Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 2682-2690

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Postharvest management of horticultural crops for doubling farmer's income

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Abstract
In India, the diverse agro climatic conditions, varied soil type and abundance of rainfall offers immense scope for cultivation of different types of horticultural crops, including fruits, vegetables, flowers, plantation crops, tuber and rhizomatous crops and crops of medicinal and aromatic importance. India is the second largest producer (after China) of both fruits and vegetables in the world. Horticultural produce including flowers also earns good in export earnings for the country. Unfortunately about 25-30% of horticulture produce, 10-25% of vegetables and 30-40% of flowers gets wasted due to lack of post-harvest management which resulted in huge loss of crores of rupees. The minimization of these post-harvest losses may be reduced by extending the shelf life of fresh horticultural produces either through pre or post-harvest management practices or by processing it into different value added products. Several factors influence the post-harvest losses in fruits and vegetables that include losses due to physical, physiological, mechanical and unhygienic conditions, lack of proper storage conditions, refrigerated facilities and diseases and pests, etc. While harvesting to handling for storage till marketing several wound pathogens are known to infect the produced that destroy the keeping quality, quantity ultimately economic losses. Post-harvest decay of fruits and vegetables occur either between flowering and fruit maturity or during harvesting and subsequent handling and storage. There are many technologies already developed in the past which are available in the literature but are not practiced may be due to either materials are not available locally, not much effective or the technology is more costly. By adoption of simple post-harvest management practices, processing and value addition operation viz., proper harvesting, sorting, grading, packaging, pulping, pickling, drying and dehydration at farmer's level during the peak season will help in minimization of post-harvest losses as well as doubling the farmer's income.

Keywords: Horticulture, Post-harvest management, Value addition, Fruits, Vegetables, Flowers, Doubling farmer's income.

Introduction

The Indian Economy is heavily dependent on agriculture, and this is projected to continue in the near future as well. The Agriculture and Allied Sector contributed approximately 13.9% of India's GDP during 2013-14 (Ministry of Agriculture, 2015) and engages about 50% of the workforce. India is a rich horticultural country producing wide variety of fruits, vegetables, spices, ornamental and medicinal plants. India is second largest producer of vegetables in the world. Food production has been steadily increased in India due to advancement in production technology, but improper post-harvest management, processing, value addition and storage results in high losses in agricultural produces. Unfortunately, having such a huge production a considerable postharvest loss to the tune of 10-25% of vegetables (Selvakumar 2014) occur annually mainly due to inefficient postharvest management practices.

According to World Bank Report, post-harvest losses in India amount to 12 to 16 million metric tonnes of food grains each year, an amount that the World Bank stipulates could feed one-third of India's poor (Chaturvedi and Raj, 2015). The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010). In India about 263.2 million MT (in 2013-14) of food grains are produced annually (Chaturvedi and Raj, 2015) and out of which 60-70 per cent are stored by the farmers for their own consumption.

The optimum postharvest management of horticultural products is not the same for all products. Growers, wholesalers, exporters and retailers must all be aware of the specific needs of a product if the postharvest shelf life and quality is to be maximized. Reduction in post-harvest losses is therefore need of the hour to feed growing population of country. Processing of food products mainly as part of a cottage industry has been a long established traditional practice imbibed in many cultures of the country. However, with changing lifestyle patterns, increasing income, increasing preference toward, Ready to Eat and packaged foods, the significance of the Food Processing Industry has increased enormously.

A nation-wide study on quantitative assessment of harvest and post-harvest losses for 46 agricultural produce in 106 randomly selected districts carried out by CIPHET, Ludhiana has estimated harvest and postharvest losses of major agricultural produce at national level to be of the order of Rs. 44,143 crore per annum at 2009 wholesale prices. In spite of a large production base, the level of processing is low (less than 10%). Approximately 2% of fruits and vegetables, 8% marine, 35% milk, 6% poultry are processed. Lack of adequate processable varieties continues to pose a significant challenge to this sector.

A wide range of conducive agro-climatic conditions across the country enable India to cultivate a large number of flowers, potted plants, foliage and aromatic flowers almost throughout the year in one part or the another. Floriculture industry is in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions, respectively. India also has a strong dry flower industry, which provides major contribution to the overall trade. Other segments like fillers, potted plants, seeds and planting material, turf grass industry and value added products also contribute a share in the overall growth of floriculture sector. Loose flowers are generally used for religious purposes, making garlands and other floral ornaments, extraction of essential oils pigments and dyes. Cut flowers with stem or branch including blossom, buds, leaves of desired length with specific purpose. The cut flowers are used as indoors in vases for decoration of homes, drawing rooms, offices, hotels etc. and for making attractive bouquet.

The term postharvest losses are defined as “losses that occur after harvest till the produce reaches consumers. It can quantity as well as qualitatively losses. Post-harvest losses are more painful and costlier than pre-harvest in terms of money and labour. Vegetables are highly perishable having moisture content of (80-90%). They are live commodities and continue their life processes like respiration and transpiration even after harvest. When the fruit is attached to the parent plant, water and photosynthates are supplied to it. But losses are not replaced during postharvest stage and hence the produce depends on its own food reserve and moisture content with the result they perish fast. Water is lost from the product due to transpiration and food reserve depleted by respiration.

