



Post-Harvest Handling and Processing of Fruits and Vegetables

I.S. Singh

POST-HARVEST HANDLING AND PROCESSING OF FRUITS AND VEGETABLES

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**POST-HARVEST HANDLING AND PROCESSING
OF
FRUITS AND VEGETABLES**

FOREWORD

Horticulture comprising of fruits, nuts, vegetables, tubers, mushrooms, spices, floriculture, medical and aromatic plants and plantation crops, has emerged as core sector in agriculture. Silent revolution in horticulture has provided insight for effective diversification to enhance farm income. The health conscious population is demanding more fruits and vegetable, thus there has been an increasing adoption of technology recently, production has achieved 7 folds increase from the level of 1950-51, 185 million tonnes in 2006-07.

There have been an appreciable increase in production, productivity and availability of fruits and vegetables. Changes are also seen in packing, grading and value addition in fruits and vegetables. Large number of processed products are also available on the shelf of super markets. Other trend observed is about the entry of corporate sector for supply chain management. Many technologies have been developed for grading, packing, storage and value addition but post harvest losses continue to be high for the want of awareness about the technology. The book 'Post-Harvest Handling and Processing of Fruits and Vegetable' written by Prof (Dr) I.S. Singh is an effort to compile the information together by putting his long professional experience on post harvest losses, its management and also processing of fruits and vegetable which shall help in reducing the losses and add value through processing

I am sure the book shall be of immense value to all those who are concerned with post harvest handling and processing of fruit and vegetables. Finally, I compliment the author for his efforts.

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PREFACE

Fruits and vegetables are strong sources of essential minerals, vitamins and fibre which are vital for health, balanced growth and normal working of human system. These crops play a unique role in diversification of agriculture, food and nutritional security and growth of economy. India is the second largest producer of fruits and vegetables in the world. The spectacular increase in production of these crops will have little values if the produce is not utilized properly.

Fruits and vegetables are seasonal in nature resulting in surplus during production period and subsequent off season shortage. A huge quantity of highly nutritive fruits and vegetables is spoiled at each and every step of the value chain due to improper post-harvest management and lack of adequate processing. The cost involved in preventing the losses is always lesser than the cost of production. Hence, post harvest management attains greater significance.

Processing of fruits and vegetable is an important sector of our economy to reduce post-harvest losses, increasing income of farmers, providing employment opportunities, diversifying rural economy and earning foreign exchange. However, only 2 per cent of annual production of fruits and vegetables is processed as against 65 per cent in USA, 70 per cent in Brazil, 78 per cent in Philippines, 80 per cent in South Africa and 83 per cent in Malaysia. There is enormous potential in India to build profitable business in food processing.

The present book has two parts, Part-I deals with the practices for post-harvest handling of fresh fruits and vegetables while Part-II describes processing of fruits and vegetables. I sincerely hope that the information provided in this book would serve as knowledge pool and help the students of horticulture and food technology disciplines, researchers, growers, processors, entrepreneurs and all those involved in research and development in post-harvest management and value addition of fruits and vegetables which are high value horticultural crops.

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PART – I

POST-HARVEST HANDLING

INTRODUCTION

Horticultural crops are high value commercial crops and play a unique role in country's economy, nutritional security, poverty alleviation and employment generation. Fruits and vegetables have special significance to human beings as a protective food due to their vitamins and mineral content. These crops are highly perishable commodities and soon begin to deteriorate after harvest because of their high moisture contents. These are living commodities, physiologically active even after harvest, continuously respiring, therefore, degrading the stored energy and losing moisture due to transpiration. Both qualitative and quantitative declines that is shriveling/wilting, loss of texture and an increase in susceptibility to spoilage organisms are, therefore, obvious. Further, these commodities are seasonal in nature and prices go down considerably during the glut period and production becomes uneconomical due to distress sale. Thus, an increase in production of fruits and vegetables will have little value if the produce is not properly handled or utilized. The losses during post-harvest operations are enormous. The cost involved in preventing the losses is always cheaper than the cost of production hence, post-harvest management receives greater attention in recent years.

Losses in fruits and vegetables both qualitative and quantitative occur between harvesting and consumption. Qualitative losses are difficult to assess because standards of quality and consumer's purchasing power are different in different countries. The post-harvest losses in various fruits and vegetables in India are provided in following table.

Post-harvest losses in fruits and vegetables

<i>Fruits</i>	<i>Post-harvest losses (%)</i>	<i>Vegetables</i>	<i>Post-harvest losses (%)</i>
Mango	15-33	Potato	30-40
Papaya	20-35	Onion	25-40
Citrus	10-30	Tomato	10-35
Pineapple	20-40	Cabbage	8-25
Grapes	10-25	Cauliflower	8-25
Banana	25-40	Chilies	5-35
Guava	10-32	Carrot	5-10
Jamun	30-60	Radish	3-5
Phalsa	20-35	Garlic	1-3

These losses in various fruits and vegetables are mostly due to physical damage during harvesting and handling, physiological loss in weight and decay after harvest. Losses vary significantly with crop variety, climate, system of harvesting, packaging, storage, nature of transport and distribution. The wastage or losses can be checked if the fruits and vegetables are produced under optimum conditions of farm and pre-harvest practices, harvesting, post-harvest handling, packaging, transportation, storage, processing for value addition are done by adopting appropriate or scientific technological processes and produce/products distributed in a well knitted way from farm to consumer to cater both domestic and export markets.

