sciendo

Journal of Horticultural Research 2022, vol. 30(1): 1–10
DOI: 10.2478/johr-2022-0002



# POSTHARVEST LOSS, CAUSES, AND HANDLING PRACTICES OF FRUITS AND VEGETABLES IN ETHIOPIA: SCOPING REVIEW

Obse F. ETEFA*[1], Sirawdink F. FORSIDO[2], Mathewos T. KEBEDE[3]
Department of Horticulture, Ambo University, Ethiopia
Department of Postharvest Management, Jimma University, Ethiopia
Department of Biology, Ambo University, Ethiopia

Received: October 2021; Accepted: April 2022

ABSTRACT

Fruits and vegetables are the horticultural crops playing a significant role in Ethiopia's food security, livelihood, and economy. However, the postharvest loss results are a severe challenge for the producers, and this review summarizes this problem. The total postharvest loss of horticultural crops, including fruits and vegetables, at various stages: harvesting, storage, transportation, and marketing ranges from 15 to 70%. Postharvest loss of vegetables alone is about 40%. Fruits like mango, banana, papaya, avocado, sweet orange, etc., take the largest share of the total postharvest loss. The postharvest causes of losses are diseases, insects, rodents, thefts, mechanical damage, premature harvesting, harvesting of overmature crops, improper harvesting and storage techniques, shortage of appropriate packaging and marketing system, seasonal fluctuation of the products, and gender inequality. Therefore, applying a possible and convenient loss reduction strategy is imperative to increase the supply of fruits and vegetables in the country.

**Key words**: postharvest chain, pests and diseases, storage technology, transport of products

## INTRODUCTION

Postharvest loss (PHL) is defined as the measurable quantitative and qualitative loss of products at any point in the postharvest chain, from harvest to consumption (Kikulwe et al. 2018). This leads to food losses and significant economic losses (Gross et al. 2000). The report found that nearly 800 million people, one in nine globally, are malnourished and that more than a billion tons of food never end up with consumers. However, the extent of PHLs varies between developed and developing countries. Plant foods (e.g., cereals, fruits, vegetables, tubers, legumes) and dairy together account for 92% of total food losses in developing countries, with the remaining 8% being meat (4%) and fish (4%) (Kader et al. 2012). Food loss in low-income countries mainly occurs in the early and middle stages of the food supply chain, with less amount wasted at the consumer level (Parfitt et al. 2010). According to Parfitt et al. (2010), inadequate harvesting stage, poor harvesting technique, transport, lack of a cold chain system, inadequate storage facilities, limited processing knowledge, and a lack of appropriate packaging and trading facilities are the main drivers of high PHLs in developing countries.

Losses in developed countries are likely to be low in the middle of the supply chain and relatively high at the consumer level (Hodges et al. 2011). Minimal mid-stage losses can be attributed to more efficient farming systems, better transport, better management, storage, extensive and efficient cold chain systems, and processing plants that ensure that the major part of the harvested product is delivered to the markets (Parfitt et al. 2010; Hodges et al. 2011).

Fruits and vegetables are important horticultural crops used in developed and developing countries. A report from sub-Saharan Africa found that net fruit and vegetable production is estimated at 230 million tons per year (Gustavsson et al. 2011).

*Corresponding author
e-mail: obsemaatii@yahoo.com

On average, about 30–40% of the total product is lost or thrown away upon exiting the farm gate for various reasons (Salami et al. 2010). The scale of PHLs can range from 5 to 35% in developed countries and from 20 to 50% in developing countries (Hailu & Derbew 2015). The postharvest period has a serious impact on food security, human health, and the environment (Lipinski et al. 2013).

Ethiopia is one of the sub-Saharan African countries on the verge of severe food insecurity and poverty (FAO 2019). Agricultural production fails to meet total domestic food needs, and nearly half of the population lives in absolute poverty due to, among others, pre- and postharvest food loss (FAO 2018). To achieve the goals of ensuring food security in the country, it is very important to design an appropriate pre- and postharvest management strategy.

Research on fruits and vegetables began in the early 1970s in some research centers, and cultivar breeding was initially the main area of research activity (Awole et al. 2011; Tigist et al. 2013). However, there is still a significant information gap on the harvested PHL status and fruit and vegetable handling practices in the country. Therefore, this review article was intended to summarize the scientific literature on fruit and vegetable handling practices in Ethiopia and PHLs.