Water loss or transpiration is a major factor affecting quality of vegetables. In addition to lower saleable weight, loss of water can affect quality in many ways, including wilting, shriveling, flaccidness, soft texture and loss of nutritional value. The rate of water loss, and the impact of this loss, will vary by product (Table 1 and 2). For example, maximum permissible losses can range from 3% for lettuce to 10% in onions. Products vary in potential for water loss by morphological differences such as cuticle thickness and composition and presence or absence of stomata and lenticels, which are structures that allow gases and moisture to move in or out of the plant. For some products these differences are affected by development stage. Also, within products, morphological differences exist among varieties. Water is another product of respiration. Water loss can be reduced by cooling products, maintaining a high relative humidity in the storage environment, controlling air circulation, and where permitted, the use of surface coatings or plastic film (Chris and Jacqueline, 2012).

The potential useful life of the cut flowers depends on several pre-harvest, harvest and postharvest factors. Nearly 70 per cent of the potential qualities of lasting quality of cut flowers are predominant at harvest, while postharvest factors influence 30 per cent of the effects. Postharvest behaviour and lasting quality of flowers species and cultivars vary considerably. Differences in flower longevity and quality among varieties may be due to anatomical, physiological, physical, biochemical and genetic makeup. Cut flower longevity depends upon carbohydrate reserves of flowers, osmotic concentration and pressure potential of petal cells, stomatal functioning, variation in stem diameter and rigidity, variation in bacterial and fungal species present in vase water etc.

In floriculture trade value addition takes place at every step to create a novel product to cater the demands of the heterozygous consumers. The trends in floriculture keep pace with the trends in the fashion industry and hence the evolution of the floriculture is much more rapid than the other industries. A large number of value added products are being prepared from the flower crops such as rose water, rose oil, ottoo or *attar*, concrete, absolute of rose, *itra* of rose etc.

Table 1: Transpiration losses for vegetables stored at various relative humidity (Chris and Jacqueline, 2012).

Crops	Storage Temperature (°F)	Percentage weight loss per day			
		95% RH	90% RH	85% RH	80% RH
Carrots	32	0.315	0.630	0.945	1.260
Cabbage	32	0.058	0.116	0.175	0.233
Celery	32	0.460	0.920	1.380	1.840
Lettuce	32	1.930	3.860	5.790	7.730
Potatoes	45	0.070	0.141	0.211	0.282
Tomatoes	45	0.060	0.119	0.180	0.240

Table 2: Post-harvest losses in major vegetables (Selvakumar 2014)

Name of vegetable	Post-harvest losses as percentage of production
Beans & peas	7-12
Brinjal	10-13
Cabbage	7-15
Cauliflower	10-15
Garlic	1-3
Onion	15-30
Potato	15-20
Tomato	10-20

Reasons for Postharvest losses in Fruits & Vegetables

Factors which are responsible for post-harvest losses vary widely from place to place and become more and more complex. The following reasons for postharvest losses are as under:

- Moisture loss causing wilting / shrinkage
- Loss of photosynthates like carbohyderates, proteins occur
- Physical damage through pest and diseases attack
- Physiological loss causing decline in quality
- Fibre development
- Greening (Potato)
- Microbial causes insects and rodents
- Activity of enzymes of the plant or food
- Chemical reaction not catalysed by enzymes of the tissue
- Physical changes such as freezing, brusing, drying & pressure etc.

Factors affecting postharvest life of Horticultural Crops

There are two approaches for reducing postharvest losses of vegetables. The first approach for loss reduction is to follow scientific postharvest management of vegetables. Another approach for loss reduction in processing into value added products. Postharvest technology of vegetable crops envisages development of appropriate techniques to reduce postharvest losses to prevent spoilage and help to utilise maximum crops in a nutritious and safe manner.

(A) Post-harvest management practices

Post-harvest losses can be reduced by adopting breeding technologies for longer shelf life, improvement of pre-harvest factors and haevesting techniques, proper methods of handling, marketing, packaging, transportation and storage, development of appropriate processing technology

1. Selection of varieties: Varieties with better keeping and processing quality and lesser handling susceptibility should be bred and selected for different vegetables. A few examples of varieties with long shelf life are Arka Vishal, Pusa Gaurav (Tomato), Arka Nidhi and Arka Neelakandh (Brinjal).

2. Harvesting: Harvesting should be done at proper stage where there is minimum damage and loss, as rapidly as possible and at minimum cost. Harvesting should be done at early morning or late evening hours. A temperature of above 27 0C during harvesting should be avoided. The products that are to be send to distant markets are harvested in the evening and transported in the cool hours of night where as commodities for local markets are harvested early morning. Harvesting should not be done immediately after rain or irrigation. Harvesting at optihmum stage of maturity ensures maximum quality and yield. Care must be taken to avoid mechanical injury to product.

3. Sorting/Grading: Sorting of harvested vegetable produce is done to remove diseased, damaged, misshapen,over mature, insect attacked and rotten vegetable. Disease/insect attacked should also be discarded to avoid any spread of infection to normal and healthy vegetable/fruit produce.

