



# **POST-HARVEST LOSSES IN AGRI-FOOD SUPPLY CHAIN: A LITERATURE REVIEW**

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## **ABSTRACT**

*Post-harvest losses and food wastage in agri-food supply chains are receiving increased attention and policies are being designed to reduce these losses. Wastages are highest for the perishable produce like horticultural crops either on-farm or off-farm. On-farm losses include improper harvesting periods, temperature, mechanical injury, poor sanitation and improper packaging. Off-farm losses include inadequate storage and transportation facilities, lack of reliable market information and processing units and poor knowledge of farmers. Post-harvest losses lead to food insecurity, higher food prices, and ultimately loss of scarce resources used in their production. Thus in order to achieve food security, these losses need to be reduced at farm, retail and consumer levels. The objective of this paper is to present a literature review concerned primarily with identifying the main causes for post-harvest losses in agri-food supply chain and recommending strategies to reduce these losses.*

**Keywords:** *Agri-Supply Chain, Farmers, Fruits, Horticultural Crops, Post-Harvest Losses*

**Paper Type:** *Literature Review*

## **I INTRODUCTION**

Post-harvest losses (PHLs) imply a measurable decrease of agri-produce in a post-harvest system that may be quantitative, qualitative and economic [1]. Food loss is a part of PHLs and denote an edible share of food that can be consumed either at retail or consumer levels, but is not consumed for some reason [2]. The post-harvest system consists of the interconnected activities from time of harvest to processing, marketing, and food preparation to the final decision by the consumer to eat or discard the food. Quantitative losses (weight or volume) and qualitative losses (changed physical attributes and characteristics) can occur at any level in post-harvest chain. The loss in the monetary value of the produce due to reduction in quality or quantity greatly contribute to economic losses [3]. Both the qualitative and the quantitative losses occur from pre-harvest to post-harvest, through handling, storage, distribution to the delivery to consumer [4]. The post-harvest losses not only reduce the share of the farmer in the final price and causes a loss of revenue but also leads to lesser availability on the consumer's side. This leads to a higher price which leaves the consumer with few available options. The major operational issues that causes post-harvest losses include demand forecasting, harvest scheduling, inventory control, transportation and logistics management [5]. The time, money and resources devoted to the cultivation of crops and irrigation facilities, fertilizers all go wasted due to inadequate attention being paid to the issues of post-harvest losses and thus increasing food insecurity [6]. With a fast increasing world population more than growth in food supply it is important that the

wastage of scarce resources used in the production of crops which go as post-harvest losses must be reduced. Hence, an essential component of any strategy for increasing food availability without overburdening the natural environment must be to reduce these post-harvest losses [2].

The poor post-harvest handling practices of the perishable produce by farmers, lack of cold storage infrastructure and inadequate transportation network, lack of capacity for processing produce, high temperature, moisture content, poor access to marketing information, mechanical damages, losses due to diseases and pests, poor quality produce, high rejection rate, loss during transit, inappropriate packaging and lack of access to credit facilities are some of the major post-harvest constraints [7].

Different food types have different level of wastages with fresh produce contributing to one-third of the global losses [8]. Identification of the causes and estimation of the magnitude of these post-harvest losses at various stages of handling and harvesting, storage, distribution, and transportation can help in reducing them and increasing food availability. This would help in developing appropriate measures and strategies to reduce the post-harvest losses in different stages of agri-food supply chain right from production to supply to the final consumer [6].

Without the reliable estimates at different stages in the agri-food supply chain the development of the appropriate policies for the reduction of the post-harvest losses becomes very difficult. There have been very few studies dedicated towards the identification of causes and estimation of the post-harvest losses in agri-food supply chain. Thus, the present study attempts to present a literature review for identification of the causes of post-harvest losses in agri-food supply chain and recommending appropriate measures to reduce these losses.

## II A BRIEF LITERATURE REVIEW

The paper aims to present a brief literature review with focus on identifying reasons of post-harvest losses in agri-food supply chain and recommending appropriate strategies to reduce these losses. The research papers were collected for nine years (2008-2016) from which a total of ten papers from reputed journals were included in this review. Citation of papers related to post-harvest losses in agri-food supply chain were referred and a cross-reference approach and forward and backward referencing was adopted to find relevant papers. The papers were mainly related to perishable produce like horticultural crops, fruits and vegetables. Works of leading authors were reviewed, with details like year of publication, objectives of the reviewed work, methodology and tools used for the study. Results were studied and gaps were identified in the research.