## The production system of fruits and vegetables in Ethiopia

Large numbers of farmers, farmers' unions, and private investors have been taking place in horticulture crops produced in the country (Banjaw 2017). The total production area of fruits and vegetables is estimated to be about 267,000 ha (42% was vegetables, 41% was roots and tuber crops excluding enset, "false banana", *Ensete ventricosum*, and 17% was fruit crops) in 2019. Banana takes approx. 56.79% and avocado 17.26% of the total area occupied by fruits, respectively. Generally, more than 7,774,306.92 quintals of fruit crops were produced this year from a total of 11390 ha of land (Bachewe & Minten 2021). Bananas, mangoes, avocados, papayas, and oranges took up 63.49%, 13.50%, 10.47%, 6.99%, and 3.93% of the total fruits produced, respectively (Hengsdijk et al. 2021).

Vegetable crops of economic importance in the country include pepper, kale (Ethiopian cabbage), onion, tomato, chilies, carrot, garlic, and cabbages, where red peppers and Ethiopian cabbage takes the lion's share, 73.09% and 16.33%, respectively (CSA 2018; Hengsdijk et al. 2021).

The area coverage of vegetables increased from 71,600 ha with a total yield of 59,000 tons in 2009 to 112,140 ha with a total production of 1,150,000 tons in 2019 (Hengsdijk et al. 2021). Vegetables like tomato, onion, capsicum, and snap beans are mostly produced in hot semi-arid areas at rain-fed irrigation, particularly in the Rift Valley. In contrast, the highland offers favorable growing conditions to produce cool-season vegetables like kale, cabbage, garlic, shallot, carrot, and beetroot (Hussen et al. 2013). The production is done mainly by small-scale producers, estimated to be about 5.7 million farmers and that produces about 95% of the fresh vegetables supplied to domestic and regional markets (Deribe & Mintesnot 2016).

Generally, commercial production of horticultural crops has been increasing in recent years due to the expansion of state farms, for example, Ethiopian Horticulture Development Corporation, and the increasing number of private investors, national and international entrepreneurs, in the sector (Joosten 2011). Commercial production is highly done in the Rift Valley areas due to the availability of irrigation facilities, water accessibility, and proximity to agro-processing industries (Deribe & Mintesnot 2016), and also because of increased exports to Djibouti, Somalia, South Sudan, Sudan, the Middle East, and European markets (Tabor & Yesuf 2012). Generally, the production of fruits and vegetables has shown a rapidly increasing trend since 2003 (Figs. 1 and 2). An increase has been also reported for export (Table 1).

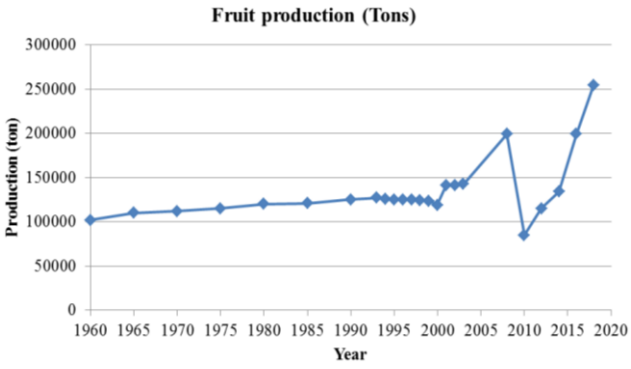


Figure 1. Trends of fruit production in Ethiopia from 1960 to 2018 (CSA 2000, 2002, 2004, 2006, 2008, 2010, 2014, 2016, and 2018)

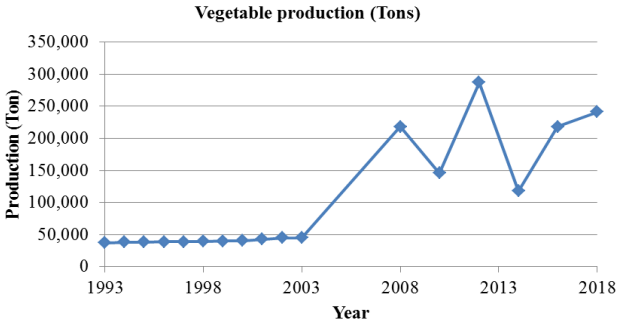


Figure 2. Trends of vegetable production in Ethiopia from 1993 to 2018 (CSA 2000, 2002, 2004, 2006, 2008, 2010, 2014, 2016, and 2018)

Table 1. Fruit and vegetable exports from Ethiopia (US$) (Chauvin et al. 2012)

| Year | Income (US$) |
|---|---|
| 1980 | 21030 |
| 1990 | 42500 |
| 2000 | 28510 |
| 2010 | 76500 |
| 2018 | 84300 |