Systematic grading coupled with appropriate packaging and storage, will extend postharvest shelf life, wholesomeness, freshness, and quality, will substantially reduce losses and marketing cost. Horticultural produce must be sorted and graded on the basis of parameters such as maturity, size, shape, color, weight, freedom from insects and pests, pesticide residues and ripeness. Vegetables like onion, potato, tomato, chillies, okra and french beans are graded on the basis of size, shape, weight and maturity stage. Elimination of off-grade and diseased horticultural crops prevents the spread of diseases. Common horticultural crops are generally graded on the basis of size and weight (Nath, 2013).

4. Washing: The Produce is cleaned/washed to remove adhering dirt, dust, insects, mould and spray residues and to improve appearance. Onion, garlic, okra anf mushrooms are not washed after harvest. Chemically mild detergent (soap solution), glacial acetic acid or Nacl (1%) can be used for surface decontamination. Chlorinated water (100 pp cholorine) is also effective in surface decontamination. Fruits and vegetables are to be rinsed again with clean wastes and excess water allowed to dry before packing.

5. Trimming: Trimming is done in crops like cabbage and lettuce etc. To remove unwanted, discoloured, rotten and damaged parts. Trimming enhances visual quality, reduces deterioration of produce, and facilitates handling packaging and transport.

6. Curing: Curing is a process of strengthening and wound periderm (skin) of root and tuber crops for a specified period under well-defined conditions of temperature and relative humidity which enhances shelf life of these crops by forming corky layer which protects against water loss and infections by decaying organisms. In bulb crops (onion &garlic).Curing is a drying process for toughening of outer skin and tightening of necks. Potato curing is most effective at about 200c and 80% relative humidity.

7. Waxing: Waxing is done mainly to minimize water loss and reduce shrivelling and wilting to enhance therefore storage life. Wax seals off the stem near the petiole and the pores on the surface of fruits which are the main routes of transpiration. Waxing on the surface of fruit or vegetable product which are the main routes of transpiration. Waxing also improves appearance of produce. Paraffin wax, Carnuba wax and various resins are common types of wax used for preparation of wax emulsion. Waxes are generally applied by foaming, spraying and brushing of which foaming is the best, since it leaves a very thin coating. Some of the common coating materials are semperfresh, prolong and waxol. Vegetables such as tomato, brinjal, sweet pepper, cucumber, muslmelon, carrot etc. are often waxed with a water emulsion by dipping or spraying to retard the moisture loss from the product and at the same time to improve their lustre. This practice of keeping the product sound and lustrous is generally not in vogue in our country.

Shelf life of fruits and vegetables may be extended by utilizing different plant based coating materials viz., neem extract, tulsi extract, aloe vera extract etc. (Nath *et al*., 2013) may be used locally which have anti fungal properties at farmers level so that more return will be generated from their agricultural produces.

8. Precooling: Pre-cooling is the process of removing field heat from the harvested commodity, particularly when harvested during hot weather.Pre-cooling helps in decreasing rate of transpiration and respiration delayed ripening and easing the load on the cooling system of transport or storage chambers. There are several methods of pre-cooling process as-

- Room cooling
- Hydro-cooling
- Contact icing
- Vaccum cooling

9. Post- Harvest Disease Control: Vegetables suffer significantly due to invasion of fungi and bacteria causing disease and resulting in huge postharvest losses. Succulence of vegetables makes them prone to infection by micro-organisms Mechanical injuries, contamination by diseases vegetables, heat and other environmental agencies pre-dispose products to diseases. Post-harvest diseases can be controlled by use fungicides as sprays or dips, incorporated in wax or impregnated in packaging materials.

10. Sprout inhibition: Tuber and bulb crops (onion & potato) enter a dormant stage at maturity, sprouting starts at the end of dormancy or rest period. Sprouting is a growth resumption process. Sprouting causes huge loss due to respiratory utlisation of substrates. Maleic hydrazide (MH-40), 3-Cholorisopropyly-N-Phynle Carbamate (CIPC), Methyl naphthalene acetic acid (MENA) and 2,3,4,6 tetra nitro benzene (TCNB) are commonly used as sprout inhibitors. Gamma irradiation at 0.02- 0.15 KGY is widely accepted by many countries for successful sprout inhibition of onion and potato without affecting other quality attributes.

11. Packaging: Packaging is a fundamental and necessary for management of highly perishable products. The main role of packaging is to assemble the produce into convenient units for handling and safeguard the produce during distribution, storage and marketing. Packaging materials are selected according to plant characteristics. It improves storage life of produce and provides greater attraction to the produce. An efficient package practices protects product from any physical, physiological and pathological deterioration throughout storage, transport and marketing packaging material should provide cushioning to fresh produce as several types like bamboos baskets, sacks (mode of plastic or jute),wooden crates, corrugated fibre board (CFB) cartons are used. Vegetables mostly bamboo baskets, gunny bags, plastic crates are used for packaging purposes.

The use of polyethylene film bags for wrapping horticultural crops like capsicum, broccoli, assam lemon, tomatoes etc for transport, has been found to be most suitable for reducing wastage. Losses in first grade tomatoes can be reduced from 15 to 3% by using upright cone baskets together with dry grass as a packaging material between the layers of fruits. Packing of tomatoes in sealed unventilated polyethylene provides a modified atmosphere which extends storage life. Printed plastic bags are used to reduce light transmission to potato tubers. Plastic oven ventilated bags of 25 and 50 kg of capacity are used for onions and potatoes. Palletization and containerization will go a long way in establishing both internal and international trade on a firm footing (Nath, 2013). Extended the shelf life of broccoli (Nath *et al*., 2011), capsicum (Nath *et al*., 2010) and tomatoes (Nath *et al*., 2015) using different packaging materials and post-harvest treatments.

