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Strategies for Reducing Post-Harvest Losses in Horticultural Products

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INTRODUCTION

Crops like fruits, vegetables, spices, flowers, and plantation crops are an essential part of human diet and play a very significant role in ensuring food security and generating income as well as developing economies related to agriculture. But because of high water content, soft tissues, and high rates of respiration, these products are highly susceptible to various post-harvest losses once they are shifted out of the farms. These losses occur at various stages, ranging from harvest to transportation, handling, storage, marketing, and reaching the retail sector. Not only do these damages affect farmers' profits, but they also impact the availability of healthy food. It is, therefore, necessary that scientific methods regarding post-harvest management be adopted.

2. Major Causes of Post-Harvest Losses

Losses that occur after harvest are impacted by physical, physiological, microbial, and environmental factors.

2.1 Physical Loss

Physical deterioration

Physical deterioration occurs in fruits and vegetables as a result of wrong handling methods, including improper harvesting, loading, unloading, transport, and injuries caused as a result of bruising, cuts, compression, and cracking. Employment of wrong tools, inefficiencies created by manual handling, wrong packaging designs, and improper crates with no cushioning, as well as transport-induced vibrations as a result of covering long distances, contribute greatly to deterioration.

2.3 Microbial

Losses due to microorganisms originate from infections caused by fungi, bacteria, and yeast that enter fruits and veggies as a result of wounds and natural openings. Unsolicited sanitation practices on farms, contaminated water, unclean packaging materials, and high moisture promote microbial growth. Various microorganisms bring about decomposition, changes in color, unpleasant smells, and slimes, making veggies and fruits unsuitable for consumption and thus causing significant loss.

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2.4 Environmental Factors

Climate conditions like high temperatures, excessive humidity, exposure to sunlight, and inadequate ventilation accelerate decomposition and physiological deterioration. Lack of proper storage facilities and unsanitary conditions also contribute to decomposition by promoting the development of insects, pests, and microorganisms. Contamination caused by dust, chemicals, and contact with contaminated surfaces is also a concern.

3. Strategies for Post-Harvest loss management

3.1 Scientific Harvesting Methods

Harvesting scientifically begins with choosing the appropriate stage of maturity because premature and delayed harvests result in low-quality produce with shorter storage life and high chances of spoilage. Harvesting should be done using sharp and clean tools like knives, clippers, and scissors, which will not bruise or tear tissues. Harvesting should be conducted at the cooler times of the day, preferably early morning and late afternoon, because at these times there will be low respiration and lesser chances of heat stress. Handling carefully will help maintain fruits and vegetables entire, and removing diseased or damaged produce will prevent healthy produce from being contaminated.

(Source, Lalpekhlua, et al., 2024)

3.2 Sorting and Grading

Sorting and grading entail the removal of defective, immature, overly ripe, and diseased produce. Grading produce based on factors like size, color, shape, and firmness ensures that consumers obtain consistent product quality and thus enables farmers to get optimal prices. It should be noted that modern graders and optical sorting machines have boosted precision and efficiency, particularly among large farmers. Grading also assists with adhering to local and global market standards, primarily with regards to produce meant for export.

3.3 Pre-cooling

Pre-cooling aims at removing field heat immediately after harvest. Metabolic processes accelerate with higher temperatures. Various methods include forced air cooling, hydro-cooling, vacuum cooling, and icing. Forced air cooling is very efficient for products packed in cartons. Hydro-cooling is useful for strong products such as apples, carrots, and leafy vegetables. Leafy vegetables and vacuum cooling are useful for leafy veggies. Crushing ice methods are applicable for products requiring high humidity. Pre-cooling aids in slowing respiration rates, reduction of microbial growth, and extending the shelf life during storage and transport.

3.4 Improved Packaging Systems

Packaging acts as an essential component that shields produce against mechanical stress, temperature changes, dehydration, and contamination. Specifically, corrugated cardboard boxes, plastic crates, trays, and clamshell packaging act as common packaging materials for easier handling. However, recent technological advancements have included modified atmosphere packaging (MAP) and active packaging, which control gas composition and prevent accumulation of ethylene. Biodegradable materials made from plants can be effectively used as packaging materials and still be environmentally sustainable.