## Postharvest losses of fruits and vegetables in Ethiopia

Fruits and vegetables are known for their high return per unit of time and area but a significant percentage of PHLs significantly reduced it (Chauvin et al. 2012; Debela et al. 2011; Tilahun 2010). However, the quantitative and qualitative information on PHL remains scarce due to the minimal work conducted on the issue (Workneh et al. 2011; Workneh et al. 2012; Emana et al. 2017). The report made 15 years ago indicated that PHL of perishable horticultural commodities, including fruits and vegetables, accounted for about 30–40% of the total production (Debela et al. 2011). Ten years later, the loss was estimated to be 15–70% and was related to various levels such as harvesting, sorting, cleaning, handling and packing, transportation, storage, distribution or marketing, and processing (Urge et al. 2014; Banjaw 2017; Emana et al. 2017). Recently, Mezgebe et al. (2016) reported that about 30% of households lost about 30% of their total fruit produce, 21.62% of households lost 10% of their vegetable produce, 50% of root crop production, and 60% of other cash crop production. Further detailed information is in the papers by Rahiel et al. (2018) and Bantayehu et al. (2018).

A high amount of PHLs concern fruits like mango, banana, papaya, avocado, sweet orange, and some vegetables (Emana et al. 2017). For the other examples, please see papers from Kasso and Bekele (2018), Mebratie et al. (2015), Debela et al. (2011), Urge et al. (2014), and Hagos (2014).

## Preharvesting causes of fruit and vegetable losses

Preharvest conditions could strongly affect the shelf life and qualities of perishable horticultural crops (Rahiel et al. 2018). The following major constraints are in Ethiopia: a shortage of improved cultivars and relying on own seeds of lower productivity, high fertilizer and seed prices, and the high price of fuel for pumping water for irrigation (Emana 2010; Rahiel et al. 2018). Other preharvesting factors that lower product quality are: the high cost of pesticides and improved seeds, lack of adequate pesticides and herbicides, the inadequacy of irrigation water, inadequate irrigation facilities, limited knowledge about proper production, and inadequate credit services (Hailu 2016). The study made at South Wollo, for instance, showed that there is limited access to irrigation water during the winter season (Hussen et al. 2013) and irregularity of the irrigation before harvesting also decreased the shelf life and sensory quality of fruits and vegetables in the Northern part of Ethiopia (Rahiel et al. 2018).

In addition to poor cultural practices such as farmland selection, crop and cultivar choosing, seeding, weeding, harvesting of the crops using traditional tools, and crop rotation, diseases and pests at a critical time were also reported to be the preharvesting causes of fruit and vegetable loss (Bantayehu et al. 2018). Potato, head cabbage, tomato, apple, and citrus are the most widely affected crops by diseases and pests (Bantayehu et al. 2018; Rahiel et al. 2018). Also, fluctuations of production and prices have to be included in the preharvesting factors contributing to the PHL of fruits and vegetables (Alamerie et al. 2014).

## Causes of fruit and vegetable postharvest loss

### Improper maturity stage

The maturity stage is the most critical factor for determining fruit and vegetable quality. Fruits picked too early have lower quality, are susceptible to physiological disorders, and have a shorter storage life than the fruits picked at the proper maturity (Arah et al. 2015). Inappropriate harvesting time is the major problem for the PHL of fruits and vegetables in Ethiopia. For instance, the study made around Hawassa showed a high proportion of unmarketable avocado fruits in the total yield (Bereda 2016). The harvesting of immature fruits and sun damage is the leading cause of banana loss in central Ethiopia. Most farmers decide to harvest immature fruits when they rapidly need money (Mebratie et al. 2015), even if most fruits are lost at the farmer's level during storage time. Similarly, overripe fruits are lost in a high percentage (Humble & Reneby 2014). Hence, harvesting fruits at the proper maturity stage helps to attain their high quality and reduces the possibility of PHL (Mebratie et al. 2015).