12. Transport: Transport is an important linkage in postharvest handling, storage and distribution. Transport of horticultural produce from field to the distribution markets is done by rail, truck, airplane and ship. Large quantities of horticultural crops are transported in open trucks. Window type conical bamboo baskets designed for stacking and aeration have been developed by the CFTRI, Mysore for transportation of produce by rail. Serious losses take place due to improper handling, careless loading and unloading and use of improper containers. Transport of produce during cool hours of night, use of ventailated, insulated evaporative cooled or regrigerated vehicles ensures preservation of quality. Pallets are used in many developed countries for trading of horticultural produce. It is also important to introduce mechanical loading and unloading particulary with the use of fork lift trucks. In advanced countries refrigerated containers known as reefer containers produce. In India use of containers working on evaporative cooling techniques should be encouraged.

13. Pre-harvest sprays: Pre-harvest sprays of chemicals have been applied to reduce postharvest losses in different fruits and vegetables. Thiophenate methyl (0.05%) was found to effectively control postharvest losses in Dashehari mango. A pre-harvest spray of 10 to 15 ppm giberellic acic (GA3) proved useful for on-tree storage of mango by controlling maturity and delaying ripening. Three sprays of Benomyl or Topsin-M or Carbendazin (0.05%) at 15-day intervals before harvest were found to control postharvest losses in Nagpur mandarin. A pre-harvest spray of 0.6% Calcium chloride ($CaCl_2$), 10 to 12 days prior to the harvest, improved the shelf life of grapes. An additional 2,720 kg/ha mango yield was obtained as a result of the pre-harvest spray of bavistin (0.5%). Use of GA3 50 ppm as a dip was found to induce seedlessness in gulabi grapes. Spraying of 2% urea on to banana bunches increased bunch weight by 2–5%. Pre-harvest heat treatment by reducing the ventilation in green houses increased the soluble solids content, fruit skin color and reduced the chilling injury of tomatoes. Application of 25% of etherel along with 2% urea in addition to 0.04% sodium carbonate solution (50 ml) facilitated uniform flowering and fruiting in high density pineapple plantations. Growth of pole beans under greenhouse conditions doubled the yield and enriched the quality of pods. Different chemicals, growth regulators and fungicides viz. calcium chloride, calcium nitrate**, g**ibberellic acid-3, 6-BAP, carbendazim and benomyl (alone or in different combinations) may be used to minimize the post-harvest losses in fruits and vegetables.

14. Marketing System: Vegetable market is often suffering from several constraints due to their high perishable nature, season market and bulky nature. Assembling and subsequent marketing of the produce is further blocked due to lack of proper storage facilities and quick transport systems. Very often the products are formed to dispose of their produce at a very nominal price where there arises seasonal gluts due to these bottle necks. Another major defect in vegetable marketing is the in volovement of several intermediaries which dominate the trade and get huge profit. Consequently producer's margin in the consumer price becomes very low. It is therefore essential that organized effort for establishing co-operative system of marketing should be enforced at village and districxt levels to control activity of intermediaries and to regulate the vegetable marketing smoothly and in a streamlined system. Moreover, close co-ordination among Agricultural Marketing Board, National Horticulture Board and state department of agriculture/Horticulture should be ensured to formulate an action plan for regulating marketing of vegetables in a smooth and streamlined way.

15. Storage: Storage of vegetable produce an important for improving shelf life avoiding market glut and to ensure supply throught the year and increase profit to the producers. The principle aim of storage is to reduce and control transpiration, respiration and disease infection at the same time maintaining life processes at the required level. Different methods of storage of vegetable produce are as:

a) Refrigerated storage: Highly perishable vegetable produce requires refrigerated vegetable storage since it retards the rate of metabolic change, moisture loss, respiratory heat products and spoilage caused by heat production and spoilage caused by micro-organisms and thereby enhances retaining life of vegetable produce. In this method, ambient air is cooled and then passed over the bulk grains via existing aeration system. Refrigerated aeration has been used for cooling dry grain in subtropical climates when ambient temperatures are too high. The initial investment for refrigerated storage system is comparatively higher, but together with the dehumidified air method, it could provide answers to the practicability of aeration for safe commercial storage in tropical climates (Navarro and Noyes, 2002).

b) Controlled/Modified atmosphere: The main purpose of controlled atmosphere (CA) or modified atmosphere is to adjust the atmosphere composition of gases surrounding the commodity by removal or addition of gases. Thus resulting in an atmospheric composition different from that of normal air. Modified atmosphere does not differ in principle from the controlled atmosphere storage except that the control of gas concentris less precise.

c) Hyobaric storage: Hyobaric storage is similar to controlled atmosphere storage in which produce is stored in partial vacumm. The vacumm is created by vacumm pump to a particular desired low pressure. The process of ripening and sencence is greatly reduced by decreasing rate of respiration and removal of ethylene.

d) Zero-energy cool chamber: In tropical areas like india, tremendous amount of quality deterioration take place immediately after harvest of produce due to lack of on farm storage facilties to overcome this problem, low cost environmental friendly zero energy cool chambers are developed by IARI New Delhi these chambers work on principle of evaporative cooling using locally available materials like brick sand and bamboos. The temperatures in these chambers are less than surrounding atmosphere. These chambers can be used for short term storage of products at the farmers field itself.

