Post-Harvest Handling and Storage

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Abstract

The perishable agricultural products are fruits and vegetables. The storage life and quality of harvested over- or under-ripe fruits are reduced. Fruits should be picked at the ideal point of maturity for maximum flavor and storage life. But when vegetables reach their horticultural peak, they're ready to be picked. There has been significant post-harvest loss of time and resources due to inefficient methods of processing crops. Lack of accessible chemical treatment and appropriate handling techniques causes massive amounts of commodity loss. As a result, producers are losing a lot of money since they don't know how to properly handle the food or how to preserve it after harvest. Produce loss can be reduced through careful planning and execution of activities like washing, grading, sorting, storing, transporting, and selling. Treatment with specific chemicals both before and after harvest helps commodities last longer by killing off potentially dangerous microorganisms and preventing contamination. The information has been summarized in the author's own words after being culled from a variety of reliable sources.

Keywords: Post harvest, handling, storage, fruits, vegetables

Introduction:

Post-Harvest refers to the time period in agriculture when crops are being processed after they have been harvested and before they are sold. As soon as a crop is dug out or cut away from its parent plant, the Post-Harvest process can begin. The quality of a crop, whether it is sold fresh or utilized as an ingredient in a processed food product, is largely dependent on how it is harvested. Post-Harvest losses are defined as the amount and quality of a product that is lost after it has been harvested. These losses might happen at any point in the Post-Harvest process. Product degradation, in addition to loss, must be taken into consideration. **(Dauda, 2014)**

One of the most pressing problems today is how to sustainably feed the world's expanding population over the long term. According to the FAO, by 2050 the world's population would have increased to 9 billion people, necessitating a 70 percent increase in food production.

Climate change, population growth in urban areas, and changes in the eating habits of a growing middle class in developing nations all place a burden on the world's freshwater supplies, biodiversity, arable land, etc. Therefore, the worldwide effort to ensure sustainable food production and consumption needs to take a holistic and creative approach. While the number of individuals who go hungry remains too large, every year vast volumes of food are lost due to rotting and infestations on the road to consumers. Waste can frequently reach 40-50% in various African, Caribbean, and Pacific ACP countries due to the problem's tropical weather and underdeveloped infrastructure. One of the most obvious strategies to improve food security is to cut down on waste.

Post-Harvest Losses (PHL) reduction interventions have gained attention in recent years due to the increased emphasis on agricultural investment that began in 2008. Investing in measures to lower PHL has a high rate of return that grows sharply with the commodity price. Action Against Hunger (ACF) prioritizes PHL reduction. In 2011, postharvest processing was identified as a top area of focus during a research prioritizing exercise conducted by the ACF Food Security and Livelihoods sector (FSL). It plays a crucial role in ACF's mission to end hunger, increase income, and enhance food security and local lives. This led to the idea of writing a short technical report about postharvest losses and possible solutions.

Food that is lost in quality or quantity during the postharvest process is referred to as "postharvest loss" or "PHL." There is a chain of causality connecting the harvest, agricultural processing, marketing, consumer preparation, and consumption or waste decisions. Many organizations now include PHL reduction measures as part of their larger strategies to combat food insecurity. The value of PHL in realizing agriculture's full potential to meet rising global food and energy demands is gaining traction in the scientific community. Therefore, it is crucial to address the problem of feeding a growing global population by decreasing PHL and making better use of current crops, increasing productivity on existing farms, and incorporating new arable land into production in a sustainable manner. ACF recognizes, however, that postharvest and value addition are essential elements of programs to boost agricultural output and strengthen ties between farmers and markets, therefore enhancing food security and promoting economic growth among the people it aims to aid.

The ideas and issues of PHL in cereals and perishable crops, as well as essential factors influencing PHL and food waste, are discussed in this technical article. It examines losses at every stage of the food chain and points up some possible solutions. In this research, we focus on nations with less developed economies where ACF missions have intervened. Loss prevention has always been a major problem for farmers and food merchants. The problem of postharvest food loss, whether from processing, spoilage, insects, rodents, or any other cause, is becoming increasingly urgent as global food consumption grows. Postharvest loss reduction has the potential to greatly enhance global food supply, which might reduce the need to intensify production in the future. Both the quantity and quality lost of a food supply may be measured. They result from the fact that agricultural products are living things that continue to breathe and change when they are handled after they have been harvested.

