

## Role of Postharvest Management for Food Security: A Review

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### Abstract

The primary role of an effective post-harvest handling system is ensuring that the harvested product reaches the consumer, while fulfilling market/consumer expectations in terms of volume, quality, and other product and transaction attributes, including nutrition, food security, and product safety. The aim of this review was how to manage postharvest losses of crops for food security. Postharvest losses of crops commodities were managed or controlled by doing proper harvesting, transportation, packing, storage, processing, sorting and cleaning. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security.

**Keywords:** Postharvest; Consumer; Security and handling; Quality losses; Upstream phases

### Introduction

Postharvest management is handling of produces from farm to fork/table i.e. harvesting, transporting, and handling, storing, processing and value addition. Post-harvest loss is an important threat to food security, loss in farmer incomes, and inefficiency in the global food system. It is estimated that a third of food produced worldwide is lost and or wasted. The Food and Agricultural Organization (FAO) estimates that the value of post-harvest loss in Sub-Saharan Africa is about US \$4 billion a year out of an annual grain crop value of US\$27 billion produced in the years 2005-2007. Important elements of the post-harvest loss challenge include: multiple points of intervention, multiple value chains, multiple technologies (a dimensionality problem in terms of the technology), and value chains embedded in weak and poorly developed agricultural systems.

Postharvest loss can be defined as the degradation in both quantity and quality of a food production from harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product. These losses are generally more common in developed countries. Quantity losses refer to those that result in the loss of the amount of a product. Loss of quantity is more common in developing countries. A recent FAO report indicates that at global level, volumes of lost and wasted food in high income regions are higher in downstream phases of the food chain, but just the opposite in low-income regions where more food is lost and wasted in upstream phases.

Food security affects almost everyone on the globe; Sub-Saharan Africa has the widespread chronic food insecurity. As of May 2006, for example, out of thirty nine countries in the world which were experiencing serious food emergencies and required external assistance for dealing with critical food insecurity: twenty five were in Africa, eleven in Asia and Near East, two in Latin America and one in Europe. Established that these food crises are fuelled by mainly armed conflict, often compounded by drought, floods and the effects of the AIDS pandemic. These have vast impact on food production and food security as millions of people who are driven from their homes are

unable to work their fields; they are also cut off from markets for their produce and from commercial supplies of seed, fertilizer and credit.

### Literature Review

#### The link between post-harvest management and food security

Cereals like maize are one of the major staple food crops in Sub-Saharan Africa. However, the climate and conditions of this area attract a huge number of factors that contribute to the destruction of the crops especially at the post-harvest level. Whenever crops are grown, insect pests and phytopathogenic microorganisms are attracted; hence the strategies which a county or individual farmers employ in post-harvest management will determine the farm utilization priority, grain quality in the market, food diversification, food security and general living standards of the people involved. However, due to poor post-harvest management strategies in the sub-Saharan region, there has been a repeated cycle of food production and post-harvest losses which have systematically depleted the mineral quality of the farms leaving substantial food insecurity in the region.

Although Africa is endowed with the highest level of plant diversities in the world, many of these have not been domesticated because the available land for such trials is always occupied by the same type of stable crops. Much of product losses are due to poor storage facilities: for example, the use of traditional wooden cribs which harbor pests like the lesser and larger grain borers; indiscriminate use of pesticides which has increased pesticide resistance of insects; high humidity and moisture content of grains during storage; climate change which has caused the time of harvest and drying to be largely unpredictable. However, proper post-harvest management strategies can enable farmers to store high quality grain which can fetch high prices in the global market. Moreover, the storage can enable a farmer to subsequently grow a different type of crop which can make a farmer to practice crop rotation.