On farm storage is also required to reduce losses in highly perishable fresh horticultural produce. Low-cost, low-energy, environmental friendly cool chambers made from locally available materials and which utilize the principles of evaporative cooling have been therefore developed in response to this problem. These cool chambers (Fig. 1) are able to maintain temperatures at 10–15°C below ambient, as well as at a relative humidity of 90 per cent, depending on the season. Fruits and vegetables are stored in plastic crates within the chamber. The shelf life of the fruit and vegetables maintained in the cool chamber was reported to be increased from 3 days at room temperature to 90 days (Anon. 2006).

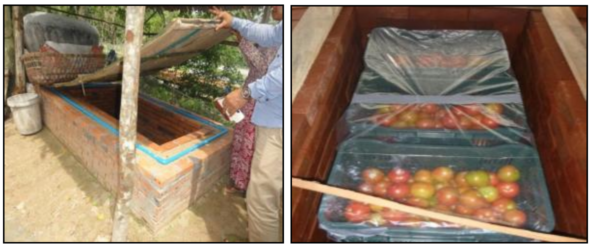

Fig 1: Zero Energy Cool Chamber for highly perishable fresh horticultural produce

Storage life is governed by several factors. These include variety, stage of maturity, rate of cooling, storage temperature, relative humidity, rate of accumulation of CO_2, prepacking and air-distribution systems. Optimum storage temperature and relative humidity requirements for different vegetables are mentioned in Table 3.

Table 3. Storage temperature and relative humidity requirements for important vegetables

Crops	Temperature (°C)	RH (%)
Tomato (ripe)	8.5-10.0	85-95
Bottle gourd	8.2-10.5	90-95
Brinjal	8.5-10.0	85-95
Cucumber	8.0-10.5	90-95
Tomato (mature green)	10.0-12.0	80-90
Pumpkin, ginger, sweet potato	11.0-13.0	80-90
French bean, okra	7.0-9.0	85-95
Asparagus, lettuce	3.0-4.0	85-95
Potatoes, tamarillo, lima bean, cowpeas	4.0-5.5	80-90

Postharvest loss is more serious as compared to production loss. Reduction of postharvest losses significantly increase availability of vegetables without bringing additional land into production and without using additional inputs. Although losses cannot be reduced completely, but can be minimised by adoption of modern cultural practices, harvesting, handling, marketing and processing techniques.

Factors affecting postharvest life of flower crops

- Preharvest factors
- Harvest factors
- Postharvest factors

Preharvest factors: Affects 30-70% flower quality. They are genetically, light, temperature, soil, nutrient, relative humidity, Season/day, CO2, chemical applications, irrigation, pests and diseases.

Harvest factors: Stage of harvest, time of harvest and methodof harvest. Harvesting stage of important flower crops are shown in Table 4.

Table 4. Harvesting stage of important flower crops

Crops	Commercial stage of harvesting
Alstroemeria hybrid	When 1 or 2 florets open in a spike and majority show colour
Anthurium	When on thirds to two third of flowers open on the spadix
Chrysanthemum morifolium	Standard: when outer petal fully expanded. Spray: fully open flower before pollen shading Pompon and decorative: centre of oldest flower fully open Anemone: fully open but before central disc floret begins to elongate
Dianthus caryophyllus	Standard: When flowers are half open at paint brush stage At least two flowers fully open
Gerbera jamesonii	When outer two row of disc floret show pollen
Gladiolus hybrid	When 2 to 4 lower florets of the spike show colour
Heliconia	When fully open
Lilium hybrid	When he buds are well matured and show colour
Rosa hybrids	Well developed and mature flower buds with one or two petals unfurling from the tip
Tulipa hybrids	Flowers not open but well developed and coloured on the upper half, and rest still green on a long stem
Zantedeschia	The spathe begins to turn downward when the flowers are fully open
Cymbidium hybrids orchid	When almost all buds on the spike open
Tuberose	Single type varieties: when buds are fully open

Postharvest factors: Temperature, light, humidity, water quality, ethylene, sensitivity, preservatives, ventilation, packaging, diseases and pests.

Storage of cut flowers

A low temperature treatment during storage or shipment period reduce the entire metabolism in the tissues, slows down the respiration, transpiration and ethylene action and retards the multiplication of bacterial and fungal attack.

Cold storage: This is a common method of storing cut flowers. In general temperate flowers (rose, carnation) are stored at $0\text{-}1^0$C whereas subtropical (gladiolus, sterlitzia, jasmines, proteas, gloriosa) and tropical (anthurium, cattleya, vandal, euphorbia) are stored at $4\text{-}7^0$C and 7 15^0C, respectively.

Wet storage: In this method, flowers are stored with their base dipped in water or preservative solution for short time. This is suitable for flower speies cut at commercial stage, destined directly for sale within 1 to 2 days. During wet storage, flowers are kept at 3 - 4^0C, a temperature slightly higher than that used for dry storage.in this method flowers are protected from fungal attack. The lower most leaves are removed from the stem to avoid wetting and subsequent decay. Wet storage period and optimum temperature of some cut flowers are shown in Table 5.