Damage is the outward manifestation of degradation (such as gnawed grain), whereas loss is the absence of something altogether. Loss prevents someone from using an item altogether, whereas damage limits how much they may use it. **(Kiaya, 2014)**

The Indian government's Ministry of Agriculture projects that India's total food grain output would reach 259.29 million tonnes in 2011-12, up from 196.8 million tonnes in 2001-02. This is an annual growth rate of 3%. The automation of agricultural processes, both during and after harvest, has greatly benefited from agricultural machinery. In order to decrease waste and guarantee that only high-quality goods make it to market, efficient post-harvest handling and processing are just as important as increased production in the agricultural industry. Producers still lose money despite great yields because of inefficient handling of the harvest. The food processing industry benefits all segments of society, from farmers to shoppers. Farmers benefit from increased yields and increased revenue, substantially reducing their exposure to risk. As a result, shoppers may choose from more options at lower rates. New business prospects for entrepreneurs are good for the economy as a whole since they lead to the development of new jobs. **(NABARD, 2014)**

Principal causes of postharvest losses and poor quality

In spite of decades of teaching, rough handling and poor cooling and temperature regulation remain the most prevalent causes of postharvest losses in underdeveloped nations.

Inadequate packaging materials and a lack of quality control checks before to storage only exacerbate the issue.

The three primary goals of harvest postharvest technologies are:

1) To prevent deterioration in appearance, texture, flavor, and nutritional content
2) To prevent contamination
3) To minimize waste between harvest and consumption.

Effective temperature management, sorting to remove damaged and sick produce, and limiting harsh handling all go a long way toward preserving product quality and decreasing storage losses. Maintaining a temperature that is as near to the ideal as possible for a specific product during the postharvest period will increase its storage life. **(Bevan JR, 1997)**

Objectives

- To study on Post-Harvest Handling and Storage

Research Methodology

"secondary research" refers to any study that makes use of previously collected information. Summarizing and compiling previously collected data enhances the study's overall utility. The ability to make inferences and form opinions without personally amassing fresh material is a major benefit of secondary research. This study used a secondary research strategy, meaning the author(s) looked at other works already in print in websites, papers and journals.

Literature Review:

(Dyck et al., 2023) Using digital twins, a revolutionary approach to systems engineering, it is possible to better manage and interact with complex settings. This is accomplished by creating a digital representation of a physical asset in order to record its history, track its current status, and forecast its possible future states. Digital twins have found limited use in agriculture, but none deal with the post-harvest processing of grains. Expert systems have been tried before as an integrated computer aid for grain quality. Since these systems failed to adequately keep operators informed, they were mainly abandoned throughout the expert systems research phase. The combination of Digital Twins and modern post-harvest sensors provides operators with a digital representation of stock and grain quality throughout the facility's processing.

(Indiarto, 2020) In order to preserve quality, increase shelf life, and reduce losses, proper handling practices are essential for tropical fruits after harvest. In this article, we will examine how different types of tropical fruits are cared for after harvest. The physical operations that make up the handling strategy include things like manual cleaning, heat treatment, modified atmospheric packaging (MAP), UV treatment, and radiofrequency (RF) heating. In a similar vein, 1-MCP, salicylic acid, methyl jasmonate, inducing -aminobutyric acid, or a combination of these chemical methods, are all workable choices. Improvements in post-harvest quality of tropical fruits have been documented using several contemporary techniques, including ultrasonication, ozonation, and loss-factor analysis using the e-nose method and the Taguchi methodology.

