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Improved storage technologies in post-harvest loss reduction of perishable crops and enhancing food and nutrition security: A review

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Abstract
Perishables crops are the crops which have high moisture content and short shelf life. They generate income since it can be used to achieve zero hunger and food security. However the major problem with perishable crops due to high moisture content, short shelf life and change quality parameters particularly storage. According to most of research and review shows, approximates 40-50% perishable crops loss in the supply chain at globally level. In Ethiopia also, postharvest loss of perishable crops is 50% due to lack of appropriate post-harvest handling practice and inappropriate storage technologies. In order to reduce post-harvest loss of perishable crops and enhance food and nutrition security, the of roles of low cost and improved storage technologies is great. Storage technologies like Low cost storage can be beneficial for farmers needing a small-scale storage system. On other hand, improved storage technology includes refrigerated storages like cold storages, controlled atmospheric storage, modified atmosphere storage, and hypobaric storage play great role to reduce post-harvest loss of perishable crops. This technology reduces post-harvest losses of perishable crops by controlling temperature, concentration of gases and relative humidity of the storage area. Therefore, the aim of this review paper is to review studies made by several researchers and reviewers on the roles of improved storage technologies in post-harvest loss reduction of perishables crops and enhances food and nutrition security. So to alleviate post-harvest loss of perishable crops and to solve problems of food and nutrition security, using improved storage technology is very important and determinant.

Keywords: food security, fruits and vegetables, improved technology storage, low cost storage, and perishable crops

Introduction

1. Back ground information

Perishables crops are the crops that have high moisture content and soft structure result not last long and they have a limited shelf life. Production of those crops has complexity due to their perishable nature characteristics, so horticulture industry in sub-Saharan Africa and in Ethiopia particular stays at its infant stage (Hailu and Derbew, 2015) [21]. Production of those crops in Ethiopia small, when compared to other crops. World population is expected to reach 10 billion by 2050 which will require a 70% increase in food production (Hodges, 2011) [22]. According to report of Capone (2014) [10] indicate, 870 million people were food insecure and chronically undernourished during the year 2010-2012 (Sebeko, 2015) [48]. Agricultural of perishable crops plays role in increasing food availability and incomes, and contributing to the overall economy and a key issue to improve food and nutrition security. Not only production, PHL reduction of perishable crops is very important to income enhancement of the community and economic development of countries

Reducing Postharvest loss of perishable crops also important in supplementary source of nutrition and improves food security. Therefore, enhance Production of perishable crops, falling of PHL and increased food security for better nutrition intake is leads to economic development (Weinberger and Lumpkin, 2007) [55]. In addition to contribute income enhancement and improves food and nutrition security, perishable crops are important as sources of nutrients for human beings consumption and for health benefits. In 2017, 3.9 million deaths worldwide were attributable to not eating enough fruit and vegetables (Noorwali, 2019). Insufficient intake of perishable crops is estimated to cause around 14% of deaths from gastro-intestinal cancer worldwide, about 11% of those, due to ischemic heart disease, and about 9% of those caused by stroke (Kimble, 2020). Particularly, fruits and vegetables have health benefits for consumers, due to their content of fiber, vitamins (A and C), minerals and antioxidant compounds (Rahiel *et al*., 2018) [41].

The high moisture and nutrient content of perishable crops make their Post-harvest loss high. Hodges *et al.* (2011) [22] estimate, Post-harvest losses of perishable crops in the developing countries due to improper handling and storage are enormous because of inadequate storage facility and factors like temperature, relative humidity and gases concentrations (O_2 and Co_2) balance. Massive quantity of fruits and vegetables are lost every year due to the lack of proper storage technology and post-harvest management. Oelofse *et al*. (2013) [36] estimated annual quantitative perishable crops loss in the supply chain globally, approximates 40-50% fresh produces. After some time Ahmad, and Siddiqui, (2015) [4] estimated that, about 30–40 % of total perishable crops production also lost in between harvest and final consumption. In Africa, post-harvest losses are not properly documented but experts have projected the losses up to 80% (Ndukwu, and Manuwa, 2014) [33].