## Impacts of Post-Harvest handling loss (Phl) and food security

Postharvest technologies can contribute to food security in multiple ways. They can reduce PHL, thereby increasing the amount of food available for consumption by farmers and poor rural and urban consumers. For example, the control of the Larger Grain Borer (LGB) greatly reduced the loss of maize in on-farm storage among smallholders in a number of African countries, thus improving their food security. The benefits to consumers from reducing losses include lower prices and improved food security. Techniques to reduce food losses require cultural and economic adaptation. This is so because all food losses occur at a particular socio-cultural environment. The issue of food losses is of high importance in the efforts to combat hunger, raise income and improve food security in the world's poorest countries.

Current world population is expected to reach 10.5 billion by 2050, further adding to global food security concerns. This increase translates into 33% more human mouths to feed, with the greatest demand growth in the poor communities of the world. According to food supplies would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security.

Food and Agriculture Organization of U.N. predicts that about 1.3 billion tons of food are globally wasted or lost per year. Reduction in these losses would increase the amount of food available for human consumption and enhance global food security, a growing concern with rising food prices due to growing consumer demand, increasing demand for biofuel and other industrial uses, and increased weather variability. A reduction in food also improves food security by increasing the real income for all the consumers (World Bank, 2011). In addition, crop production contributes significant proportion of typical incomes in certain regions of the world (70 percent in Sub-Saharan Africa) and reducing food loss can directly increase the real incomes of the producers (World Bank, 2011).

Over the past decades, significant focus and resources have been allocated to increase food production. For example, 95% of the research investments during the past 30 years were reported to have focused on increasing productivity and only 5% directed towards reducing losses. Increasing agricultural productivity is critical for ensuring global food security, but this may not be sufficient. Food production is currently being challenged by limited land, water and increased weather variability due to climate change. To sustainably achieve the goals of food security, food availability needs to be also increased through reductions in the post-harvest process at farm, retail and consumer levels.

Food losses do not merely reduce food available for human consumption but also cause negative externalities to society through costs of waste management, greenhouse gas production, and loss of scarce resources used in their production. Food loss is estimated to be equivalent to 6-10 percent of human-generated greenhouse gas emissions. A significant contributor of this problem is through methane gas generation in landfills where food waste decomposes anaerobically.

Considering the criticality of post-harvest loss reduction in enhancing the food security, it becomes very important to know the

pattern and scale of these losses across the world, especially in developing countries, and identify its causes and possible solutions. Although losses occur at each stage of the supply chain from production to consumer level, storage losses are considered most critical in developing countries. Technology interventions play a critical role in addressing the issue of PHL, and several efforts have been made to develop and disseminate these technologies for smallholders in developing.

## The impacts of food wastage interventions on food security

**Linkage between food wastage interventions and food security often not explicit:** In spite of the popularity of food wastage interventions in policy circles, the number of studies and documents on the relationship between food wastage actions and food security is relatively small. Although the claim that food wastage interventions contribute to food security is quite pervasive in both the academic and grey literature, the relationship between both variables is rather implicit. There are few documents or studies on a possible causal relationship between reducing, reusing, or recycling food wastage on the one hand and food security, including environmental conditions and necessary natural resources for food security, on the other. Those that do, often lack a sound empirical foundation or an evaluation after the intervention has finished, a so-called ex post evaluation. This void is reinforced by a lack of available data concerning the number of actions in general, and their effects in particular, which makes it difficult to measure any form of progress.

**Short-term impacts of food wastage interventions:** It is generally agreed in the literature, that some food wastage interventions can have a direct impact on short-term food security conditions. This is particularly true for pre- and post-harvest loss reduction actions in developing countries, particularly interventions at a local level in smallholder agriculture. Not only can these actions positively affect national food supplies, they also contribute to enhanced household food security by increasing farmers' incomes and ensuring year-round food availability. Pre- and post-harvest loss reduction can help smallholders to adapt to climate variability.

**Middle-and long-term impacts of food wastage interventions:** In this section, two categories of more indirect impacts of food wastage interventions on middle-and long-term food security are synthesized. The first group of impacts concerns those that have an effect on food security in a narrow sense, i.e. on the direct availability, affordability, stability of and access to food. The second group is related to impacts on the broader food system factors that interact with these food security dimensions, notably environmental conditions and natural resources.