### Harvesting techniques

In Ethiopia, severe PHL and quality deterioration of horticultural crops occur during harvesting, followed by marketing, transportation, and storage time (Banjaw 2017). The harvesting system is conventional; the producers do not have enough knowledge regarding how and when to collect, and the tools used to harvest, sticks, sickle, spade, hoe, and ax, are not able to maintain the proper quality of the produce (Emana et al. 2015). Harvesting is mostly manual with the use of long sticks with a hook attached to the end (for fruits) and manual digging (for vegetables). These kinds of harvesting cause high PHL due to the increased possibility of injury and deterioration due to the increased possibility of microbial infection (Bantayehu et al. 2018; Rahiel et al. 2018; Parmar et al. 2017). About 76% of the producers and 60% of the traders encountered high PHL of tomatoes due to the physical damage during harvesting and transportation in eastern Ethiopia (Emana et al. 2015). Humble and Reneby (2014) reported that the most significant PHL of avocado is the result of the cracking down during harvesting. Harvesting of the injured sweet potato (up to 40%) is common in some parts of the country (Mitiku & Gutema 2017). Other reports on the bad harvesting techniques that affect the fruit and vegetable losses are published by Emana et al. (2015), Bereda (2016), and Rahiel et al. (2018).

### Improper storage methods

In Ethiopia, the storage techniques and instruments used are traditional and very poorly to maintain the required level of storage quality (Debela et al. 2011; Workneh et al. 2012). For example, most farmers store avocados before transporting them to the markets at their homestead, without cooling. Fruits are stored without cooling also at trading (Humble & Reneby 2014). The study conducted in Gondar town, for example, showed that only 31.1% of the shops store physically injured and spoiled fruits separately from healthy ones (Banjaw 2017; Gultie et al. 2013). Generally, farmers have faced significant challenges in storing fruits and vegetables due to the shortage of appropriate storage conditions in the country (Banjaw 2017).

### Improper packaging method

A well-designed packaging method helps to reduce damage to horticultural products, particularly perishable ones such as fruits and vegetables (Fellows 2011). In Ethiopia, several traditional packaging materials are used to hold agricultural products, but there is a shortage of standardized packaging materials for fruits and vegetables (Bereda 2016). The common are wooden boxes, baskets, plastic bags, and sacks (Kuyu & Tola 2018). In the Bahirdar area, 80.7% of the farmers use wooden boxes, 16.1% sacks, and 3.2% plastic boxes for packaging the fruit products, mainly mango and sweet orange (Dessalegn et al. 2016). The wooden boxes are too big (30–50 kg holding capacity) and too rough to protect the fruits on the bottom, which causes crushing and bruising during transportation (Mebratie et al. 2015).

Bananas are transported mostly in wooden boxes, baskets, or plastic bags and mango, avocado, papaya, and sweet orange – in sacks (Debela et al. 2011). In a few parts of the country, jute sacks are used as packaging materials for the fruits like mango and avocado, which are poor in ventilation and do not protect the fruits from mechanical damage and compression (Humble & Reneby 2014).

Leafy vegetables such as cabbage, lettuce, spinach, and Swiss chard are packed using sacks of local materials (Rahiel et al. 2018). Generally, all packaging materials are traditional and rudimentary to maintain the required quality of the products and prolong the shelf life. As a result, farmers face severe PHLs in their products before they arrive at the consumer level (Debela et al. 2011; Mebratie et al. 2015; Bantayehu et al. 2018; Rahiel et al. 2018).

**Improper transportation and marketing**

In Ethiopia, the transportation mechanisms used for horticultural products are human backs and shoulders, animals (donkey, horse, or mule), and rarely trucks (Humble & Reneby 2014; Mebratie et al. 2015; Dessalegn et al. 2016; Emana et al. 2017). In most cases, both farmers and traders use carts and human labor for short-distance transport. Such transportation methods predispose the products to overheat and mechanical damage (Mebratie et al. 2015; Dessalegn et al. 2016; Kuyu & Tola 2018). Agents collecting products from farms use vehicles (Emana et al. 2015), however, the cars do not have ventilation facilities to transport highly perishable commodities such as fruits (Dessalegn et al. 2016).

According to Hussen et al. (2013), such methods of transportation contributed to 5–20% of the total PHLs. The extending transport time of fruits and vegetables without using cushioning materials, in uncovered vehicles (Debela et al. 2011; Dessalegn et al. 2016), together with mixing the products from different sources (Kuyu & Tola 2018), overfilling, and loading with other harmful chemicals (Emana et al. 2017) are the other significant factors aggravating the PHL of fruits and vegetables. The problem with transportation concerns almost all parts of the country (Debela et al. 2011; Hussen et al. 2013; Mebratie et al. 2015).