According to research done show, India is the second largest producer of fruits and vegetables in the world with huge postharvest losses 6-18% due to lack of appropriate storage (Rais and Sheoran 2015) [42]. According to research done in Kenya by Kitinoja and Kader (2015) [28], PHL of perishable crops high as 50% mainly due to poor storage and handling practices. The loss for perishable crops are accounting for as high as 30 to 40% loss in Ethiopia (Demissew *et al.*,2017; Raheil *et al*.,2018) [13]. The loss up to 50% due to biological and environmental factors in developing countries like Ethiopia (Ambuko *et al*., 2017) [6]. However, both low cost and high cost storage technologies are crucial for storage of perishable crops in order to reduce the problems of PHL and enhance food security. The keeping longevity of perishable crops requires high cost storage and energy consuming technology and this is difficult for most farmers due to farmers cannot find the money. This is one of the important sources of food insecurity in Africa. In sub Saharan Africa, about 27% or 234 million people have no sufficient food available (Capone, 2014) [10].

Access to adequate food is limited in currently at world level especially in Ethiopia. Therefore, has a need to grant food security by increasing perishable crops production and reducing PHL from harvest to consumption especially during storage. Production and reducing PHL of fresh produces can be one of the solutions to enhance food availability and relieve undernourishment. So to reduce PHL of perishable crops and enhance food and nutrition security; storage technologies specially, improved storage technologies are important. Those storage technologies play great roles in reducing PHL of perishable crops and enhance food and nutrition security.

Therefore, the main aim of this review is to review and summarize role improved storage technology on post-harvest loss reduction of perishable crops and enhance food and nutrition security.

Methodology

Published results from both qualitative and quantitative data about role of improved storage technologies on post-harvest loss perishable crops and enhancing food and nutrition security were all included to this review paper. The data for this review were collected from different internet sources such as the essential electronic agriculture library (TEEAL), Health inters network access to research initiative HINARI), Google scholar data bases up to 2022 were used. Accordingly to summarize all contents less than sixty (60) published papers were collected from specified sources and included in this review papers. All these sources have been used for reduce PHL of perishable crops and to solve problem of food and nutrition security. The research of those articles was conducted using key words: Food security, fruits and vegetables, improved technology storage, low cost storage, and Perishable crops, post-harvest losses

2. Post-Harvest Loss of Perishable Crops and Food and Nutrition Security

2.1. Perishable Crops

In developing countries, approximately 30% of food consumed is perishable (kitinjo, 2015). The quality loss of perishable crops after harvest happens as a result of different factors such as physical, biochemical, physiological and biological factors, the rates of which are influenced primarily by product temperature at harvesting and relative humidity surrounding the produce. Decreasing the temperature of the product as quickly as possible after harvest will maintain a great level of quality remaining attractive for customers. The rate of spoilage increases by 2 or 3 folds with in temperature of 10^{o}C (Mansuri, 2019).

2.1.1. Fruits and Vegetables

Due to their live tissue and extreme perishability, fruits and vegetable harvests are prone to respiration, water loss, and cell softening throughout the postharvest system. Also due to inappropriate post-harvest management, the amount of loss in fruits and vegetables is between 35 and 40% (Sharma and Mansuri, 2017).The main factor that reduces the amount of fruits and vegetables that reach the market after harvesting is a lack of storage temperature and relative humidity. This has a direct effect on how much food is distributed and consumed in order to maintain a healthy lifestyle. As a result, postharvest management of physiological processes respiration and transpiration is necessary to control the storage life (Gomez *et al*., 2019).

2.2. Importance of Perishable Crops

Perishable crops are essential for a nutritionally balanced diet (Yahaya *et al.,* 2015). Specially, Vegetables and fruits contribute considerably to improving the quality of diet and human nutrition and income. These crops are excellent sources of Vitamins (A and C), and minerals (iron, calcium), carbohydrates and proteins. On all of these counts-economics, nutrition, acceptability perishable crops play a major role in developing countries.

From a nutritional point of view, roots and tubers also have great potential to provide an economical source of energy in the form of carbohydrates. Globally, 5% of root and tuber production is consumed as food, with the rest used as animal feed or for other uses such as industrial processed products such as starches, spirits and various by-products ((Reddy, 2015).