(Tibagonzeka et al., 2018) Efforts to increase food security are undermined by high postharvest losses in poor nations. Another major issue is the often low standard of produce being sold in stores. Post-harvest losses can be minimized and food safety can be increased via the use of proper handling and processing methods. The goal of this study was to estimate the qualitative and quantitative postharvest losses of maize, millet, sorghum, beans, groundnuts, cassava, and sweet potatoes, as well as to determine the postharvest practices of farmers in three districts (Kamuli, Apac, and Nakasongola) in Uganda that are representative of different agro-ecological zones. The research was conducted towards the end of the first harvest season (June–August, 2014). Farmers, focus groups, and key informants were interviewed for their insight on postharvest loss estimates and methods. Standard laboratory protocols were used to examine the gathered food samples for physical quality features, mold count, and aflatoxin contamination. The findings highlight the prevalence of inefficient and improper postharvest practices. Estimates for postharvest losses were high across the board: 41% for maize, 33% for millet, 33% for sorghum, 26% for beans, 31% for groundnuts, 17% for sweet potatoes, and 19% for cassava. The greatest amount of food was lost during storage. The prevalence of aflatoxin contamination in maize, sorghum, groundnuts, millet, sweet potatoes, and cassava was 44%, 91%, 55%, 36%, 35%, and 60%, respectively. Aflatoxin contamination was found to be highest in sorghum, maize, and groundnuts. Aflatoxin concentrations in grain dried on the ground were considerably higher than those in grain dried on a covered surface, as determined by a Chi-square test ($p = 0.024$, odds ratio = 5). This study highlights postharvest treatments as a strategy to combat food poverty.

(Kimiywe, 2015) Nearly a billion people worldwide are unable to reliably access enough food. A staggering 30 percent of Kenyan children are undernourished, 35 percent are stunted, and micronutrient deficiency is pervasive, according to statistics. Furthermore, between 2 and 4 million people in Kenya are in need of immediate food aid. Among the primary challenges leading to insufficient food are a lack of certified seeds, seasonal production (rain-fed), high post-harvest losses and wastages, inadequate transportation, and low value adds that restrict their market competitiveness. This study looks at some of the issues that have prevented Kenya from reducing its very high rates of food waste. The report also summarizes some of the fundamental remedies that have been proposed by different parties. Community-based, participatory interventions that increase resilience to climate change and better the lives of smallholder farmers in a variety of ecosystems are urgently needed to fill the gaps left by recent efforts to curb food waste.

(Kaminski & Christiaensen, 2014) The global food crisis of 2007-2008 brought additional attention to the problem of post-harvest loss (PHL), although reliable estimates remain elusive, especially in Sub-Saharan Africa. In the article, we make use of PHL metrics that individuals in Malawi, Uganda, and Tanzania have self-reported to us through nationally representative household surveys. Although PHL on farms accounts for just 1.45–5.9 percent of national maize output, the FAO (2011) evaluated PHL for grains at 8 percent. It's also not available in more than 80% of American households. Humidity and temperature both contribute to a rise in PHL, whereas increased post-secondary education, larger seasonal pricing variations, and maybe better storage procedures all work to reduce it. The research of PHL requires a more widespread use of nationally representative surveys.

(Gupta & Jain, 2014) Plant extracts may be a safer and more environmentally friendly alternative to conventional fungicides for use in postharvest fruit and vegetable care. The goal of this study was to see if the storage life of cv mango fruits could be lengthened by using extracts from four plants (neem, Pongamia, custard apple leaf, and marigold flowers). In a cold shop or at room temperature, you'll find the Dashehri variety. Before being stored in cold storage and at room temperature in perforated linear low density poly ethylene bags, the fruit was sprayed with two different amounts of plant extracts (10% and 20%). The combination of cold storage and neem leaf extract was a successful treatment. Up to the end of the storage trial, the combination of 20% neem leaf extract and refrigeration completely eliminated the microorganisms and prevented spoilage. This combination yielded the highest organoleptic score (7.93/10) and the fewest negative physiological outcomes: 6.24 percent weight loss, 0.62 percent waist reduction, 0.19 percent acidity, 20.9 percent total soluble solids, 12.5 percent total sugars, 4.12 percent reducing sugars, and 7.96 percent non-reducing sugars. It was determined that azadirachtin, the active ingredient in neem leaves, was responsible for the inhibitory action.