Weinberger et. al (2008) investigated the volume and value of vegetable produce as post-harvest losses along the vegetable supply chain and identified causes and suggested preventive measures to be undertaken at each stage in the vegetable supply chain to reduce these post-harvest losses. Data was collected using the structured questionnaire technique, interviews and surveys. An upstream interview approach from retailers/supermarkets to farmers was applied. Simple mathematics was used for calculation. The maximum post-harvest loss of vegetables was incurred by farmers followed by other supply chain actors. The highest physical loss of fresh produce was incurred by farmers and the maximum monetary loss was incurred by the retailers. Losses were due to high disease incidence, increasing temperature, oversupply of vegetables accruing to losses during transportation, and poor quality of the produce. Post-

harvest losses could be reduced by careful harvesting, providing adequate infrastructure for reducing the quality loss including cold storage facilities, proper processing techniques, maintaining the quality of the produce during transit, information sharing, developing an integrated disease management system for increasing disease tolerance in vegetables. The study could be further extended to fruits, and similarities and differences in post-harvest losses incurred in both fruits and vegetables could be investigated which would help in identifying the key reasons for post-harvest losses along the supply chain.

Meena et. al (2009) examined the farmers' attitude towards post-harvest losses of horticultural crops and studied the demographic attributes and utilization of agricultural information sources of the farmers. Data collection was done from eighty different horticultural crop growers through personal interviews and a Likert-type scale was developed with a five-point Likert continuum. Cronbach's alpha coefficient of reliability test was conducted. It was found that farmers showed a positive attitude towards post-harvest losses of horticultural crops. The factors responsible for post-harvest losses were environmental factors like moisture content, temperature, mechanical damage during handling, inadequate cold storage infrastructure, poor post-harvest sanitation, unfavourable weather conditions, poor quality standards, and lack of training programs for adoption of improved post-harvest technologies for increasing the knowledge-level of small farmers. The researcher suggested that farmers' attitude could be boosted by providing them with proper training for new post-harvest technologies and their proper selection, financial assistance, access to primary education, encouragement towards income-generation activities, linking farmers to markets, proper planning and implementation of development programs, extension activities and agricultural diversification. Identification of major causes for post-harvest losses in horticultural crops and development of appropriate strategies for their reduction could be a possible extension of this research.

Murthy et. al (2009) assessed the post-harvest losses of major fruits at different stages of handling, computed the magnitude of losses at national level and recommended appropriate strategies for reducing these losses. Crops were selected on the basis of importance and area of production and marketing. Data collection was done from various agencies involved in post-harvest handling of fruits based on seasonality. Multi-stage purposive and random sampling techniques were used. It was found that the marketing practices of different fruits were considerably different like pre-harvest contracts, cooperative marketing, field sale, and direct selling by farmers. The major causes of post-harvest losses were identified as fungal diseases, mechanical injury, discarding due to immaturity, over-ripening, strict quality requirement during procurement, irregular irrigation, improper packaging, poor market knowledge and awareness of farmers. The loss in agricultural GDP was found to be 1.2%. The researcher recommended strengthening of marketing infrastructure, establishment of processing units, provision for proper training of farmers for post-harvest handling and knowledge of optimum maturity index for harvest, adoption of appropriate packaging technologies, specialized transportation facilities with cold storage provision for long distance transit. Assessing the post-harvest losses of major vegetables at various levels in the agri-food supply chain and comparing them to form generic strategies for reducing post-harvest losses could be a possible extension of this research.