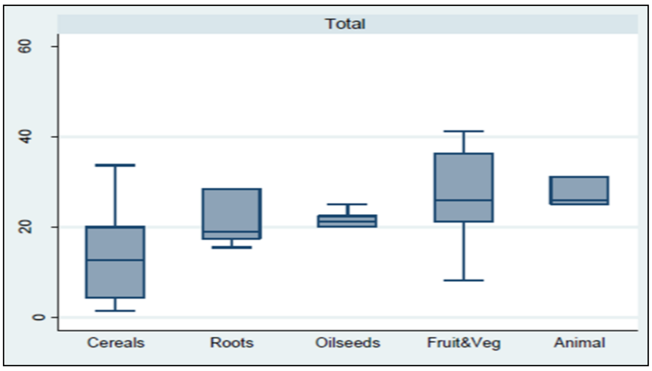
Root and tubers are mainly contributed for; supporting food and nutrition security; Industrial raw material source; animal feeding and Income generating for producers and traders. A weight loss becomes an economic loss when the produce is marketed on a weight basis as well as being less attractive to potential customers and it is directly related with cost. It is very difficult to give precise data on transpiration weight loss, because of factors such as temperature, relative humidity, the rate of air movement surrounding the tuber, permeability of the skin and how this may have been affected (Abewoy and Damtew, 2021).

The energy of tubers is about one-third the weight equivalent of rice or wheat due to the high water content of tubers (Chandrasekara and Josheph 2016). Roots and tubers are also important perishable crops to enhance food and nutrition security. Generally, roots and tubers are important nutritional components for human nutrition. Tubers and roots serve as a functional food and dietary supplement to alleviate non-communicable chronic diseases and maintain good health due to presence of antioxidant (Chandrasekara and Josheph 2016).

2.3. Post-harvest losses of perishable crops

Major causes of post-harvest losses of perishable crops occur during harvesting, post-harvest handling and storage, processing stages, distribution and consumption are environmental factors (Abewoy and Damtew,2021). A recent study by Gustavsson *et al*. (2011) estimated annual quantitative food losses in the supply chain to be around 40% to 50% globally for fresh produce, grain is 30% and

20% for oilseeds. According to Capone (2014) [10], post-harvest losses are one concern food security and global hunger in developing countries and it range from 15 to 50%.A recent literature review by Rosegrant *et al*. (2018) [46] estimated losses for these crops to be between more than 20% and 35%. In figure 1 below, the PHL for fruits and vegetables is extremely or much higher than for other cereals. Najiri et al. (2014) estimated because of perishability; physical loss of crops like cassava at 12% in Ghana, 7% in southwestern Nigeria, 3% in Vietnam and 2% in Thailand.



Source: Ishangulyyev *et al*., 2019.

Fig 1: losses in SSA occur at production or during storage and handling stages.

2.4. Causes of Losses in Perishable Crops

There are so many causes for losses in the perishable crops and they are classified into two group namely primary and secondary losses (Pessu *et al*., 2011).

2.4.1. Primary causes of loss

Factors or causes that are directly affect the fruits and vegetables shelf life and quality.

It includes microorganism, physical factors, physiological factors and etc.

2.4.2. Secondary causes of loss

A secondary cause of loss is one that leads to a situation that contributes to the encourage the primary cause of loss increase. Some of them are:

- Inadequate harvesting, packaging and handling skills.
- Lack of adequate containers for the transport and handling of perishables.
- Storage facilities inadequate to protect the crops
- Transportation inadequate to move
- Inadequate refrigerated storage.
- Traditional processing and marketing systems can be responsible for high losses.

2.5. Ways of Reducing Loss of Perishable Crops

One of the main problems contributing to the high PHL of perishable crops is the inadequacy of improvements in infrastructure and information and temperature management problem. Therefore, reducing Post harvest losses (PHL) of perishable crops, especially fruits and vegetables, by using improved storage technology is a complementary measure to increase food and nutrition security (Mustapha and Yahaya 2006) [31].

2.5.1. Used Improved Storage Technology

One of the main reasons for postharvest losses of perishable crops is inappropriate storage technology. Storage of fruits and vegetables becomes essential step to make them available during off season and also to control surplus situations in the market. Appropriate storage like improved storage technologies for safe storage of perishable crops become essential for regular supply of commodities (Abadi *et al*., 2016) [1].