3.5 Cold Chain Management

A properly maintained cold chain will enable fruits and vegetables to be transported within an optimal temperature range from the time of harvest. The components necessary for a cold chain include pre-cooled units, pack houses, cold storage facilities, refrigerated trucks, and chilled display units. Temperature and humidity control will enable fruits and vegetables to be transported with low rates of spoilage, physiological deterioration, and microbial action. Solar-powered coolers, insulated containers, and IoT-based temperature tracking will offer an additional safeguard. It will be very essential to maintain an unbroken chain for highly perishable commodities like berries, leafy veggies, and cut flowers.

3.6 Controlled Atmosphere (CA) and Modified Atmosphere Storage

Controlled Atmosphere CA) storage requires precisely controlled concentrations of oxygen, carbon dioxide, and nitrogen. CA storage slows down respiration, ethylene production, and enzymatic reactions. The technique proves highly successful for apples, pears, kiwifruit, and long-vegetables. Modified Atmosphere Storage MAS) represents a more flexible variant. A particular packaging material will result in self-regulated gas phase composition. Refined storage life and controlled chilling injuries are attained.

3.7. Post-harvest technologies

Post-harvest technologies include fungicides, antioxidants, andethylene inhibitors, including 1-MCP, which delay fruit ripening and microbial growth. Hot water treatment reduces microbial contamination on the surface, and an edible barrier made from aloe vera, chitosan, or wax creates a physical barrier that retards water loss and respiration. These technologies improve freshness, aesthetic value, and physiological disorders associated with storage and distribution.

3.8 Transportation Management

The transportation should be efficient and thus reduce mechanical damage. The transport should be well-ventilated and cushioned with shock-absorbing materials. It should not be overloaded, as this will crush the produce. It should be refrigerated or insulated if it contains perishable goods. It should be transported via an optimized route and on time.

3.9 Storage Technologies

Various storage technologies are adopted based on product traits. Ambient storage can be adopted for more resistant produce such as onions and potatoes. Evaporative cool chambers and zero energy cool chambers are cost and environmentally friendly technologies suited for small farmers. Common cold storage facilities offer controlled temperatures and humidity for perishable goods. Onion and potato storage facility designs minimize loss due to sprouting and shrinkage. Storage allows for regular market distribution and helps prevent distress sales and price volatility.

3.10 Value Addition and Processing

It ensures that surplus and cosmetically defective produce, if any, is processed into hard, valuable goods. Drying, dehydration, candying, freezing, and fermentation are some processes that turn perishable materials into more permanent goods. Some common value-added goods include juices, jams, purees, pickles, sauces, frozen veggies, and ready-to-cook food. Processing raises the longevity and market value of goods and also helps in creating employment opportunities and developing rural regions.

3.11 Training, Awareness & Camp

It is imperative to train farmers, traders, and handlers on optimal methods relating to post-harvest practices. Moreover, agencies involved in extension services, Krishi Vigyan Kendra (KVK), and Agriculture Universities have an important role in making farmers aware about Good Agriculture Practices (GAP), Good Handling Practices (GHP), sanitation, and hygiene. Demonstrations, workshops, and mobile-based services make it easy for farmers to get access to modern technologies and techniques. Building capacity strengthens farmers and makes them aware about efficient and optimal ways.

4. Role of ICT and Modern Technologies

Information and Communication Technologies (ICTs) are revolutionizing post-harvest practices with capabilities for real-time decision support and traceability. IoT sensor technologies monitor temperature, humidity, and ethylene production within storage and transport infrastructure. Smartphone applications offer farmers market information, weather forecasts, and knowledge services. Artificial intelligence grading machines improve sorting accuracy and uniformity. Blockchain technologies enable traceability and food safety with immutable records and tracking capabilities for all steps within the food chain.

CONCLUSION

Post-harvest practices remain a challenge for food security, sustainable environments, and an increase in farmer profits. The implementation of scientific harvest methods, cold storage technologies, packaging innovations, and modern technologies would greatly improve loss reduction. Cold chain developments and market linkages would enable farmers to provide better produce from production to consumption. By working together, scientists, government, and private sector partners can make post-harvest practices an instrument of progress and waste reduction, and improved profitability, for better growth and performance within the horticultural sector.

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