Dry storage: This is used for long-term storage of flowers. In this method, fresh flowers harvested in the morning, graded and sealed in plastic bags or boxes to prevent the loss of moisture. This method saves the space in the storage room. Prior to storage, flowers should be treated with fungicides. They may be pulsed with floral preservatives containing sugar, anti-microbial and anti-ethylene compounds. Recommended dry storage temperature and maximal period of storage of cut flowers are shown in Table 6.

Table 5: Wet storage period and optimum temperature of some cut flowers

Cut flower	Temperature (^0C)	Period
Antirrhinum	4	4 weeks
Carnation	4	4weeks
Chrysanthemum	1	3 weeks
Gladiolus	0.5 -1.5 4- 6	2-4 days
Gerbera	4	3- 4 weeks
Lily	0-1	6weeks
Rose	4 2	10 days
Tulip	- 0.5 - 0	2-3 days

Table 6: Recommended dry storage temperature and maximal period of storage of cut flowers

Cut flower	Temperature (^0C)	Period
Anthurium	13	4 weeks
Carnation	0-1	16-24 weeks
Cattleya	7-10	2 weeks
Dendrobium	5 -7	2 weeks
Gladiolus	4	4 weeks
Lily	1	6 weeks
Rose	0.5 -3 2 1	2 weeks 4 weeks 3 weeks
Tulip	0 - 1	8 weeks

Controlled atmospheric storage (CA): In this method of storage, cut flowers are kept in gas tight cool chambers equipped with cooling systems at a higher level of CO_2 and lower level of O_2 to reduce the respiration rate and production and action of ethylene. Table 7 shows the CA storage of some cut flowers.

Table 7: CA storage of some cut flowers

Flowers	CO_2 (%)	O_2 (%)	Storage Temperature (^0C)	Storage period (Storage)
Carnation	5	1.3	0-1	30
Freesia	10	21	1-2	20-22
Gladiolus	5	1-3	1.5	21
Lily	10-20	21	1.0	21
Rose	5-10	1-3	0	20-30
Tulip	5	21	1	10

Low Pressure Storage: Plant materials are stored under reduced pressure, low temperature and cooled moist air. In LPS, gaseous substances like CO_2 and ethylene produced by plants or their organs are removed from the plants or parts through stomata and intercellular spaces much quicker under low pressure than normal pressure. The desirable effect of LPS is attributed to the reduction in ethylene production at low O_2 levels and other volatile compounds. Low Pressure storage of some cut flowers and herbaceous cuttings are shown in Table 8.

Table 8: Low Pressure storage of some cut flowers and herbaceous cuttings

Cut flowers	Storage period (days)	
	Cold storage	**Low Pressure Storage**
Carnation	10	91
Chrysanthemum	7-14	2
Rose	7-14	56
Unrooted cuttings		
Chrysanthemum	10-28	42-94
Carnation	10-20	300
Geranium	5-10	21-28
Poinsettia	5-10 3	21-28 3
Rooted cuttings		
Chrysanthemum	7-14	90
Geranium	14	28
Poinsettia	7	14

Modified Atmospheric Storage (MA): MA storage is less precise form of CA storage. The dry storage of flowers in sealed bags leads to reduction in O_2 and increase in CO_2 levels due to respiration of the tissue.

Processing and Value addition in vegetables and Flowers

Processing industry of horticulture crops including vegetables and ornamental crops are very backbone of horticulture industry taking care of gluts and wastes. Processing can fetch an additional income to the grower, s and helps in stabilising the prices with economic returns. The best indicator of the economic contribution of food processing to the food system is the value addition. Value addition is the indicator of the industry, s contribution to GDP.

During the peak season and also to avoid market glut, vegetables may be processed, preserved and marketed during off season which will thereby minimizes the post harvest losses. Different value added products can be prepared from various vegetables such as ready to cook (RTC) vegetables, tomato soup, jam, candy, canned peas, tomato sauce and ketch up, puree and paste, frozen and dehydrated product of capsicum, cabbage, French bean; oil, oleoresin, powder, pickles etc of ginger and turmeric (Nath *et al*, 2016).

Low Cost Processing Technologies suitable for Small and Marginal Farmers

Processing of Chow-chow (*Sechium edule* SW.) into tuity fruity

Chow-chow (*Sechium edule* SW.) is a commonly used local vegetables that grown widely in the Hilly Regions of India. With minimum inputs, this crop is grown and the farmers get on an average 120 numbers of fruits per plant and yield of 30-40 tons per hectare. During the season viz. May to September, it is available in planty in the market at very low price. No value added products are so far prepared from this vegetable and so there is no demand of this vegetable in the food processing industries. Therefore, the price of this crop is very low which ultimately discourages the farmers to cultivate in large scale.