**Effects of seasonal fluctuation, change**

Production of horticultural crops is highly seasonal based, and the price is inversely related to supply. The situation is worsened by the perishability of the products and poor storage facilities (Emana & Gebremedhin 2007). The steep fall in market prices during harvest season has been the most common grievance of the Ethiopian farmers (Alamerie et al. 2014; Haji 2008). The primary causes of seasonal variations are the greater availability of products in the main harvesting season, which forced them to sell them at 6–25% discounted prices for alternative uses (animal feed) (Parmar et al. 2017). The inability to absorb fruit and vegetables for storage results in the necessity for another utilization. Thus, the farmers were enforced to sell the products on the farm or at local markets (Hussen et al. 2013). Generally, poor market access is a common problem in most parts of the country (Teshome & Dürr 2016). Lack of sufficient markets to absorb products, low price of the products at the market, lack of coordination among the producers to increase their bargaining power, imperfect pricing system, and lack of transparency in the market information are the other responsible factors for PHLs of fruits and vegetables (Emana et al. 2017). The lack of well-organized markets is highly considerable for producers, agents, and retailers engaging in tomato produce (Debela et al. 2011; Emana et al. 2017). Marketable vegetable supply is also significantly affected by lack of access to market information, farming experience, and distance from the market (Woldesenbet 2013). Besides, fruits and vegetables markets are characterized by unethical practices of cheating and information collusion that led to uncompetitive market behavior in the country (Teka 2009).

**Effect of minimal technology adoption on postharvest loss**

The other important constraint in the PHL of fruits and vegetables in Ethiopia is the cost of postharvest technologies. The cost of procuring patented technologies even for local adaptation is prohibitive, and the lack of access to financing exacerbates the situation. Financing and investment in agriculture ventures are the least priorities for the commercial and financial sector (FAO 2018). According to FAO (2018), where agricultural technologies have been made available, particular problems have arisen, for instance, in the area of mechanized harvesting and threshing with higher PHLs. These losses are not necessarily a result of the technology itself, but the ill use of the technology, like lack of adherence to the manufacturer's specification in machine calibrations or service requirements.

### Practices of fruits and vegetables postharvest loss reduction in Ethiopia

Even though the production of the horticultural crop is increasing very fast, the PHL of the product is also very significant, and there is meager and insufficient government support to reduce a PHL (Banjaw 2017; Kasso & Bekele 2018). In most parts of the country, fruit and vegetable harvesting and trading is mainly done by youths and women (Dessalegn et al. 2016). Despite their paramount role in this activity, they have a small role in decision-making over the benefit obtained from the products (FAO 2018). In other ways, most farmers do not use preharvesting cautions to reduce the PHL and simply use traditional harvesting practices like handpicking or shriving, digging with equipment like sickle, spade, hoe, and ax. The poor preharvesting cautions result in mechanical damages like bruising, abrasion, sprouting, decay, chilling, rotting, and softening of the produce. Some farmers practice integrated pest management (IPM) to reduce the impact of pests in the northern part of Ethiopia, and some produce fruits and vegetables using inorganic farming systems. Some farmers also protect their fruits by covering them with local plastic materials. Nevertheless, the problem of fungal colonization of the outer part of fruits is repeatedly reported in some areas. According to Rahiel et al. (2018), about 36% of vegetables produce decay due to soft rot bacteria in the northern region. Postharvest treatments like applying N-benzyl adenine prolong the shelf life of leafy vegetables. The management practices slightly reduced the level of PHLs in fruits and vegetables; however, none of them were able to reduce the level of PHL to zero. Comparatively, IPM was better in reducing the PHL. In most areas, diseases arising from preharvest and postharvest practices were the primary problem. Generally, the postharvest management system of fruits and vegetables is inferior and unsatisfactory. Therefore, tremendous efforts are required in harvesting, storage, and transportation of fruits, infrastructure establishment, fruit processing, and capacity development throughout the country (Dessalegn et al. 2016; Rahiel et al. 2018).

### Future scenarios of fruits and vegetable losses in Ethiopia

The report indicated that the projected Ethiopian population will be increased from 83.7 million in 2012 to 133.5 million in 2032 and 171.8 million in 2050 (Parmar et al. 2017). In this regard, the demand for food is expected to be doubled. If the extent of PHLs continues in this way and is not reduced in the future, the demand for food for this growing population will not be met. Therefore, future activity should be focused on improving the preharvesting activities, harvesting system, and postharvest handling to minimize the problem of PHL. Reducing PHL can play a pivotal role in eliminating extreme hunger and malnutrition of the growing population by creating food availability and increasing food access, utilization, and stability (Gross et al. 2000). It is necessary to ensure that additional production is consumed rather than lost. Therefore, designing PHL interventions of fruits and vegetables is one of the very imperative methods to broaden the economic, health, and environmental implications for fruits and vegetables in the country (Gebremeskel 2018).