(Ambaw et al., 2013) For some time now, there has been curiosity in how mathematical models may be used to enhance the performance and design of post-harvest refrigeration systems. Biophysical events that occur during post-harvest treatment of horticultural goods can be predicted using these mathematical models. Because to CFD, previously inaccessible phenomena may now be investigated, including product stacking, gas transport and kinetics, and droplet or particle dispersion. The purpose of this research was to survey the progress made in the use of CFD to the post-harvest storage of horticulture crops. Seeing that semi-empirical models for turbulence and porous media have inherent limitations, the post-harvest sector is beginning to see success with innovative strategies leveraging multiscale approaches.

(Ravindra & Goswami, 2007) Producing countries rely heavily on international commerce and economic activity fueled by mango fruit. Recently, there has been an uptick in sales of authentic mango types in Western grocery stores. Due to its localized production and potential global markets, however, it has not yet reached its full potential as a marketable commodity. It has been estimated that between 25 and 40 percent of harvested mangoes are lost in the post-harvest process before they are sold to consumers. Such losses might be reduced by the adoption of better harvesting, handling, shipping, and storage practices. Therefore, it is vital to employ strategies and technologies that will lengthen the post-harvest shelf life and transit times in order to properly utilize it. Among these are chemical and coating storage, irradiation storage, chemical-free storage, storage at low pressure, and storage in a controlled or modified environment. Adopting post-harvest procedures like as grading, packing, and precooling is crucial for improving the efficacy of preservation methods. It is important to weigh the benefits and drawbacks of each preservation method before settling on one, and to choose the best method based on its technological and financial viability. In this article, we take a close look at many methods for caring for and preserving mangoes.

(Aidoo, 1993) Globally, it is estimated that 10% of durable crops are lost in the post-harvest process; however, this number rises to over 20% in Africa, Asia, and Latin America. For all crops, including staple foods, export crops, secondary food items, and animal feeds, many developing countries are working to improve their post-harvest systems at the farm level. The prevalence of microbes on food crops and animal feed in the humid tropical environment typically leads to the development of mycotoxins. Losses from biodeteriorative agents might be reduced or eliminated with just a few tweaks to the standard post-harvest crop handling and storage procedures. Some tropical crops and the customary means of preserving them after harvest are discussed.

(**Klein** & **Thorp**, **1987**) The commercial storage life of feijoas (Feijoa sellowiana Berg. ; 'Apollo,' 'Gemini,' and 'Triumph') is around 4 weeks at 4°C, followed by 5 days at 20°C. Chilling damage (CI) occurred in fruit kept at 0 degrees Celsius for 3-8 weeks, but not 4 degrees Celsius. The intensity of CI worsened over the 7-10 day storage period. The vascular components of the plant became brown when exposed to CI from the inside, whereas sunken areas formed at the stem's apex when exposed to CI from the outside. Neither pre-storage immersion in water at 50°C nor in CaCl2 prevented the skin or pulp from becoming brown and decaying. The proportion of soluble solids and titratable acidity lost throughout a 10-day shelf life at 20°C had no relationship to the treatment given before to storage.

(Knee et al., 1985) On April 26, 1984, the Post-Harvest Biology Group of the Association of Applied Biologists convened to discuss the role of ethylene in the storage and distribution of horticultural products after harvest. The dangers associated with unintentional exposure to ethylene, which is produced naturally by plants, were investigated. Plants' responsiveness to ethylene and their sensitivity to the hormone's effects were defined in terms of these concepts, respectively. All plant tissues may have a sensitivity that is linked to the characteristics of ethylene receptors. Fruits, vegetables, and flowers were all shown to react differently to ethylene. Study looked at the few research that have looked at ethylene synthesis and activity in the typical post-harvest environment. The effectiveness and efficiency of several ethylene application and removal techniques were assessed. Ethylene measuring techniques were briefly discussed. Research on the role of ethylene in the post-harvest period was discussed.