**Decrease pressure on natural resources:** A motive is mentioned based on natural resources linked to food production and food security. If food wastage is reduced, less land, water, inputs and energy are needed, and less greenhouse gas emitted. These natural resources could be used to increase food production, or affect the food system in other ways. Linked to this motive, is a specific one based on the future need for food, and increasing global food supply.

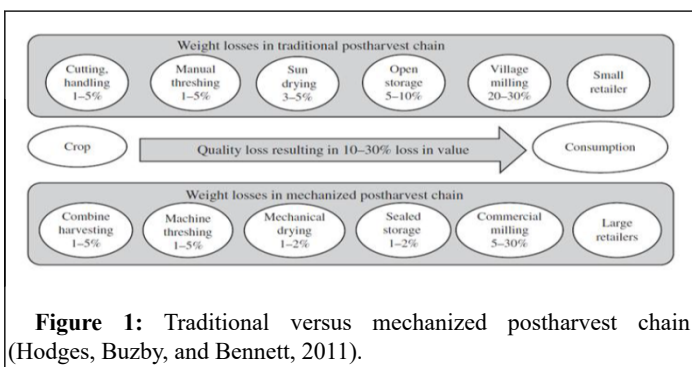
On a global level, the World Resources Institute (WRI), a global research organization, for example states from a natural resources perspective that reducing food loss and waste is part of creating a sustainable food future. From a recent study, it concluded that reducing wastage could contribute to future food availability: 'The world will need about 60 percent more calories per year by 2050 in

order to adequately feed the projected population of more than 9 billion people. Cutting current rates of food loss and waste in half would reduce the size of this food gap by about 22 percent.

**Information, knowledge and expertise:** Worth mentioning as a separate indirect, long term link between food wastage and food security that a number of actors embrace, is the claim that information, knowledge and expertise can help to deal with food waste and loss.

### Factors contributing to total food loss

Factors that contribute to food loss range from mechanization of practices such as harvesting to handling, processing and others, to weather conditions, production practices, management decisions, transportation facilities, grading issues, infrastructure, consumer preferences/attitudes, and availability of financial markets. A typical post-harvest chain comprises of a number of stages for the movement of harvested output from the field to the final retail market. The losses incurred at each step vary depending upon the organization and technologies used in the food supply chain. For example, in less developed countries where the supply chain is less mechanized, larger losses are incurred during drying, storage, processing and in transportation (Figures 1 and 2). The magnitude and pattern of Post-Harvest Losses (PHLs) therefore vary across countries based on their stage of economic development. In high- and middle-income countries, significant losses occur in the early stages of the food supply chains and at the consumer level (United Nations, 2011).



**Figure 1:** Traditional versus mechanized postharvest chain (Hodges, Buzby, and Bennett, 2011).

### Biological and environmental causes on postharvest losses

Biological (internal) causes of deterioration include respiration rate, ethylene production and action, rates of compositional changes (associated with color, texture, flavor, and nutritive value), mechanical injuries, water stress, sprouting and rooting, physiological disorders, and pathological breakdown. The rate of biological deterioration depends on several environmental (external) factors, including temperature, relative humidity, air velocity, and atmospheric composition (concentrations of oxygen, carbon dioxide, and ethylene), and sanitation procedures. All these factors have been discussed by numerous authors.

### Socioeconomic factors

Although the biological and environmental factors that contribute to postharvest losses are well understood and many technologies have been developed to reduce these losses, they have not been implemented due to one or more of the following socioeconomic factors.

