UNIT III: Post-Harvest Management

IMPORTANCE, SCOPE OF POST-HARVEST TECHNOLOGY AND PROCESSING

India is a second largest producer of fruits and vegetables after China these are share 10% or 16% respectively in total world production and is the leader in several horticultural crops, namely mango, banana, papaya, cashew nut, areca nut, potato, and okra (lady's finger). Horticulture crops occupy 24.472 million ha. and production is estimated around 286.188 million tones. Total area of fruits, vegetable, plantation crops, spices, loose flower and aromatic plant are 6301, 10106, 3680, 3474, 278 and 634 thousand ha, respectively and production are 90186, 169064, 16658, 6988, 2184 and 1022 thousand tones, respectively with productivity are 11.32, 17.22, 4.54, 1.87, 6.59, 1.19 thousand tones per ha, respectively (2015). The total productions of cut flowers are 74305 Lakh stem (2012-2013). During 2015-16, India exported fruits and vegetables worth Rs. 8,391.41 crores which comprised of fruits worth Rs. 3,524.50 crores and vegetables worth Rs. 4,866.91 crores. . In terms of volume, fresh fruits & vegetables comprised about 76 % of exported horticulture produce followed by processed fruits & vegetables (23 %) and floriculture & seeds (1%). After that losses found 20-30 % in fruit and 30-40 % in vegetable while harvesting to consumption in India. It's due to the perishable nature of horticulture commodity, non-availability of appropriate post-harvest infrastructure transportation, inadequacy of the market or lack of processing.

India is a main horticulture producer even though processing only less than 2 % which is very low as compare to 80 % of Malaysia, 78 % of Philippine, 70 % of Brazil and 30 % of Thailand. The most of developed country 40-60 % fruits and vegetables utilize in processing.

Proper handling, packaging, transportation and storage reduce the post harvest losses of fruits and vegetables. For every one percent reduction in loss will save 5 million tons of fruit and vegetable per year. Processing and preservation technology helps to save excess fruit and vegetable during the glut season. The technology has become a necessity to improve the food safety and strengthen nations food security. The technology helps to boost export of agricultural commodities in the form of preserved and value added products.

- **Food processing industries could be divided into four group, based on their capacity of production:**
  - **A.** Large scale unit ›250 t/year
  - **B.** Small scale unit 50-250 t/year
  - **C.** Cottage scale unit 10-50 t/year
  - **D.** Home scale unit ‹10 t/year
- **Estimated post-harvest losses of fruit and vegetables**

S. No.	Fruit/Vegetable	Percent loss
1.	Papaya	40-100
2.	Mandarin	20-95
3.	Banana	20-80
4.	Grape	27

5.	Lemon	20-85
6.	Cauliflower	49
7.	Tomato	5-50
8.	Onion	16-55
9.	Cabbage	37
10.	Potato	5-40

❖ **Indian production of processed fruits & vegetables**

Product	**% Share**
Fruit pulp & juice	27
Ready-to-serve beverages	13
Pickles	12
Jams & jellies	10
Synthetic syrups	8
Squashes	4
Tomato puree & ketchup	4
Canned vegetables	4
Others	18

❖ **Indian processing industry profile**

Industry	**Share %**
Unorganized	42%
Organized	25%
Small scale	33%

❖ **India export of process products to different country**

Product	**Country**
Mango Pulp	Saudi Arabia, UAE, UK, USA
Fruit Juice	USSR
Canned Fruit (mango, guava)	USSR, UAE
Canned vegetable (Green pepper)	UK, USA, UAE
Dehydrated (Garlic, Onion)	USSR, Japan, UK
Pickles, Chutney (mango)	USA, Japan, USA

History

- The first recorded cause of spoilage in stored food by Needham (1749).
- Iron container was discovered by Aes the bptngusts de Heine (1800).
- Peter Durand(1800) discovered the metal container.
- Fermentation firstly recorded by Lovoisier in 1789.