Post-Harvest Handling and Storage:

Organic foods are grown using methods that reduce the use of harmful chemicals and conserve natural resources like water and soil. Synthetic fertilizers, insecticides, components, and processing aids are not used in the cultivation or preparation of horticultural crops. Genetically engineered crops and components are not allowed in organic farming, nor is the use of ionizing radiation. Produce must meet the same standards for safety and shelf life as conventional goods, but there is a restricted set of options for postharvest cleanliness and preservation techniques. In order to keep organic integrity intact, both the practitioner and the researcher need to be aware of every potential site of contamination along the postharvest handling and processing chain. This article will provide a summary of the primary processes that a postharvest horticulturist will go through while preparing organic crops for storage or further processing. **(Mishra & Shukla, 2013)**

Handling:

Food waste and food loss are the primary causes of food waste in both developing and wealthy nations. Here we examine the specific situation of wasted food. Several processes occur after harvesting the crop. To begin, we clean the crops that were harvested. In first-world nations, this is often done by a piece of machinery, while in third-world nations, it is done by hand. Because of this, the postharvest processing output of crops using manual methods is lower than that using mechanical means. As a human procedure, threshing can leave postharvest goods incomplete or damaged, rendering some processed crops unsuitable for sale. Additionally, many postharvest vegetables naturally retain water, thus drying them is necessary for long-term storage. Similarly to washing, drying postharvest crops is typically done by hand in impoverished nations but by machine in wealthy countries. Drying postharvest crops in the sun is common in impoverished nations but more common in affluent countries where mechanical dryers are utilized. Crops dried under the sun are susceptible to the vagaries of the weather, require a long time, and can only be dried in small batches. In order to reliably dry a large quantity of crops, the use of mechanical dryers is preferable. Third, food supplies are kept in warehouses after harvest. For consistent delivery of large quantities of crops to merchants, it is crucial to secure them in a storage facility after harvest. In developing countries, however, most silos are only makeshift structures constructed of wood, grass, or straw. Many crops are lost to insects and mildew during storage because no measures are taken to protect them from the weather. The final step is the distribution of postharvest commodities to shops. In wealthy nations, transportation procedures are highly streamlined, with crops gathered at distribution centers, sorted meticulously, and sent to their final destinations in refrigerated trucks. The quality of such crops is maintained during transport. In addition, most highways in industrialized nations are paved, allowing delivery vehicles to go swiftly and efficiently. Produce reaches consumers in pristine condition thanks to this efficient distribution system. Conditions in emerging nations, on the other hand, are very different from those in industrialized nations. Transport may be accomplished not just by automobiles but also by motorbikes or even cattle. Naturally, neither the temperature nor the humidity can be adjusted in such transit. Also, delivery times are lengthened because of the lack of paved roads, and crops are frequently damaged by vibrations. In addition to these steps, research emphasizes the absence of market supply chains in underdeveloped nations. Producers risk heavy losses if they lack a safe, fast, and fair way to get their goods to customers. Because of poor lines of communication between manufacturers and buyers, this problem further worsens.

All of this points to important distinctions in postharvest procedures in industrialized and underdeveloped nations. Despite common opinion, high food waste and food insecurity rates in developing countries are not inevitable results of poor planning and management, but rather of a lack of resources and infrastructure in postharvest processing. **(Oishi, 2022)**

Storage:

Post-harvest temperature control is the most crucial factor in preserving food quality. With the exception of field-cured or long-lasting goods, it is preferable to get rid of field heat as soon as feasible. When vegetables are harvested, they are removed from their water supply. It's still alive, but breathing causes it to lose water and turgor. The rate of respiration and, by extension, quality loss, can be hastened by the field heat. The sensory (taste) and nutritional shelf lives of fruits and vegetables are prolonged by proper chilling. The ability to refrigerate and store food provides retailers with more options. Growers frequently fail to account for the full capacity of their refrigeration systems during times of high cooling demand. In order to preserve the greatest possible levels of appearance, flavor, texture, and nutritional content, it is sometimes necessary to immediately obtain the required short-term storage or shipment pulp temperature. The most typical types of air conditioning are:

1. **Room cooling:** A portable, temperature-controlled chamber Refrigerators installed for room cooling. There are faster ways to chill a room. Depending on the commodity, packing unit, and stacking arrangement, the product may cool too slowly, leading to water loss, premature ripening, or deterioration.
2. **Forced-air cooling:** Produce bundles may be kept fresh for longer with the use of fans and a chilling chamber. The rate of cooling can vary from 75-90% quicker than conventional room cooling, depending on the air temperature and circulation.
3. **Hydro-cooling:** Chilled water showers are an effective method of cooling product and washing it at the same time. It's crucial to use water disinfectant. Some fruits and vegetables aren't suited to hydro-cooling. Watertight containers or waxed-corrugated

cartons with resistance to moisture are required. Recyclable, foldable plastic containers are on the rise, whereas waxed corrugated boxes are finding less takers.