**Inadequate marketing systems:** Growers can produce large quantities of good-quality fruits, ornamentals, and vegetables, but, if they do not have a dependable, fast, and equitable means of getting such commodities to the consumer, losses will be extensive. This problem exists in many locations within developing countries. It is accentuated by lack of communication between producers and receivers, and lack of market information. Marketing cooperatives should be encouraged among producers of major commodities in important production areas. Such organizations are especially needed in developing countries because of the relatively small farm size. Advantages of marketing cooperatives include: providing central accumulation points for the harvested commodity, purchasing harvesting and packing supplies and materials in quantity, providing for proper preparation for market and storage when needed, facilitating transportation to the markets, and acting as a common selling unit for the members, coordinating the marketing program, and distributing profits equitable. Alternative distribution systems, such as direct selling to the consumer (roadside stands, produce markets in cities, local farmers' market in the countryside, etc.) should be encouraged. Production should be maintained as close to the major population centers as possible to minimize transportation costs. In several countries, there are plans to build better whole sale marketing facilities, but their implementation has been delayed more because of social and political than financial considerations.

**Inadequate transportation facilities:** In most developing countries, roads are not adequate for proper transport of horticultural crops. Also, transport vehicles and other modes, especially those suited for fresh horticultural perishables, are in short supply. This is true whether for local marketing or export to other countries. The majority of producers have small holdings and cannot afford to own their own transport vehicles. In a few cases, marketing organizations and cooperatives have been able to acquire transport vehicles, but they cannot do much about poor road conditions.

**Government regulations and legislations:** The degree of governmental controls, especially on wholesale and retail prices of fresh fruits and vegetables, varies from one country to another. In many cases, price controls are counter-productive. Although intended for consumer protection, such regulations encourage fraud and provide no incentive for producing high-quality produce or for postharvest quality maintenance. On the other hand, regulations covering proper handling procedures and public health aspects (food safety issues) during marketing are, if enforced properly, very important to the consumer.

**Unavailability of needed tools and equipment:** Even if growers and handlers of fresh horticultural crops were convinced of the merits of using some special tools and/or equipment in harvesting and postharvest handling, they most likely will not be able to find them in the domestic market. This is true of harvesting aids; containers; equipment for cleaning, waxing, and packing; and cooling facilities. Most of the tools are neither manufactured locally nor imported in sufficient quantity to meet demand. Various governmental regulations in some countries do not permit direct importation by producers of their needs. It is imperative that the tools that will enable handlers to use recommended technology for a given situation be available for them to use. In many cases, such tools can be manufactured locally at much lower cost than those imported.

**Lack of information:** The human element in postharvest handling of horticultural commodities is extremely important. Most handlers involved directly in harvesting, packaging, transporting, and

marketing in developing countries have limited or no appreciation for the need for, or how, to maintain quality. An effective and far-reaching educational (extension) program on these aspects is needed critically now and will continue to be essential in the future.

The availability of needed information on the marketing is an important step in the right direction, especially with the expanded access to the Internet worldwide.

**Poor maintenance:** In many developing countries, some good facilities that were built a few years ago are currently “out of order” or not functioning properly because of lack of maintenance and unavailability of spare parts. This problem is especially true of public-sector facilities.

### Estimation of postharvest losses

Poor PHL estimates impact the quality of food availability. For example, food security assessments and other analyses which consider projections of future food needs rely on food balance sheet information. Thus, strengthening of PHLs database will help improve other estimations and projections which rely on food balance sheets.

Both quantitative and qualitative losses occur in horticultural crops between harvest and consumption. Goal of estimating postharvest losses is to minimize these losses, and to do so we must: 1. understand the biological and environmental factors involved in postharvest deterioration and 2. Use the appropriate postharvest technology procedures that will slow down deterioration and maintain quality and safety of the commodities.

Qualitative losses, such as loss in edibility, nutritional quality, caloric value, and consumer acceptability of the products, are much more difficult to assess than quantitative losses. Standards of quality and consumer preferences and purchasing power vary greatly among countries and cultures.

For example, elimination of defects from a given commodity before marketing is much less rigorous in developing countries than in developed countries. This, however, is not necessarily bad, because appearance quality is often over-emphasized in developed countries [1-7].