2.6.1. Basic criteria and factors to consider during of storing perishable crops

2.6.1.1. Identification/Considerations/ for Climacteric and Non-Climacteric

There are some factors we have to consider during storage of perishable crops. One of best criteria or factors is identifies whether they are respire or not after cut from mother tree. According to their respiration behavior during maturation and ripening, Perishable crops like fruits are classified to either climacteric or non-climacteric (Ariwaodo, 2022) [7, 8]. Respiration is the process of breaking down a cell's complex substances into simpler energy-providing molecules**.**

Climacteric or Menopausal crops: Crops that respire after cut from mother trees **(**Chen *et al*., 2018) [12]. They show a sharp increase in respiration and ethylene production during ripening. They include Apple, Avocado, and Apricot, mango, tomato and guava

Non-climacteric or Non-menopausal crops: in those crops no more respiration after they separated from mother tree **(**Tietel *et al*., 2010) [52]. Generally low respiration rate and no change in ethylene production during ripening. Both menopausal and non-menopausal berries respond to ethylene. Ethylene As a plant hormone, it is involved in regulating growth, maturation, aging, and disposal processes. In non-menopausal fruit, respiration rate increases proportionally with increase ethylene concentration. They include Eggplant, cacao, cucumber, lychee and blackberry.

Two classification of storage technology for perishable crops are there based on the requirement of refrigeration (Kaur *et al*., 2021) [25]. Low-cost storage technologies and improved storage technologies the main technology used to reduce post-harvest losses.

2.6.2. Low-cost storage technologies

These storage technologies perishable crops hold huge importance to reduce losses taking place in world developing countries. Low cost storage technologies or traditional storage structures can be beneficial for poor farmers needing a small-scale storage system (Kaur, 2021) [25].

2.6.2.1 On-site or field storage

This storage technology technique of storage involves in the delaying the crop harvest through leaving it with inside the soil. This technique is in particular used for root, and tuber crops. But the problem of on site or field storage technique is that land stays occupied. It should be ensured that the crops are blanketed from pest and disorder attacks, chilling, and freezing injuries (Pavlatos and Vita, 2016).

2.6.2.2. Sand and Coir
According to the work of El- Ramady *et al*. (2015) [17] in India, covering potatoes underground using sand and coir is a low cost storage technology. Cellar also low cost that work by the underground structures that are used to store vegetables, fruits. Cellars must ideally be dark and cold (Rees, 2012) [44]. It lower PHL perishable crops by reduce temperature and steady humidity conditions, reducing oxygen and increasing the carbon dioxide content (Kale *et al.*, 2016) [24]

2.6.2.3. Ventilated storage structures
Ventilated storage have a flow of air that ensures minimal storage temperature. The natural ventilation storage where the heat around the product is continuously removed by natural airflow along with humidity generated by product respiration.

This storage technology used for the storage of fruits and vegetables such as roots and tubers.

Fig 2: Ventilated storage; Source (Kale *et al*., 2016)

Like natural ventilation, forced air ventilation is running through the using of supporting fan to boom the rate of warmth and gases exchange. Related with the running ideas of this technology Elansari *et al*. (2019) factor out that, the air is compelled via the stored crop and forcing the air used for improved the exchange of gases and warmth into the storage systems with the assist of a fan.

2.6.2.4. Evaporative cool chambers (Zero energy cooling chambers, ZECC)
Based on the fundamental premise that when water evaporates, it results in a cooling effect that affects objects that come in contact with it, crops are cooled in an evaporative cooling chamber

(Ndukwu, 2014). *Evaporative cool chambers* work through cool the environment temperature drops and humidity increases. it enhance the shelf-life of Avocado fruits through controlling temperature and relative humidity (Khan *et al*., 2022) [26]. This storage technology system can reduce the temperature of the crop by 10-15°C and maintain a high humidity of nearly 90% (Devi and Singh, 2018).

According to the work of Perez *et al*. (2004), Storage conditions of mature avocados fruits at 5ºc and a relative humidity of 85-90% could result in maintain a shelf life two to three weeks.

According to the research done in Ghana showed that, the storage perishable crops in ZECC, produce available for sale increased to 62% of the original harvest, compared to 42 percent without a cooling chamber. The Weight losses reduced by 20% and vegetable shelf-life increased from one day to between five and six days (Ridolfi *et al.*, 2018) [45].

Fig 3: Evaporative cool chamber (ECC) (A) and improved ECC (B and C);Source kale *et al*., 2016

2.6.2.5 Pits
Pits are ground in the floor made by digging a gravel pit and its storage must be prepared on the boundaries of the field and at an increased point in which there's availability of small or less rainfall accumulation in the cultivated field. This storage technology can practice for tubers, carrot, onion, cabbages, and beets are covered up with straw (Ariwaodo and Chinenye,2022) [7, 8].