## CONCLUSION

The present review indicates that postharvest loss of fruits and vegetables is a severe problem in Ethiopia, attributed to many human and natural factors. PHLs contribute significantly to food insecurity and pose a serious problem to the livelihood of the society and the economy of the country as well. The attention given by the government, academicians, and researchers to the reduction of PHL is deficient. The management system being practiced and the existing policy are also not satisfactory to overcome the problem. Urgent government intervention and integration work are, therefore, very imperative for effective and sustainable management of the PHL.

### Acknowledgments

The authors would like to thank all individuals and organizations that provided the necessary materials used in this review paper. The sources used in this paper are also duly acknowledged.

**Disclosure statement**

The authors declared that we have no conflict of interest.

**Funding**

There was no fund granted for this review paper.

REFERENCES

Alamerie K., Ketema M., Gelaw F. 2014. Risks in vegetables production from the perspective of smallholder farmers: The case of Kombolcha Woreda, Oromia region, Ethiopia. Agriculture, Forestry and Fisheries 3(6-1): 1–5. DOI: 10.11648/j.aff.s.2014030601.11.

Arah I.K., Amaglo H., Kumah E.K., Ofori H. 2015. Preharvest and postharvest factors affecting the quality and shelf life of harvested tomatoes: A mini-review. International Journal of Agronomy 2015; 478041; 6 p. DOI: 10.1155/2015/478041.

Awole S., Woldetsadik K., Workneh T.S. 2011. Yield and storability of green fruits from hot pepper cultivars (*Capsicum* spp.). African Journal of Biotechnology 10(56): 12662–12670. DOI: 10.5897/ajb10.1661.

Banjaw T.D. 2017. Review of post-harvest loss of horticultural crops in Ethiopia, its causes and mitigation strategies. Journal of Plant Sciences and Agricultural Research 2(1); 006; 4 p.

Bantayehu M., Alemayehu M., Abera M., Bizuayehu S. 2018. Determinants and extent of pre- and postharvest losses of fruits in Northwestern Ethiopia. International Journal of Sustainable Agricultural Research 5(4): 68–75. DOI: 10.18488/journal.70.2018.54.68.75.

Bachewe F., Minten B. 2021. The fruits and vegetable value chain in Ethiopia: Transformation, prices, and implications for consumption and nutrition. Webinar, NIPN, EPHI, IFPRI-ESSP, Addis Ababa, Ethiopia.

Bereda S. 2016. Effect of harvesting, handling and storage techniques on quality and shelf life of avocado fruits in Sidama Ethiopia. MSc thesis, School of Plant and Horticultural Sciences, College of Agriculture, Hawassa University, Ethiopia, 72 p.

Chauvin N.D., Mulangu F., Porto G. 2012. Food production and consumption trends in sub-Saharan Africa: Prospects for the transformation of the agricultural sector. Report WP 2012-011, United Nations Development Program, Regional Bureau for Africa.

CSA 2000, 2002, 2004, 2006, 2008, 2010, 2014, 2016, 2018. Report on area and production of major crops. Central Statistical Agency, Addis Ababa, Ethiopia.

Debela A., Daba G., Bane D., Tolessa K. 2011. Identification of major causes of postharvest losses among selected fruits in Jimma zone for proffering veritable solutions. International Journal of Current Research 3(11): 40–43.

Deribe H., Mintesnot A. 2016. Review on contribution of fruits and vegetables on food security in Ethiopia. Journal of Biology, Agriculture and Healthcare 6(11): 49–58.

Dessalegn Y., Assefa H., Derso T., Haileslassie A. 2016. Assessment of fruit postharvest handling practices and losses in Bahir Dar, Ethiopia. African Journal of Agricultural Research 11(52): 5209–5214. DOI: 10.5897/ajar2016.11731.

Emana B., Gebremedhin H. 2007. Constraints and opportunities of horticulture production and marketing in Eastern Ethiopia. DCG Report No. 46, Addis Ababa, Ethiopia.

Emana B. 2010. Market assessment and value chain analysis in Benishangul Gumuz Regional State, Ethiopia. Final Report. SID-Consult-Support Integrated Development, Addis Ababa, Ethiopia.

Emana B., Afari-Sefa V., Dinssa F.F., Ayana A., Balemi T., Temesgen M. 2015. Characterization and assessment of vegetable production and marketing systems in the Humid Tropics of Ethiopia. Quarterly Journal of International Agriculture 54(2): 163–187. DOI: 10.22004/ag.econ.210313.