The elimination of post-harvest losses will significantly increase the fruit supply without bringing an additional land into production or using additional inputs. When constraints on food production, i.e., land, water and energy are continually increasing, the need to reduce post-harvest losses of perishable fruits and vegetables become of paramount importance. Therefore, the massive thrust to post-harvest management of fruits and vegetables in India will assist in reducing significant economic loss, obtaining stable income, meeting dietary target, generating employment and ensuring intensive production in the regions. This will diversify rural economy and faster rural industrialization for the socio-economic development of the rural people.

POST-HARVEST LOSSES

Fruits and vegetables are perishable commodities and they begin to spoil shortly after harvest. A considerable quantity of these is lost every year after harvest which is a significant economic loss. These losses are known as post-harvest losses which occur at different stages in the chain of harvesting, packaging, storage, transport and marketing. Poor production planning, ill equipped markets, insufficient storage capacity, unsatisfactory transport infrastructure, lack of organizational setup and poor state of processing industries are the important factors responsible for post-harvest losses.

2.1. NATURE OF LOSSES

The important sites where post-harvest losses occur in India are 15-20 per cent at farmers field, 15-20 per cent in packaging, 30-40 per cent in transportation and 30-40 per cent in marketing. The need of the hour is to minimize these losses. Nature of losses observed in fruits and vegetables is as under:

- (i) **Loss in weight:** Leafy vegetables, potato and onion and most of the fruits get reduced in weight due to transpiration of water.
- (ii) **Shrinking and wilting:** Most of the fruits shriveled. Tender and leafy vegetables get wilted due to loss of water.
- (iii) **Change in colour:** Many fruits and vegetables lose their original colour due to high temperature or hot and dry conditions, e.g., Litchi becomes brown, and spinach and lettuce become pale yellow and white head of cauliflower becomes yellow.
- (iv) **Change in texture:** Many fruits including tomato become very soft due to over ripening and some vegetables such as leafy vegetables become very hard and brittle.
- (v) **Change in taste:** Some fruits give flat, sour and unpleasant odour. Vegetables tend to become sweet, e.g., potato at low temperature.

- (vi) **Bruising:** Fruits and vegetables get bruised due to defective harvesting, handling, packing, transport and storage.
- (vii) **Sprouting:** It is a great problem in vegetables like onion, garlic, ginger and potatoes if not stored at proper temperature and humidity.
- (viii) **Toughening:** Vegetables like green beans and sweet corn become tough due to development of spongy tissue in prolonged storage.
- (ix) **Greening:** Exposure of potatoes and sweet potatoes to light during storage cause green tissue. These portions contain solanine which has toxic properties.
- (x) **Rotting:** Rotting of fruits and vegetables is caused by diseases and pests. Fungi are the main contributory factor to post-harvest losses.

2.2. CAUSES AND CONTROL OF LOSSES

Many factors are responsible for the losses of fruits and vegetables during various stages of handling. These can be broadly classified into three groups, i.e., physical injuries, physiological disorders and pathogenic disorders.

2.2.1. Physical Injuries

Injury caused in fruits or vegetables during harvesting, grading, packing, transportation and storage is the source for entrance of micro-organisms that causes spoilage or losses. Improper physical handling can result in injuries due to the followings:

- (i) **Abrasion:** It can occur during harvesting, packing and transport. Rough containers or slackly packed containers permit the individual fruits to rub against each other or against containers surfaces and causes abrasion.
- (ii) **Compression:** Packing more produce into little container or stacking of containers higher than their design strength cause compression damage.
- (iii) **Impact:** Dropping of crates and bags of fruits or vegetables on a concrete floor or careless dumping of produce from containers on to retail display causes impact damage, i.e., bruise or crack.
- (iv) **Punctures:** Punctures are sometimes caused by stem or pedicel in egg plant, cucumber, tomato, etc.
- (v) **Tears:** This is most common in leafy vegetables and tissue exposed, lead to rapid dehydration, discoloration and decay.

The important diseases which enter through wounds or injury are stem end rot of mango, crown rot of banana, green and blue mold of citrus, pedicel rot of pineapple, *Rhizopus* rot of sweet potato, bacterial soft of potato etc. Moreover the injured fruits and vegetables faced serious problem in marketing.