2.6.2.6 Pot-in-Pot
This is a traditional storage technology used in homes and simple to prevent crop losses. A storage pot is placed in an earthenware bowl filled with water (Ridolfi *et al*.,2018) [45]. During this work, the pot has to close with a damp cloth that is dipped or hollowed into the water reservoir. The water drawn up the cloth evaporates, keeping the storage pot cool.

Fig 4: Pot-in-pot Source: (Verploegen *et al*.,2021)

2.7. Improved Storage Technologies in PHL Reduction of Perishable Crops

They also preserve perishable crops by controlling factors like environmental factors, physical, physiological factor (respiration) factors, biological and chemical reaction. PHL reduction by improved storage technology can simultaneously optimize agricultural productivity and increase the incomes of small-scale food producers (Stathers *et al*., 2020) [50].

Several improved storage techniques are being investigated today for perishable crops such as fruits and vegetables. These include cold storage, CAS, MAS, and (hypobaric storage) low-pressure storage.

2.7.1. Cold storage of perishable crops

Lowering the temperature slows down the respiration rate of the product and biochemical reactions and increasing the shelf life of the product. A cold chain maintains quality from harvest to consumer use (Sahoo *et al*., 2019) [47]. Refrigerated storage is the only widely used method for bulk processing of perishables from production to sale. Most perishable goods require maintenance of 80-90% relative humidity in the storage space, which negatively impacts product shelf life (Moharana *et al*., 2016) [30]. Therefore, to reduce PHL of perishable crops, the management of temperature and relative humidity are the most important and low temperature should be optimum to prevent physiological disorders.

2.7.2. Control atmosphere storage (CAS)

Under Control atmosphere conditions, products can be stored for 2 to 4 times longer than usual (Dhatt and Mahajan, 2007) [15]. In a CAS system, the produce is kept at reduced O_2 and high CO_2 concentrations with an appropriate temperature range and relative humidity. CAS reduce the post-harvest losses and extends the shelf life of perishable crops by Decreasing respiration and ethylene production rates, softening and retard senescence of perishable crops. Reduce fruit sensitivity to ethylene action and Alleviate physiological disorders such as chilling injury

However, the main problems of CAS at Very low of oxygen concentration and very high volume of carbon dioxide is change of an aerobic into anaerobic respiration which leads to formation of fermentation process. Anaerobic respiration and fermentation due to low oxygen and high carbon dioxide volume can lead to the development of off-odours and off-flavours. Also according to the work of (Yahia *et al*. (2019) [16, 58] at low levels of oxygen and/or very high levels of carbon dioxide, development of microorganism may occur.

2.7.3 Modified atmospheric Storage (MAS)

Modified atmosphere storage (MAS) technology offers the possibility to retard produce respiration rate and extend the shelf life of perishable crops. A composition of CO_2, O_2 and N_2 is injected into the headspace that replaces the storage atmosphere. MAS reduce PHL of perishable crops like CAS through controlling gases concentration and reduce respiration rate by decreasing O_2 concentration. A reduction in oxygen concentration below 8% and/or increase in carbon dioxide concentration slow down fruit ripening (Caleb *et al*., 2012) [9]. Hence, a decrease in respiration rate delays enzymatic degradation of complex substrates, thereby extending the shelf life of the produce.

2.7.4 Hypobaric Storage

In this technology, the crops placed in a flowing stream of extremely moistened or humidified air which is kept at a reduced pressure and controlled temperature. Hypobaric storage technology is a highly much less understood sort of managed atmospheric storage wherein low-oxygen surroundings is created at sub-atmospheric pressure ranges; which in turn reduces the respiration rates and metabolism kinetics of commodities, thereby increasing storage life. The product is stored under a partial vacuum in a chamber. The chamber is vented continuously with saturated air to preserve the low-oxygen partial pressure ranges. Generally, the work of (Vithu and Moses, 2017) [54] estimate that, a 10kPa lower with inside the air pressure same with oxygen partial strain of 2.1 kPa that allows a 2% discount in oxygen attention at regular atmospheric pressure.