Emana B., Afari-Sefa V., Nenguwo N., Ayana A., Kebede D., Mohammed H. 2017. Characterization of pre- and postharvest losses of tomato supply

chain in Ethiopia. Agriculture and Food Security 6; 3; 11 p. DOI: 10.1186/s40066-016-0085-1.

FAO 2018. Reducing food losses through improved postharvest management in Ethiopia. Final evaluation of phase 1. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO 2019. The state of food security and nutrition in the world 2019. Safeguarding against economic slowdowns and downturns. Food and Agriculture Organization of the United Nations, Rome, Italy.

Fellows P. 2011. Packaging of agricultural products. Agromisa Foundation and CTA, Wageningen, the Netherlands. Agrodok 50; 70 p.

Gebremeskel A.F. 2018. Post-harvest loss vs food and nutrition insecurity; challenges and strategies to overcome in Ethiopia. International Journal of Food Science and Nutrition Engineering 8(4): 95–102. DOI: 10.5923/j.food.20180804.02.

Gross R., Schoeneberger H., Pfeifer H., Preuss H.J. 2000. Four dimensions of food and nutrition security: Definitions and concepts. SCN News 20: 20–25.

Gultie A., Sahile S., Subramanian C. 2013. Assessment of fruit management in Gondar town markets of North Western Ethiopia. Global Journal of Biology, Agriculture and Health Sciences 2(4): 4–8.

Gustavsson J., Cederberg C., Sonesson U., van Otterdijk R., Meybeck A. 2011. Global food losses and food waste: Extent, causes and prevention. Food and Agriculture Organization of the United Nations, Rome, Italy.

Hagos D.G. 2014. Supply chain management (SCM) approach to reduce post-harvest losses with special emphasis on cabbage supply from Akaki to Addis Ababa. MSc thesis, Department of Civil Engineering, Addis Ababa University, Ethiopia.

Hailu A. 2016. Value chain analysis of vegetables: The case of Ejere district, West Shoa zone, Oromia national regional state of Ethiopia. MSc thesis, School of Agricultural Economics and Agribusiness, Haramaya University, Ethiopia.

Hailu G., Derbew B. 2015. Extent, causes and reduction strategies of postharvest losses of fresh fruits and vegetables – A review. Journal of Biology, Agriculture and Healthcare 5(5): 49–64.

Haji J. 2008. Economic efficiency and marketing performance of vegetable production in the eastern and central parts of Ethiopia. Acta Universitatis Agriculturae Sueciae 17. PhD thesis, Department of Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Hengsdijk H., Sertse Y., Tesfaye S., Likoko E. 2021. Fruits and vegetable scoping study: Ethiopia; An assessment of current constraints and opportunities for development. Wageningen Economic Research, Report 2021-108, Wageningen, the Netherlands, 80 p.

Hodges R.J., Buzby J.C., Bennett B. 2011. Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. Journal of Agricultural Science 149(S1): 37–45. DOI: 10.1017/s0021859610000936.

Humble S., Reneby A. 2014. Post-harvest losses in fruit supply chains – a case study of mango and avocado in Ethiopia. Degree thesis 899, Department of Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Hussen S., Beshir H., Hawariyat Y.W. 2013. Postharvest loss assessment of commercial horticultural crops in South Wollo, Ethiopia "Challenges and Opportunities". Food Science and Quality Management 17: 34–39.

Joosten F., Boselie D., Wolde B., Desalegn L. 2011. Exporting fruits and vegetables from Ethiopia: Assessment of development potentials and investment options in the export-oriented fruit and vegetable sector. Ethiopian-Netherlands Horticulture Partnership, Study Report. EHDA, EHPEA, Addis Ababa, Ethiopia.

Kader A.A., Kitinoja L., Hussein A.M., Abdin O., Jabarin A., Sidahmed A.E. 2012. Role of agro-industry in reducing food losses in the Middle East and North Africa region. Food and Agriculture Organization of the United Nations, Regional Office for the Near East, Cairo, Egypt.

Kasso M., Bekele A. 2018. Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia. Journal of the Saudi Society of Agricultural Sciences 17(1): 88–96. DOI: 10.1016/j.jssas.2016.01.005.

Kikulwe E.M., Okurut S., Ajambo S., Nowakunda K., Stoian D., Naziri D. 2018. Postharvest losses and their determinants: A challenge to creating a sustainable cooking banana value chain in Uganda. Sustainability 10(7); 2381; 19 p. DOI: 10.3390/su10072381.