4. **Top or liquid icing:** Icing is a handy method for chilling products that can withstand low temperatures and may be made in larger or smaller batches without losing quality. It is crucial that the ice be completely devoid of any chemical, physical, or biological dangers.
5. **Vacuum cooling:** During a vacuum, the water in the pipe Tissue heat is removed by evaporation during vacuum cooling. This technique works well on vegetables like lettuce, spinach, and celery that have a high surface area to total volume ratio. The vegetables can be doused with water before being vacuum-sealed. Like hydro-cooling, water disinfection is crucial. Due to its high price tag, the vacuum chamber system is often reserved for industrial-scale endeavors.
6. **Drying food preservation:** An ancient technique Foods can be dried to preserve them, as this method significantly lowers water activity, making it impossible or very difficult for germs to thrive. Since drying cuts down on weight, it also increases portability. Apples, pears, bananas, mangoes, papayas, apricots, and coconut are just some examples of the many fruits that may be dried. Dried grapes come in many forms, and the Zante currant, sultana, and raisin are all examples. Drying is a common method of preserving cereal grains including wheat, maize, oats, barley, rice, millet, and rye.
7. **Food preservation freezing:** Commercially and at home, freezing is one of the most popular ways to store a broad variety of foods, even many that would not have needed to be frozen in their unprocessed form. To keep for a long time, potatoes don't even need to be refrigerated or frozen, but potato waffles do. Strategic food stockpiles stockpiled in case of national disaster can be stored in cold depots for lengthy periods of time and in enormous quantities.
8. **Vacuum packing food preservation:** Putting food in an airtight container and then vacuuming it up is called vacuum-packing. The lack of oxygen in a vacuum setting makes spoilage more slower since bacteria can't survive there. Nuts are often vacuum-packed to prevent oxidation and subsequent flavor loss.
9. **Food preservation sugar:** Fruits like apples, pears, peaches, apricots, and plums can be preserved in syrup made from sugar, or they can be crystallized by cooking them in sugar until the sugar crystallizes, after which they can be stored dry. The peels of citrus fruits

(candied peel), angelica, and ginger are processed in this manner. The sugar content of the fruit and the surface coating of syrup sustain the preservation in a modified version of this method that yields glacé fruit like glacé cherries, which are preserved in sugar but subsequently separated from the syrup and sold.

10. **Mixed storage:** Small-scale organic farmers often need to store a wide variety of crops together due to the low yields they get. Very little literature exists on the topic of the long-term storage of mixed crops. Temporary storage of somewhat perishable crops is the primary use for the vast majority of data. Mixed storage is viable and is commonly used by organic farmers to successfully store crops including potatoes, carrots, onions, and cabbage. Even with the rudimentary storage methods, this is conceivable.
11. **Controlled atmosphere storage:** This emerging technique will be helpful in the future for the extended storage of various vegetable crops. It is already accepted for usage under both EU and IFOAM regulations. UKROFS and other UK recognized organic sector authorities need to examine and clarify the situation around the permissible use of this technology. (Mishra & Shukla, 2013)

Conclusion

The duration and quality of a fruit's or vegetable's shelf life is greatly influenced by the postharvest handling techniques, treatments, and harvesting method. Fruits and vegetables, being perishable, should be consumed quickly. If care is taken during post-harvest processing and storage, not only may quality be greatly improved, but the condition can be maintained as well. Losses have been substantial, especially in developing nations that have been slow to adopt certain postharvest handling practices. By carefully manipulating postharvest handling methods, it is possible to significantly reduce postharvest loss and increase storage life. Careful harvesting, handling, use of crucial cultural procedures, storage, packaging, and transportation can all help reduce waste. Fruits and vegetables keep for much longer after being stored at low temperatures in a regulated environment. Fruit and vegetable handlers in developing countries worry about postharvest losses unless basic postharvest procedures are used.

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