2.8. The contribution of Improved Storage Technologies in perishable crops

The global population is projected to reach 9.7 billion people by 2050 (UNDESA, 2019) [56]. The Khan (2022) [26] estimated that, each year, about one third of the world's food production for human consumption is lost. This will require a 60% increase in global food production compared with 2005–2007 levels, alongside more equitable access (Alexandratos *et al*., 2012) [5]. With the increasing health awareness of consumers, there has been an increasing concern over the use of perishable crops products. But for the preservation of horticultural perishable produce and enhance shelf life thermal processing methods are very important (Gupta, 2014) [19].

2.8.2. Reducing postharvest losses and enhancing food and nutrition security

Postharvest management of perishable crops important to solve problem of food. Food security is the availability and access to food and it exists when all people have physical, social and economic access at all times to sufficient, safe and nutritious food to satisfy their nutritional needs and food preferences for an active and healthy life. Agriculture of perishable crops plays a central role in increasing food availability and incomes and a key factor to improve food and nutrition security (Ishangulyyev *et al*. 2017). The reduction of Post-harvest loss is a crucial way to food and nutrition security in sub-Saharan Africa (Affoghon *et al*., 2015).

The nutritional and health value of perishable crops vegetables is well recognized in countries like Ethiopia because they play important roles in human health through control chronic diseases and due to providing antioxidants (Tabor and Yesuf, 2012) [51]. Therefore reducing post-harvest losses play a critical role in eliminating extreme hunger and Feeding a growing worldwide population (Gustafsson, 2013) [20].

3. Summary

Post-harvest losses of perishable crops due to improper storage are major problem for producers of developing countries in this world. After harvest, perishable crops need to be handled with care to maintain their general quality and to reduce PHL due to they are highly perishable. Storage technologies is critical to reducing postharvest losses of perishable crops including maintain quality, preserve nutrient content, and get higher prices at market. Despite progress in perishable production, failure to reduce postharvest loss can decline food availability due to increase in physical loss and decrease in income from the diminished market opportunities. Different storage technologies are developed based on temperature and relative humidity environment control to reduce these losses and retain the crop quality until their demand in the market. Low cost Storage technologies like clamps, pits, pot in pot, cellar and evaporative cooling chambers are being traditional storage technology used and help the farmers generate greater income by reducing post-harvest losses. However, these are incompetent to store a bulk of products for an extended time. To solve those problems, improvement in high cost storage technology are coming up. Now, improved storage technologies are being utilized, which include storage in cold stores, CAS, MAS and hypobaric storage. These techniques have proved effective in reducing PHL and enhancing the shelf life of numerous perishable crops by creating an appropriate storage environment for them and enhance food and nutrition security.

Therefore, mitigation of PHL of perishable crops particularly for fruits and vegetables by using low cost and improved storage technologies contributed to increase food and nutritional security.