Prusky (2011) discussed the causes for the qualitative as well as the quantitative losses in agri-foods from pre-harvest to post-harvest and handling to final delivery to the consumer and suggested appropriate methods to reduce these



losses. The paper was descriptive in nature. The causes of post-harvest losses were inadequate infrastructural facilities, strict quality control standards, high temperature and humidity, perishability of the produce, poor packing, inadequate transportation facilities, lack of processing units, lack of market demand, poor post-harvest handling practices, inappropriate time of harvesting, mechanical injury during harvest, over-ripening, and poor knowledge of marketing information. The strategies for reduction of post-harvest losses as recommended by the researcher were development of cold storage infrastructure to maintain temperature and humidity, improved attention to ripening practices, well-developed transportation facilities, minimal handling to reduce physical injury, proper packaging, training programs for post-harvest handling techniques for farmers, application of pre-harvest treatments, development of processing units, improved quality of the produce to avoid rejection, direct interaction of the farmers to the buyers for improved income, and improved marketing strategies for matching supply and demand. Further, causes for post-harvest losses in specific fruits and vegetables could be researched and identified at the different levels in the supply chain and strategies could be developed at each level to reduce the overall food loss and increase food availability.

Tefera (2012) investigated the magnitude of post-harvest losses in maize in Africa and its relative effects on food security and ecosystem health and also recommended strategies for its mitigation. It was a descriptive type of research. The researcher found that there were considerable post-harvest losses in both quality and quantity of maize grains. The reasons for these losses were unfavourable weather conditions, outdated harvesting practices, inadequate transportation facilities, inappropriate storage facilities, limited access to marketing information, temperature and humidity. The strategies for reducing post-harvest losses suggested by the researcher were maintenance of moisture content at acceptable levels, adoption of improved storage technologies, selection of improved low-cost post-harvest technologies, adoption of appropriate mechanisms for transfer of knowledge of new technologies from researcher to farmer, training programs for farmers for creating awareness about causes of post-harvest losses, development infrastructure for connecting small farmers to markets, and development of collective marketing strategies. Identifying reasons for post-harvest losses in selected fruits and vegetables and comparing them for recommending generic strategies for reducing post-harvest losses in agri-food supply chain could be a possible extension of this research.

Adepoju (2014) studied the extent to which post-harvest losses in tomatoes production affect the welfare of farmers in Ogbomosho and also estimated the value of losses. Primary data was collected using questionnaire method. Multi-stage sampling was used. Analytical tools like descriptive statistics, gross margin analysis, Ordinary least Square (OLS) model and regression models were used. The causes for post-harvest losses were inadequate storage, processing and transportation facilities, inappropriate packaging, long distances of transit, poor access to credit facilities, perishable nature of the produce, high moisture content of tomatoes, constraints like poor government support and low working capital. It was found that the value of the post-harvest losses negatively affected the per-capita income and welfare of farmers. The strategies recommended by the researcher for reducing post-harvest losses were establishment of adequate infrastructure, improvement of road infrastructure and rail transportation system, establishment of processing units, and investment in post-harvest processing technologies. Identification of causes of

post-harvest losses for different fruits and vegetables using the similar approach and recommending appropriate strategies for its reduction at each level of the agri-food supply chain could be a possible extension of the research.

Aidoo et. al (2014) examined the factors influencing the extent of post-harvest losses in fresh-tomatoes supply chain at the farm level in Offinso, North district of Ghana. Primary data collection was done through standardized structured questionnaire and personal interviews. Purposive and simple random sampling techniques were used. Description Statistics was used and multiple regression analysis was conducted. The researcher found significant post-harvest losses in tomato production in Offinso North district. It was also found that factors like gender, size of household, variety cultivation, farm size, storage-time after harvest determined the level of the post-harvest losses. Proper management of these factors could help in the reduction of the post harvest losses and increased food availability. The constraints identified were limited access to credit, lack of storage facilities, lack of post-harvest technology, lack of market opportunities, and inadequate transportation facilities. The researcher also suggested establishment of small processing centres for alternative products, creation of awareness for improved quality of produce for improving adoption rate, periodic training of farmers for post-harvest techniques, and encouragement of investment into cold storage infrastructure. Further research in determining factors affecting the quality of the tomatoes for reducing the adoption rate could be a possible extension of the study.

Minten et. al (2016) estimated the extent of food loss at various stages of potato food supply chain in three Asian countries(India, Bangladesh and China). Data collection was done through primary surveys and interviews were conducted. Stratified random sampling technique was used. It was found that India had the highest potato yield among the three countries due to greater land productivity and larger farms. There was significant variation among countries with respect to retailers and wholesalers. It was found that adequate cold storage technologies allowed higher consumption during off-season. Lowest wastage levels in the value chain were found in India. The researcher limited the research to only well-connected production area supplying potatoes rather than selecting them randomly. Future research could be in the direction of conducting large sample surveys which are conducted at consumer level and not only retailer's level and wastage on account of consumer could be estimated. Further, research could be conducted in other countries also for useful comparison.