Kuyu C.G., Tola Y.B. 2018. Assessment of banana fruit handling practices and associated fungal pathogens in Jimma town market, southwest Ethiopia. Food Science and Nutrition 6(3): 609–616. DOI: 10.1002/fsn3.591.

Lipinski B., Hanson C., Lomax J., Kitinoja L., Waite R., Searchinger T. 2013. Reducing food loss and waste. Working Paper, Installment 2 of Creating a sustainable food future. World Resources Institute. http://pdf.wri.org/reducing_food_loss_and_waste.pdf

Mebratie M.A., Haji J., Woldetsadik K., Ayalew A. 2015. Determinants of postharvest banana loss in the marketing chain of central Ethiopia. Food Science and Quality Management 37: 52–63.

Mezgebe A.G., Terefe Z.K., Bosha T., Muchie T.D., Teklegiorgis Y. 2016. Post-harvest losses and handling practices of durable and perishable crops produced in relation with food security of households in Ethiopia: Secondary data analysis. Journal of Stored Products and Postharvest Research 7(5): 45–52. DOI: 10.5897/jsppr2016.0205.

Mitiku M., Gutema T. 2017. Assessment of postharvest handling practices and problems on major crops of South Ari District, South Omo Zone, SNNPR, Ethiopia. Journal of Biology, Agriculture and Healthcare 7(11): 1–4.

Parfitt J., Barthel M., Macnaughton S. 2010. Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society Biological Sciences 365(1554): 3065–3081. DOI: 10.1098/rstb.2010.0126.

Parmar A., Kirchner S.M., Sturm B., Hensel O. 2017. Pre-harvest curing: Effects on skin adhesion, chemical composition and shelf-life of sweetpotato roots under tropical conditions. East African Agricultural and Forestry Journal 82(2–4): 130–143. DOI: 10.1080/00128325.2017.1340141.

Rahiel H.A., Zenebe A.K., Leake G.W., Gebremedhin B.W. 2018. Assessment of production potential and postharvest losses of fruits and vegetables in northern region of Ethiopia. Agriculture and Food Security 7; 29; 13 p. DOI: 10.1186/s40066-018-0181-5.

Salami P., Ahmadi H., Keyhani A., Sarsaifee M. 2010. Strawberry post-harvest energy losses in Iran. Researcher 2(4): 67–73.

Tabor G., Yesuf M. 2012. Mapping the current knowledge of carrot cultivation in Ethiopia. Consultancy report for Carrot Aid. Addis Ababa, Ethiopia, 20 p.

Teka A.G. 2009. Analysis of fruit and vegetable market chains in Alamata, Southern Zone of Tigray: The case of onion, tomato and papaya. MSc thesis, Department of Agricultural Economics, School of Graduate Studies, Haramaya University, Ethiopia.

Teshome A., Dürr J. 2016. Horticulture value chains in Ethiopia: Opportunities for better nutrition and new market access? International Research on Food Security, Natural Resource Management and Rural Development. University of Natural Resources and Life Sciences, September 18–21, Vienna, Austria.

Tigist M., Workneh T.S., Woldetsadik K. 2013. Effects of variety on the quality of tomato stored under ambient conditions. Journal of Food Science and Technology 50(3): 477–486. DOI: 10.1007/s13197-011-0378-0.

Tilahun S.W. 2010. Feasibility and economic evaluation of low-cost evaporative cooling system in fruit and vegetables storage. African Journal of Agriculture, Nutrition and Development 10(8): 2984–2997. DOI: 10.4314/ajfand.v10i8.60885.

Urge M., Negeri M., Selvaraj T., Gebresenbet G. 2014. Assessment of post-harvest losses of ware potatoes (*Solanum tuberosum* l.) in Chelia and Jeldu districts of West Shewa, Ethiopia. International Journal of Research in Science 1(1): 16–29. DOI: 10.15613/sijrs/2014/v1i1/53853.

Woldesenbet A.T. 2013. Value chain analysis of vegetables: The case of Habro and Kombolcha woredas

in Oromia region, Ethiopia. MSc thesis, School of Agricultural Economics and Agribusiness, Haramaya University, Ethiopia.

Workneh T.S., Osthoff G., Steyn M.S. 2011. Physiological and chemical quality of carrots subjected to pre- and postharvest treatments. African Journal of Agricultural Research 6(12): 2715–2724.

Workneh T.S., Osthoff G., Steyn M. 2012. Effects of preharvest treatment, disinfections, packaging and storage environment on quality of tomato. Journal of Food Science and Technology 49(6): 685–694. DOI: 10.1007/s13197-011-0391-3.