References

1. Abadi, Gebre Mezgebe, *et al*. "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,2016:7.5:45-52.
2. Abewoy Damtew. "Review on postharvest handling practices of root and tuber crops." *International Journal of Plant Breeding and Crop Science*,2021:8:992-1000.
3. Affognon, Hippolyte *et al*. "Unpacking postharvest losses in sub-Saharan Africa: a meta-analysis." World development,2015:66:49-68.
4. Ahmad MS, Siddiqui MW. Factors affecting postharvest quality of fresh fruits. In Postharvest quality assurance of fruits, Springer, Cham., 2015, 7-32.
5. Alexandratos Nikos, Jelle Bruinsma. "World agriculture towards 2030/2050: the 2012 revision.", 2012.
6. Ambuko J, Wanjiru F, Chemining'wa GN, Owino WO, Mwachoni E. Preservation of postharvest quality of leafy amaranth (Amaranthus spp.) vegetables using evaporative cooling. Journal of Food Quality, 2017.
7. Ariwaodo, Chinenye Agnes. "Handling Strategies and Facilities for Horticultural Crops." Open Access Library, Journal.,2022:9.5:1-29.
8. Ariwaodo Chinenye Agnes. "Handling Strategies and Facilities for Horticultural Crops." Open Access Library Journal.,2022:9.5:1-29.
9. Caleb, Oluwafemi James, Umezuruike Linus Opara, Corli R Witthuhn. "Modified atmosphere packaging of pomegranate fruit and arils: a review." Food and bioprocess technology,2012:5.1:15-30.
10. Capone Roberto *et al*. "Food system sustainability and food security: connecting the dots." Journal of Food Securit,2014:2.1:13-22.
11. Chandrasekara Anoma, Thamilini Josheph Kumar. "Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits", International Journal of Food Science, 2016.
12. Chen Yi *et al*. "Ethylene receptors and related proteins in climacteric and non-climacteric fruits." *Plant* science,2018:276:63-72.
13. Demissew Ayalew, Ayenew Meresa, Mehiret Mulugeta. "Testing and demonstration of onion flake processing technology in Fogera area at Rib and Megech river project." *J. Food Process. Technol*.,2017:8.677:8-10.
14. Devi S, Laishram Kanta Singh. "Zero energy cool chamber, low cost storage structure for vegetables and fruits in Churachandpur District of Manipur." *Journal of Krishi Vigyan*,2018:7.1:216-219.
15. Dhatt AS, Mahajan BVC. Horticulture Post Harvest Technology: Harvesting. Handlingand Storage of Horticultural Crops Punjab Horticultural Postharvest Technology Centre Punjab Agricultural University Campus, Ludhiana, 2007.
16. Elansari Atef Mohamed, Elhadi M Yahia, Wasim Siddiqui. "Storage systems." Postharvest Technology of Perishable Horticultural Commodities. Woodhead Publishing, 2019, 401-437.
17. El-Ramady, Hassan R *et al*. "Postharvest management of fruits and vegetables storage." Sustainable agriculture reviews, 2015, 65-152.
18. Gomez Jose M, Diego A Castellanos, Anibal O Herrera. "Modeling respiration and transpiration rate of minimally processed pineapple (Ananas comosus) depending on temperature, gas concentrations and geometric configuration." chemical engineering, 2019, 75.
19. Gupta RK. "Technology for value Addition and preservation of horticultural produce." Food Processing: Strategies for Quality Assessment. Springer, New York, NY, 2014, 395-425.
20. Gustafsson J, *et al*. "The methodology of the FAO study: Global Food Losses and Food Waste-extent, causes and prevention"-FAO, 2011." (2013).
21. Hailu Gebru, Belew Derbew. "Extent, causes and reduction strategies of postharvest losses of fresh fruits and vegetables–A review." Journal of Biology, Agriculture and Healthcare,2015:5.5:49-64.
22. Hodges Richard J, Jean C Buzby, Ben Bennett. "Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use." The Journal of Agricultural Science,2011:149.S1:37-45.
23. Ishangulyyev Rovshen, Sanghyo Kim, Sang Hyeon Lee. "Understanding food loss and waste why are we losing and wasting food?." *Foods*,2019:8.8:297.
24. Kale SJ *et al*. "Low cost storage structures for fruits and vegetables handling in Indian conditions.", 2016.
25. Kaur Jaspreet, Raouf Aslam, Panayampadan Afthab Saeed. "Storage structures for horticultural crops: a review." Environment Conservation Journal.,2021:22.SE:95-105.
26. Khan Ilham *et al*. "Plant Molecular Responses to Nanoparticle Stress." Plant and Nanoparticles. Springer, Singapore, 2022, 239-264.
27. Kimble Rachel. Dietary anthocyanins and cardiovascular risk factors: the influence of tart Montmorency cherries on health indices in middle-aged adults. University of Northumbria at Newcastle (United Kingdom), 2020.

