major food losses occur due to socio-cultural factor (gender,

lifestyle), consumer behavior, technical and managerial limitations, quality standard requirements and strict safety policies for fruit and vegetables (FAO, 2011; FAO, 2015; Porat *et al.,* 2018).

4. POST HARVEST LOSS EXTENT

In developing countries, food losses occur early in the food supply chain at postharvest and processing stages (Gustavsson *et al.,* 2011). However, the magnitude of losses and waste are still lacking based on horticultural commodity and season of production losses are estimated at 20 to 40% in developing countries (Kader, 2005; Garnett, 2006). Production of fruits and vegetables in Sub-Saharan Africa as of 2014 is approximately at 34.22 and 31.95 million tons, respectively (FAOSTAT, 2017). At the same time, postharvest losses of fruits and vegetables in Sub-Saharan Africa range from 30 to 80% depending on nature of the crop, while globally postharvest losses is estimated at 30% (Kitinoja *et al.,* 2011; Gustavsson *et al.,* 2011; Niewiara, 2016) (Table 2).

In Ethiopia studies conducted on seven fruit and vegetable crops (tomato, cabbage, onion, potato, mango, banana and avocado) revealed that the total average post-harvest losses range from 14 to 60%. Highest losses observed on cabbage were 58.9% and lowest loss (14.1%) recorded on onion crop (Gebresenbet *et al*., 2016). According to CSA (2012/13) during the main production season about 192,555.39 and 61,972.6 hectares of land were under production of vegetables and fruits in Ethiopia, respectively (Table 3 and Table 4). The rough estimation of yearly global quantitative food losses and waste reached at 40–50% for fruits, vegetables and root crops grown in Ethiopia (FAO, 2012). This is because the rate of the perishability of fresh horticultural produce in terms of post-harvest losses is pegged between 30 percent to 50 percent in fruits and vegetables (Atanda, 2011).

5. CONCLUSION

Postharvest loss as going beyond the loss of the actual crop to include loss in the environment, resources, labor needed to produce the crop and livelihood of the individual involved in the production process. However, it is important to note that much is being invested to production compared to postharvest handling, much produce is wasted in few days after harvest .Therefore; to increase food availability, it is not enough to increase the productivity in agriculture rather it need to know major cause of post harvest loss of horticultural commodity and lower the higher extent of post harvest losses.

Currently there are limited review on the cause and extent of postharvest losses of fresh fruits and vegetables in Ethiopia due to lack of research works in the sector. Although, it is possible to estimate such losses of perishables horticultural commodity based on the annual production data of central statistics agency (CSA) and food and agricultural organization of the country (FAO). It is too early to reach a conclusive recommendation since limited study were conducted in the cause and extent of post harvest loss of horticultural crops. Hence, in this review we states that further studies must be done to tackle the cause of post harvest loss of horticultural crops and minimized loss extent.

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Table 1. Major factors for post-harvest loss.

Factors/cause	Frequency	Percent
Climate and weather conditions	58	19.6
Harvesting and handling techniques	58	19.6
Packaging, storage and transportation facility	57	19.3
Market situation	53	17.9
Disease	37	12.5
Pests	33	11.1
Total	296	100

Source: Kasso,M and Bekele, A.(2016)

Table 2. Percentage of food losses in low-income sub-Saharan African countries.

Food type	Agricultural Production (%)	Post-harvest handling practices (%)	Processing and packaging (%)	Distribution (%)	Consumption (%)	Total loss (%)
Cereals	6	8	3.5	2	1	20.5
Roots and tubers	14	18	15	5	2	54
Oilseeds and pulses	12	8	8	2	1	31
Fruit and vegetable	10	9	25	17	5	66
Meat	15	0.7	5	7	2	29.7
Fish and seafood	5.7	6	9	15	2	37.7
Milk	6	11	0.1	10	0.1	27.2

Source: Mezgebe et al., 2016.

Table 3. Estimated values of postharvest losses of vegetables in Ethiopia during the production year of 2012/13

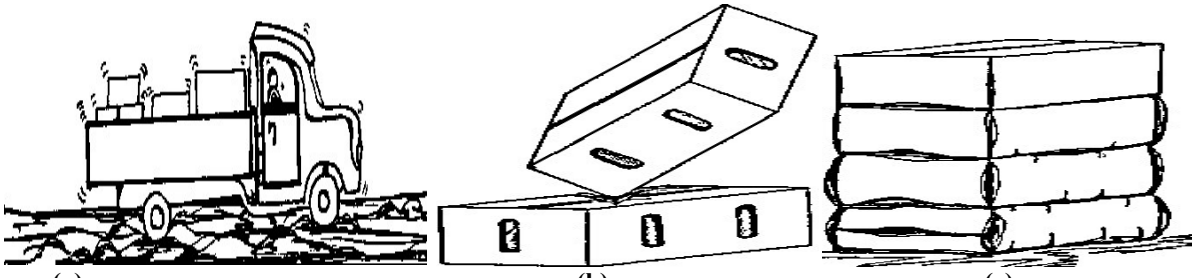
Vegetable crops	Area of production (ha)	Total production (ton)	Estimated postharvest losses (ton)
Potatoes	74,934.57	863,347.8	345,339.1-431,673.9
Cabbage	34,791.05	370,995.2	148,398.1-185,497.6
Red peppers	136,503.7	316,554.1	126,621.6-158,277.0
Green peppers	10,588.52	85,547.8	34,219.1-42,773.9
Tomatoes	7,237.35	55,514.3	22,205.7-27,757.1
Head cabbage	3,049.01	23,224.7	9,289.9-11,612.3
Swiss chard	310.70	329.04	131.6-164.5
Lettuce	75.01	*	*
Total vegetables	**192,555.39**	**852,308.3**	**340,923.3-426,154.1**

Source : CSA 2012/2013

Table 4. Estimated values of postharvest losses of fruits in Ethiopia during the production year of 2012/13

Fruit crops	Area of production (ha)	Total production (ton)	Estimated postharvest losses (ton)
Bananas	36,012.2	302,502.2	121,000.9-151,251.1
Mangoes	8,808.64	69,750.7	29,900.3-34,875.3
Papayas	2,752.08	38,694.3	15,477.7-19,347.1
Oranges	2,999.21	35,745.8	14,298.3-17,872.9
Avocadoes	8,938.24	25,633.2	10,253.3-12,816.6
Lemons	754.23	5,516.7	2,206.7-2,758.3
Guavas	1,492.32	1,173.0	469.2-586.5
Pineapples	215.69	*	*
Total fruits	**61,972.6**	**479,336.1**	**191,735.6-239,668.0**

Source : CSA 2012/2013



(a) **(b)** **(c)**

Fig 1. Mechanical injury (a) Abrasion, (b) puncturing, (c) compression injuries respectively)

(a) **(b)** **(c)**

Fig 2. (a)Biological and microbiological (b) chemical , (c) physiological losses respectively)

a **b** **c**

Fig3. (a)Inappropriate packaging, (b) poor marketing (c) poor transportation