Control Measures

- (i) **Careful handling:** Precaution should be taken during harvesting, grading, packing, storage, transportation and marketing to prevent injury.
- (ii) **Removal of injured fruits:** Injured fruits by any physical injury must be removed during grading, packing and storage to avoid the infection of various diseases.
- (iii) **Chemical Protection:** Injuries incurred by fruits and vegetables during harvest and handling are the major sites of infection by wound pathogens. Chemical treatment to control these infections should be applied as soon as possible after harvest. Post-harvest treatment of fruits with Benomyl (0.1%) before storage minimizes the problems.

2.2.2. Physiological Disorders

Physiological disorders are abnormal non-parasitic metabolism that usually shortens useful post-harvest life of fresh fruits and vegetables. Some disorders inherited at harvest and other develop later. These disorders cause losses and affect marketability of fruits and vegetables.—

2.2.2.1. Pre-harvest Period Causing Post-harvest Physiological Disorders

- (i) **Water relations or imbalance:** Fluctuation of moisture during growth and ripening causes fruit splitting of lime, lemons, grapes, litchi, fig, pomegranate and tomato, Blossom end rot of tomato, Black heart of celery and Tip burn of lettuce.
- (ii) **High temperature:** High temperature during growth period causes ohanez spot of grapes, Kelsey spot of plums, scald in fig, pomegranate and potato, failure of ripening in avocado (26-30 °C) and tomato (above 30 °C) and browning in litchi fruits.
- (iii) **Low temperature:** Low temperature causes cold injury in terms of chilling injury in chill sensitive crops including tomato and freezing injury in citrus fruits during winter.
- (iv) **Mineral nutrition deficiency:** Several physiological disorders of fruits and vegetables are attributed to the deficiency of mineral nutrients, calcium being the most important one. Bitter pit in apple due to calcium deficiency, blossom end rot in tomato due to calcium deficiency, internal cork of apples to boron deficiency, necrosis in aonla due to boron deficiency and exanthema (rind browning) in citrus due to copper deficiency are some of the example of physiological disorders caused by mineral deficiency.

2.2.2.2. Post-harvest Period

- (i) **Senescent period (Ageing):** Senescent fruits and vegetables are highly susceptible to micro-organisms due to decreased level of microbial inhibitors such as tannin, 3, 4 dehydroxy benzol dehyde, 6- methyl mullein, etc.

- (ii) **High temperature:** Heat or high temperature during storage speed up the physiological process in stored fruits and vegetables. It also causes excessive transpiration with resultant of shriveling/wilting, cracking of stored fruits and vegetables. This is due to water loss. Water loss is a loss of saleable weight and thus is a direct loss in marketing. A loss in weight of only 5 per cent causes shrinkage in many fruits and vegetables. Such fruits and vegetables are also highly susceptible to micro-organisms. The direct effects of excessive heat in storage are blemishes such as spotting, russetting and scald in apple and potato. High temperature also causes failure of ripening in banana (above 30 °C) which cease ethylene production. Tomatoes do not develop proper colour (red/pink) due to high temperature.
- (iii) **Low temperature injury during storage:** Extremely low temperature causes numerous physiological disorders. Which are described as chilling and freezing injuries.
 - (a) **Chilling injury:** Chilling injury reduces the quality of the product and shortens shelf life. Low temperature break down is the major physiological disorders of tropical fruits. It is a major problem in post-harvest handling of these fruit, which are most susceptible. Chilling injury differs from freezing injury and it occurs at temperature, which are low but above the freezing point of the tissue. It is responsible for large economic loss during storage. It occurs at 0-12.8 °C in many fruit such as mango, banana, citrus, apple and vegetables such as potato, onion and tomato. Various disorders caused by chilling are: pitting in rind, discolouration of rind, failure of ripening in banana, and browning of flesh in apple and plum, rusty brown specks, spots, in lima beans and surface scald, blackening of seeds in brinjal.
 - (b) **Freezing injury:** This type of injury results when temperature drops below the freezing point of the fruits and vegetables in storage. It occurs in many fruits such as mango, banana, citrus, grapes, apple and vegetables such as potato, onion, tomato, *etc.*, it occurs at -1.5 °C -1 °C. It causes watery break down, soft break down and browning or discolorations of fruits and vegetables.
- (iv) **Humidity:** Relative humidity is the best-known term for expressing the humidity of moist air. It is defined as the ratio of water vapour pressure in the air to the saturation vapour pressure at the same temperature expressed as percentage.

Most of the fruits and vegetables require 85-90 per cent relative humidity during storage. Both high and low humidity causes spoilage of fruits and vegetables. High humidity causes growth of fungus that causes spoilage, e.g., *Botrytis* rots in grapes. Low humidity causes shrinkage and loss in weight in many fruits and vegetables. Dehydration injury occurs when the humidity of storage house falls below normal. When this occurs, potato, sweet potato, apples and stone fruits become soft, flabby and wrinkled with consequent reduction in quality.