Postharvest losses vary greatly among commodities and production areas and seasons. In the United States, the losses of fresh fruits and vegetables are estimated to range from 2% to 23%, depending on the commodity, with an overall average of about 12% losses between production and consumption sites estimated the U.S. total retail, foodservice, and consumer food losses in 1995 to be 23% of fruits and 25% of vegetables.

Fresh fruits and vegetables accounted for nearly 20% of consumer and food service losses, which are due to product deterioration, excess perishable products that are discarded, and plate waste (food not consumed by the purchaser).

The latter is often due to consumer dissatisfaction with product quality, especially flavor. Estimates of postharvest losses in developing countries vary greatly from 1 to 50% or even higher (National Academy of Sciences) [7-10].

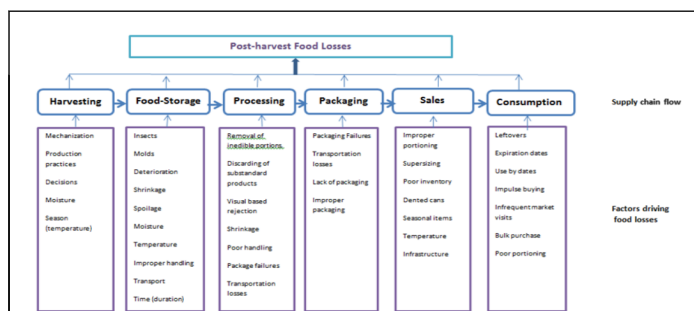


Figure 2: Conceptual model in post-harvest loss estimation.

### Strategies for postharvest management for food security

A systematic analysis of each commodity production and handling system is the logical first step in identifying an appropriate strategy for reducing postharvest losses. Also, a cost-benefit analysis to determine the return on investment in the recommended postharvest technologies is essential. It is important to select the technologies that are appropriate for the size of each postharvest enterprise. Marketing companies and cooperatives are essential for handling produce and reducing postharvest losses by providing facilities for accumulating, preparing and transporting produce to markets; by coordinating marketing activities; and by distributing profits equitably to members. Indicated an evolution of priorities within the postharvest sector of developing countries from a primarily technical focus geared towards the reduction of losses, to a more holistic approach designed to link on-farm activities to processing, marketing, and distribution. However, the major constraints continue to be high postharvest losses, poor marketing systems, weak research and development capacity, and inadequacies in policies, infrastructure, and information exchange. The Agricultural and Food Engineering Technologies Service of FAO, in collaboration with the Global Forum for Agricultural Research (GFAR) and the Global Post-Harvest Forum recently embarked upon the development of a new global post-harvest initiative geared toward addressing the challenges faced by the sector in developing countries. Goletti listed the most relevant issues for developing countries as follows: the need for a regulatory framework that promotes growth while safe-guarding welfare; for adequate market information to be given to all participants involved; for further investment in postharvest research; and for participation in international agreements that promote trade and food safety.

### Post-harvest management in perishable crops (fruits and vegetables) for food security

It is important to highlight that, some varieties of the same crop store better than others. Therefore, to reduce food loss and to achieve maximum shelf-life, only varieties known to store well should be stored.

**Harvesting:** Harvesting should be carried out as carefully as possible to minimize mechanical injury such as scratches, punctures and bruises to the crop. The time of the day when harvesting is done also affects produce quality and shelf-life. In general, harvesting during the coolest time of the day (early morning) is desirable; the produce is not exposed to the heat of the sun and the work efficiency of the harvesters is higher. If harvesting during the hotter part of the day cannot be avoided, the produce should be kept shaded in the field to minimize product weight loss and wilting.

**Handling:** Mechanical injury provides sites for pest attack and increases physiological losses. Therefore, avoid mechanical injury to the crop while handling. Because of their soft texture, all horticultural products (fruits and vegetables) should be handled gently to minimize bruising and breaking of the skin. The skin of horticultural products is an effective barrier to most of the opportunistic bacteria and fungi that cause rotting of the tissues. Breaking of the skin also stimulates physiological deterioration and dehydration. Reducing the number of times the commodity is handled reduces the extent of mechanical damage.