28. Kitinoja Lisa, Adel A Kader. "Measuring postharvest losses of fresh fruits and vegetables in developing countries." PEF white paper,2015:15:26.
29. Mansuri, Shekh Mukhtar. "Fruits and Vegetables Storage Techniques.", 2019.
30. Moharana PC *et al*. "ICAR-central arid zone research institute, jodhpur: erosion processes and desertification in the Thar Desert of India.", 2016.
31. Mustapha Y, Yahaya SM. "Isolation and Identification of Post-harvest fungi of Tomato (L. esculentum) and Pepper (Capsicum annum) sample from selected Irrigated sites in Kano." Biological and Environmental Science Journal for the Tropics,2006:3:139-141.
32. Naziri Diego *et al*. "Not All Those Who Wander Are Lost: A Comparative Analysis of Postharvest Losses in Cassava Value."
33. Ndukwu MC, Manuwa SI. "Review of research and application of evaporative cooling in preservation of fresh agricultural produce." International Journal of Agricultural and Biological Engineering,2014:7.5:85-102.
34. Niewiara Matthew. "Postharvest loss: Global collaboration needed to solve a global problem." *i-ACES*,2016:2.1:29-36.
35. Noorwali, Essra Abdulsalam A. Sleep and fruit and vegetable consumption in UK adults. Diss. University of Leeds, 2019.
36. Oelofse Suzan HH, Anton Nahman. "Estimating the magnitude of food waste generated in South Africa." Waste Management & Research,2013:31.1:80-86.
37. Ogle Britta M, Pham Huang Hung, Ho Thi Tuyet. "Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety." Asia Pacific journal of clinical nutrition,2001:10.1:21-30.
38. Pavlatos C, Vita V. Linguistic representation of power system signals. In Electricity Distribution Springer, Berlin, Heidelberg, 2016, 285-295.
39. Perez K, Mercado J, Soto-Valdez H. "Note. Effect of storage temperature on the shelf life of Hass avocado (Persea americana)." Food science and technology international,2004:10.2:73-77.
40. Pessu PO *et al*. "The concepts and problems of postâ€“harvest food losses in perishable crops." *African Journal of Food Science*,2011:5.11:603-613.
41. Rahiel HA, Zenebe AK, Leake GW, Gebremedhin BW. Assessment of production potential and post-harvest losses of fruits and vegetables in northern region of Ethiopia. *Agriculture & Food Security*,2018:*7*(1):1-13.
42. Rais M, Sheoran A. "Scope of supply chain management in fruits and vegetables in India." Journal of Food Processing and Technology, 2015, 6.3.
43. Reddy PP, Plant protection in tropical root and tuber crops New Delhi, India:: Springer India, 2015, 293-303.
44. Rees Debbie *et al*. "Tropical root crops." *Crop Post-*Harvest: Science and Technology, Perishables,2012:3: 392-413.
45. Ridolfi Carlotta, Vivian Hoffmann, and Siddhartha Baral. Post-harvest losses in fruits and vegetables: The Kenyan context. Intl Food Policy Res Inst, 2018.
46. Rosegrant, Mark W *et al*. "Returns to investment in reducing postharvest food losses and increasing agricultural productivity growth." Prioritizing development: A cost benefit analysis of the United Nations' sustainable development goals, 2018, 322-338.
47. Sahoo K *et al*. "Cold storage with backup thermal energy storage system." Progress in Solar Energy Technologies and Applications, 2019, 181-232.
48. Sebeko Tesfaye. "Assessment of Postharvest loss for perishable produces from Wholesalers to consumers.", 2015.
49. Sharma PK, Shekh Mukhtar Mansuri. "Studies on storage of fresh fruits and vegetables in solar powered evaporative cooled storage structure." Agricultural Engineering Today,2017:41.1:10-18.
50. Stathers Tanya *et al*. "A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia." Nature Sustainability,2020:3.10:821-835.
51. Tabor Getachew, Mohammed Yesuf. "Mapping the current knowledge of carrot cultivation in Ethiopia." Carrot Aid, Denmark, 2012, 1-20.
52. Tietel Zipora *et al*. "Effects of wax coatings and postharvest storage on sensory quality and aroma volatile composition of 'Mor'mandarins." Journal of the Science of Food and Agriculture,2010:90.6:995-1007.
53. Verploegen Eric *et al*. "Low-Cost Cooling Technology to Reduce Postharvest Losses in Horticulture Sectors of Rwanda and Burkina Faso." Cold Chain Management for the Fresh Produce Industry in the Developing World. CRC Press, 2021, 183-210.
54. Vithu P, Moses JA. "Hypobaric Storage of Horticultural Products: A Review." Engineering Practices for Agricultural Production and Water Conservation, 2017, 155-170.
55. Weinberger Katinka, Thomas A Lumpkin. "Diversification into horticulture and poverty reduction: a research agenda." World development,2007:35.8:1464-1480.
56. World Population Prospects (UNDESA), 2019.
57. Yahaya SM *et al*. "Isolation and identification of pathogenic fungi causing deterioration of lettuce plant (Lactuca sativa). A case study of Yankaba and Sharada vegetables markets." Journal of Plant Science and Research, 2016, 3.1.
58. Yahia Elhadi M *et al*. "Controlled atmosphere storage." Postharvest technology of perishable horticultural commodities. Woodhead Publishing, 2019, 439-479.