Munhuweyi et. al (2016) evaluated the quality of the post-harvest cabbage and incidence of its losses at retail level and during consumer simulated storage in South Africa. Data collection was done by taking produce samples of cabbage from three different retail outlets. Their physical losses, quality change and nutritional value were determined and estimation of economic losses and environmental impact due to post-harvest losses was done. ANOVA was done using SAS version 9.1 and Fisher's least significant difference-test was used. It was found that post-harvest losses of cabbage at retail purchasing were an average of 21% and also the estimated volume of physical losses at national level could approximately meet the dietary energy needs of thousands of people for a month. The factors determining the post-harvest losses include incidence of mechanical damage, storage temperature after harvest, and inadequate cold storage facilities. The impact of post-harvest losses was also found on fossil energy, water resources, food and nutrition security. Recommendations of strategies for reducing the level of post-harvest losses in cabbage and other vegetables could be a possible extension of this research.

Sibomana et. al (2016) highlighted the challenges faced in the tomato supply chains in Sub-Saharan Africa and identified the opportunities and appropriate technologies for post harvest management in tomato supply chains. The research was descriptive in nature. The challenges in estimation of post-harvest losses in tomato supply chains were lack of standard methods for collecting data of post-harvest losses, influence of pre-harvest treatments and conditions on quality of the produce, poor fertilizer application methods, inadequate cold storage infrastructure and transportation facilities, mechanical damages, accelerated microbial growth, improper sanitary and environmental packaging of produce. The researcher suggested that the post-harvest losses could be reduced by using appropriate post-harvest technologies, minimal handling and proper packaging material, improved market hygiene conditions, establishment of farmer cooperatives among small scale farmers for proper quality management of produce, development of a post-harvest loss information system for post-harvest loss estimates and adoption of intelligent warehouse management strategies. There was a significant difference in the post-harvest operations between the large scale and small scale farmers. Further research into development of monitoring strategies and estimation of losses along the supply chain is recommended.

### III FINDINGS

Through the review, it is found that the following are the causes of post-harvest losses in agri-food supply chain

- Environmental factors: unfavourable weather conditions, high temperature, humidity, mechanical damage, over-ripening, perishability, pests
- Inappropriate harvesting periods
- Lack of reliable maturity index
- Oversupply of fresh produce
- Unsuitable packaging and sanitation
- Inadequate on-farm storage infrastructure
- Lack of processing units and transportation facilities
- Mismatch between supply and demand
- Lack of reliable market
- Poor quality of produce
- Poor knowledge and lack of awareness of post-harvest handling techniques
- Lack of access to financial incentives and low working capital
- Lack of knowledge of market demand and marketing information

### IV CONCLUSION

Post-harvest losses along agri-food supply chain has been identified as one of the major cause of the food shortage problems in most of the developing countries. Farmers channel their limited resources to crop production, and lose the harvested produce before it reaches the market or consumers due to factors beyond their control leading to a significant loss in their expected income and jeopardizing their welfare. Hence, the problem of post-harvest losses which is responsible for food insecurity should be dealt with utmost priority with an attempt to attain food self-

sufficiency, increased market participation by farmers, and proper use of our limited natural resources. This study would help the scientists, technologists, policy makers, administrators, farmers, industrialists, retailers etc. in developing strategies for improving the production and pre-harvest and post-harvest handling techniques for minimizing the post-harvest losses and making them available to the farmers through training programs.

From the review of literature, we have identified the causes for the post-harvest losses and we recommend the following generic measures to reduce these losses.

- Encouragement of adequate training of farmers for post-harvest handling techniques
- Establishment of processing units
- Mechanization of harvesting and procurement
- Appropriate cold storage facilities during transit and on-farm storage facilities
- Following quality standards to reduce rejection rate
- Adequate packaging and sanitation
- A well connected logistics network
- Strengthening of marketing infrastructure
- Proper pre-harvest management and appropriate time of harvest
- Processing of unmarketable produce to avoid food wastage
- Reliable estimates of the post-harvest losses will help in developing correct policies

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