**Sorting and cleaning:** Systematic sorting or grading coupled with appropriate packaging and storage, will extend shelf life, maintain wholesomeness, freshness, and quality, and substantially reduce losses and marketing costs. Sorting is done to separate poor produce from good produce, and further classify the good produce based on other quality parameters like size.

**Packaging:** Proper packing is essential to maintain the freshness of leafy vegetable. Packaging should be designed to prevent premature deterioration in product quality, in addition to serving as a handling unit. Use clean, smooth and ventilated containers for packaging. This is a very important factor in cutting down losses in these crops during harvesting, transportation, marketing and storage. Use containers that are appropriate for the crop.

**Transportation:** Minimizing losses during transport necessitates special attention to vehicles, equipment, infrastructure, and handling. Load and unload transport vehicles carefully. Use clean, well-ventilated vehicle covered at the top for transportation. Transport crops during the cool part of the day by driving carefully over smooth roads to minimize damage to crop. Fresh produce must not be watered prior to loading, as this will lead to decay, rotting, and extensive losses. Major causes of losses are improper handling during loading and unloading.

**Storage:** Only crops with high initial quality can be stored successfully; it is therefore essential to ensure that only crops of the highest quality (mature, undamaged) are stored. Shelf life can be extended by maintaining a commodity at its optimal temperature, relative humidity and environmental conditions.

**Processing:** Processing is an important value-added activity that stabilizes and diversifies food supplies and creates employment and income opportunities. Excessive hulling or threshing can also result in grain losses, particularly in the case of rice (hulling) which can suffer cracks and lesions. It can minimize the high perishability problem of leafy vegetables. Processed products are also more stable, have improved digestibility, and permit a better diet diversity, giving consumers access to a wider choice of products and a wider range of vitamins and minerals. Few processing technologies are listed: Drying, salting, fermenting, and pickling.

## Discussion

### Value of postharvest research and development

Postharvest research contributes to food security and health in several ways. Improved storage technologies, such as biological pest control or controlled atmosphere storage reduce postharvest food losses. Several authors have presented a strong argument in favor of devoting more recourse to postharvest research and development efforts in developing countries. Although minimizing postharvest

losses of already produced food is more sustainable than increasing production to compensate for these losses, less than 5% of the funding for agricultural research is allocated to postharvest research areas. In a more recent discussion paper, Goletti and Wolff stated that “while research on the improvement of agricultural production has received considerable attention and funding, until recently postharvest activities have not attracted much attention from international research organizations (CGIAR, FAO, ACIAR, IDRC, GTZ, CIRAD, NRI, USAID).” They identified the following five reasons to justify an increased commitment to postharvest research by the international agricultural system: 1. high internal rates of return, 2. international public good character, 3. effect on poverty, 4. effect on food security and health, and 5. effect on sustainable use of resources. Goletti and Wolff concluded that: “As the significant contribution of postharvest research to CGIAR goals such as poverty reduction, food security and sustainability becomes clear, and in the light of high rates of return, the much skewed allocation of funds to production versus postharvest topics cannot be justified. Since so far, relatively little has been invested in postharvest research, there is potential for large impacts as constraints and bottlenecks are removed. It would thus be desirable to reexamine current funding priorities and to allocated a larger proportion of resources to the postharvest area.”

## Conclusion

Postharvest Management is handling of produces from farm to fork/ table i.e. harvesting, transporting, and handling, storing, processing and value addition. Minimizing postharvest losses of crops are a very effective way of reducing the area needed for production and/or increasing food availability. Postharvest technologies can contribute to food security in multiple ways. They can reduce PHL, thereby increasing the amount of food available for consumption by farmers and poor rural and urban consumers. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security. Generally, significant role food loss reductions could have toward sustainably contributing to global food security.

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