A process for producing a natural chow-chow tuity fruity may be prepared from matured chow-chow vegetables (Nath *et al*. 2014). In this method, peeled vegetables should be sliced into pieces of 10 x 10 x 5 mm followed by blanching in boiling water for 5-10 minutes. Blanched vegetables should be dipped in sugar syrup of 40% for 1hour and 70% for another 2 hours with slow heating along with 15-20% Sohoing (*Prunus nepalensis*) juice and 10-15% fresh ginger (*Gingiber officinale*) juice as a natural colouring, acidulant and flavouring agent. After required period of boiling slices are to be drained and dried in tray drier for 30 minutes at 50°C. The final products i.e. chow-chow tuity fruity thus prepared may have 70-73% TSS. This product should be packed in suitable packaging materials for higher shelf life. This may be used in confectionery, bakery and pan massala purposes. Flow chart for preparation of chow-chow tuity fruity is shown below:

Fresh Chow-chow
⇓
Peeling
⇓
Slicing
⇓
Blanching
⇓
Dipping in Sugar syrup ⇐ Addition of Sohoing juice and fresh ginger juice
⇓
Slow heating
⇓
Draining
⇓
Drying
⇓
Packing and storage

Production of Beet root tuity fruity, Nectar and Jam
Red beetroot (*Beta vulgaris*) is a good natural food colorant because it contains significant amounts of red-colored betalain pigments. There is increasing interest in the use of natural food colors, which provide health benefits like antioxidant activity. The antioxidant capacity of beetroot has been associated with the constitutive presence of phenolic compounds, which allow nutraceutical benefits in the promotion of the human health and in the prevention of degenerative diseases and cancer. Freshly harvested red beetroot were procured from the local vegetable mandi, Meerut, UP during the months of February, 2015 and were washed with clean water. Beetroots were peeled and sliced using SS knife. Different slice thickness (2-12mm) and blanching time (0-15 min.) are considered as per RSM design. These blanched slices were dipped into 60% sugar syrup and slow heating was carried out for 2 hours. Different quality parameters viz., oganoleptic scores, antioxidant content, betalain, ascorbic acid and phenol content were evaluated. Among different treatments, beetroot treated with slices thickness (8 mm) and blanching time (4 min.) recorded the maximum overall acceptability score (8.1), taste score (8.3) and texture score (7.8). Beet root nectar was standardized with 25% beetroot juice, 0.3% acidity and 22% TSS in the final products with acceptable colour and taste. Similarly, beetroot jam was standardized by using juices obtained from boiling of beetroots with water in the ratio of 1:2, pectin powder (1.2%), citric acid (0.4%) and final TSS (69%).

Beet root tuity fruity

Beet root Nectar

Beet root Jam

Instant Ginger Candy
Nath *et al* (2013) optimized quality attributes of instant ginger candy using different slice thickness and blanching time. Uniform size ginger rhizomes Cv. Nadia or Baroda of six months old should be used for candy preparation. Materials should be washed thoroughly with clean water to remove dirt and other undesirable particles from the surface and also to reduce the microbial load causing contamination. After washing, rhizomes should be dried at room for few hours. Dried fresh rhizomes should be peeled manually, made slices with different slice thickness (5.0-25.0 mm) with the help of SS knife. Slices are to be blanched in boiling water for 25-30 minutes followed by dipping in 40°B and 75°B sugar solutions containing 2.0% citric acid for 1 and 2 hours at 95ºC, respectively. As soon as the retention time reached the predetermined level, the materials are to be taken out from the syrup and kept at laboratory tray drier at 60°C for 1 hour. Dried materials should be cooled at room temperature before being packed in air tight containers for further analyses. Flow chart for preparation of instant ginger candy is shown below:

Freshly harvested uniform size ginger rhizomes
⇩
Washing with clean water
⇩
Peeling
⇩
Cutting into round shaped slices
⇩
Blanching in boiling water
(25-30 minutes with 2.0% citric acid)
⇩
Dipping in 40°Brix sugar syrup with 2.0% citric acid
(for 1 hr at 95ºC)
⇩
Dipping in 75°Brix sugar syrup with 2.0% citric acid
(for 2 hrs at 95ºC)
⇩
Draining and drying at 60 ºC for 1 hour
⇩
Cooling and packing

Preparation of Ginger Slice in Brine

This is the minimally processed fresh ginger product which may be stored for more than six months at ambient condition. Fresh and tender ginger rhizomes are generally used for preparation of this product. It should be prepared by peeling and cutting the rhizomes into slices of 5-10 mm thickness followed by blanching in boiling water for 5-10 minutes at 100°C and filling into bottles or cans cover with brine solution (9.0% salt and 2.0% citric acid). Preservatives (50 ppm KMS + 50 ppm sodium benzoate) may be added in the brine solution for better shelf life. Seal the bottles and store in cool place.

Recipe for Ginger Slice in Brine

Sl. No.	Raw materials	Quantity
1.	Sliced ginger (5mm thickness)	1.0 kg
2.	Water	1.0 liter
3	Salt	90.0 g
4.	Citric acid	20.0 g
5.	KMS	0.05 g
6.	Benzoic acid	0.05 g

The flowchart for the preparation of ginger slices in brine is given below:

Fresh Ginger
⇩
Peeling
⇩
Slicing
⇩
Blanching (5-10min at 100°C)
⇩
Filling into bottles/cans
⇩
Covering with brine solution
⇩
Sealing/seaming
⇩
Storage

Preparation of Ginger Paste

This is a ready to use ginger product prepared from different cultivars low in fiber content. Different processing steps, which are very essential for preparation of ginger paste, are shown below:

- Take fresh and fiber less variety of ginger which are quite tender
- Peel the rhizomes and grind to paste with the help of mixer grinder
- Add common salt of 3-5% to the paste and mix thoroughly. Little amount of water may be added, if required get desired consistency
- Heat the whole mass for 10-15 minutes with continuous mixing
- Finally add acetic acid and KMS to the paste and fill into glass jar or plastic container

Recipe for ginger paste

Sl. No.	Raw materials	Quantity
1.	Ginger pulp	1.0 kg
2.	Salt	30-40.0 g
3.	Acetic acid	15-20.0 ml
4.	KMS	1.0 g
5.	Water (if needed)	100.0 ml/kg

The flowchart for the preparation of ginger paste is given below

Fresh ginger
⇩
Peeling
⇩
Pulping
⇩
Heating for 10-15 minutes
(Addition of salt & water)
⇩
Addition of Acetic acid & KMS
⇩
Heating
⇩
Filling in bottles

Tomato Ketchup

It is made from strained tomato juice or pulp and spices, salt, sugar and vinegar, with or without onion and garlic, and contains not less than 12 per cent tomato solids and 25 per cent total solids. Different steps for preparation of tomato ketchup are shown below:

Processing Steps

- Wash tomatoes with clean water
- Blanch in boiling water for 20 minutes
- Remove the peel and extract the juice/pulp
- Add one third quantity of sugar to the extracted tomato juice and start heating
- Add all required ground spices tied in a muslin cloth (spice bag) into the pulp and continue heating
- Heat the masses until the pulp volume reaches to one third of the original volume
- Remove the spice bag and stop the heating
- Add vinegar, salt and the rest of the sugar and mix thoroughly
- Heat again slightly to mix the ingredients properly
- Add calculated amount of sodium benzoate to the product
- Fill the product in sterilized bottles and cool for sometimes to reach product temperature of about 40°C
- Seal the bottles and label itStore in dark and cool place

Recipe for Tomato Ketchup

Ingredients	Amount	Ingredients	Amount
Tomato juice	1 kg	Sugar	200-250 gm
Salt	10 gm	Onion	20 gm
Garlic	1 gm	Cinnamon	1.0 gm
Black Pepper	1 gm	Ginger	5.0 gm
Clove	2 no.	Red chilli	5.0 gm
Vinegar	5%	Sodium benzoate	750 ppm (0.75 gm per liter)

Preparation of Low Cost Tomato Powder

It is made from matured and ripe fruits. This product is generally used for preparation of various tomato products viz. juice, soup, ketchup, puree, chutney etc. Different steps for preparation of tomato powder are shown below:

Processing Steps

- Take fully ripe tomatoes
- Wash with clean water
- Make slices of 5.0-7.0 mm thickness

- Place the slices in single layer in the aluminum trays
- Dry the slices in Cabinet drier at 60°C for 7-8 hours till slices becomes crisp
- Cool the slices and grind with laboratory grinder to converted into free-flowing powder
- Pack the powder either in air tight plastic containers or flexible plastic packaging materials
- Store the product in dark, dry and cool climate for future use

Value added products of commercial flowers

Rose water: Rose water is prepared by boiling the rose flowers in water and condensing the steam. In India, a crude method is used with copper kettle (Deg) and a condenser of bamboo covered with rope, which is kept wet all the time. Mainly Attar and rose water are produced by this method.

Rose oil, ottoo or attar of roses: The attar constitutes the remaining eleven essential oils, together with wax from the surface of the petals and other minor impurities. It is costliest among the natural essential oils used in high-grade perfumery products all over the world. The ottoo of rose is not obtained directly from the distillate, but from the rosater collected during the distillation of rose petals. Rose water stored in earthen pots or metallic vessels in cool nights in the open collects the fragrant butter like substance i.e. otto floating on the surface of water.

Concrete: It is an extract of fresh flower using hydrocarbon solvent. It is rich in hydrocarbon soluble material and devoid of water-soluble compounds. It is generally waxy, semi-solid, dark coloured material free from original solvent.

Absolute: It is highly concentrated alcoholic extract of concrete, which contains only alcohol soluble material, its primary use is in alcoholic perfumes.

Itra of rose: It is a type of oil produced by distilling rose flowers and absorbing the vapours in oil of sandalwood in receiver. The various attars commonly in demand are rose, jasmine, heena, kewda, etc.

Pomade: It is obtained from process known as effleurage, which is undertaken almost exclusively in France. The effluerage process is primarily used for producing aromatic materials from flowers, which contain minute quantities of aromatic components and are too delicate to withstand other processing condition such as exposure to heat or steam. Effuerage is a cold extraction method. Fresh petals or whole flowers are spread out on the surface of the fat and the frames are stacked in piles. It can take anywhere from 12-30 hours for jasmine and 24-100 hours for tuberose for making respective pomade.

Conclusions

The post-harvest management, processing and value addition of vegetables and ornamental crops are in underdeveloped stage in country and there is an urgent need to look into more closely at some basic aspects of post-harvest management of horticultural produces for minimization of wastage and ensure more return to the farmers. This will help to increase the per capita availability, improve the economic condition of the farmers and ensure even distribution of agricultural products throughout the country. Value addition is one of the most visible tools to reduce post-harvest losses in flower crops. Availability of gigantic genetic diversity enables India to produce a wide array of value added products like dry flowers pigments, neutraceutical compounds, essential oils, petal embedded papers and floral craft etc. for both domestic and international markets.

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