- Spallanzani (1765) disputed the theory of preservation by mean of heating. This constitutes the basic principle of canning.
- M. Nicholos Appart (1804) was the first to report the successful preservation of food in glass container. He is known as 'Father of Canning'.
- Fastier (1824) discovered the Hold the Cap Can.
- Cooking of food by mean of preserve started by Papin in 1861.
- Autoclave firstly used by Shriver in 1874.
- Modern refrigeration discovered by James Haryson in 1857.
- Fruit and Vegetable processing was Ist started in organized manner in 1857.
- In India, the first fruit and vegetable processing factory was established in 1920 at Mumbai.
- The Central Food Technological Research Institute was establish at Mysore in 1950.
- Fruit Preservation and Canning Institute was established at Lucknow in 1949.
- Burg and Burg (1966) discovered the hypobaric storage.

Practice

Fill in the Blank

1. …………………………was the first to report the successful preservation of food in glass container. He is known as 'Father of Canning'.
2. Autoclave firstly used by …………………in 1874.
3. The first recorded cause of spoilage in stored food by ……………..(1749).
4. Fermentation firstly recorded by ……………. in 1789

Descriptive

1. Write down the present status of processing in India.

POST-HARVEST MANAGEMENT OF FRUITS AND VEGETABLES

Fruits and vegetables are living tissues subject to continuous change after harvest. Some changes are desirable from consumer point of view but most are not. Post-harvest changes in fresh fruit cannot be stopped, but these can be slowed down within certain limits to enhance the shelf life of fruits. The post-harvest handling plays an important role in extending the storage and marketable life of horticultural perishables.

Post-Harvest Treatment of Fruits and Vegetables Washing

It is useful in removing surface adhering material water. Mechanically, it is also accomplished by passing the fruits/vegetables through machine arranged with water tank equipped with rotating brush. In some produce washing improves appeal by facilitating removal of sap as case in mango, papaya, jackfruit, kronda, dirt in case of carrot, reddish, turnip, sugar beet, sweet potato, etc. and for removal of debris in case of banana. The water use for the purpose should be cleaned otherwise fungal and bacterial levels may build up. Disinfected treatment using ultraviolet light, ozone, chlorine, calcium hydroxide, etc. help to clean water for washing purpose.

Pre-cooling

It refers to the repid removal of the field heat from freshly harvested horticultural produce in order to slow ripening and senescence, conserve weight and reduce deterioration prior to storage and transport. Pre-cooling is accomplished by hydro cooling (immersing in water), contact icing (Placing cursed ice in or on the package), vaccum cooling (rapid evaporation of water at low presser to effect cooling) and air cooling (cooling based on refrigeration system).

List of commodity-wise cooling method

S.No	Cooling Method	Commodity
1	Room Cooling	All fruits and vegetables
2	Forced Air Cooling (Pressure Cooling)	Fruits and fruit type vegetables, tubers and cauliflower
3	Hydro Cooling	Stem and leafy vegetables, some fruits and fruit type vegetables
4	Package Icing	Roots, stem, some flower type vegetables, green onion and brussel sprouts
5	Vacuum Cooling	Some stem, leafy and flower type vegetables
6	Transit Cooling, Mechanical refrigeration	All fruits and vegetables
7	Top Icing and Channel Icing	Some roots, stem, leafy vegetable and cantaloupes

Curing

Curing done for root, tuber and bulb crops in which holding the produce at high temperature and high relative humidity for several days while harvesting wounds heal and a new, protective layer of cells form. While curing can be initially costly, the long extension of storage life makes the practices economically worthwhile.

S.No.	Commodity	Temperature (^{0}C)	Relative Humidity (%)	Curing Time (days)
1	Potato	15-20	90-95	5-10
2	Sweet Potato	27-33	>90	5-7
3	Yam	32-40	>90	1-4
4	Taro	30-35	>95	4-7
5	Cassava	30-35	>80	4-7
6	Onion and Garlic	35-45	60-75	0.5-1

Degreening

The process of decomposing the green pigment in fruits by applying ethylene (10-20ppm) at 27^{O}C and 80-90% or similar metabolic inducers to give a fruit to its characteristic colour as preferred by consumers, generally followed in citrus fruit but also practiced in banana, mango, tomato, etc.

Sorting

It is the process of separation of commodities into different categories on the basis of measurable physical properties. It also helps in removing of unwanted material or diseased portions.

Grading

Separation of commodity for getting maximum benefit on the basis of uniformity is termed as grading. It is an important aspect of quality as the product is rated on the basis of homogeneity of lot. Grading is done on the basis of size, shape, weight, colour, texture, firmness, composition, defects, etc.

Waxing

Waxing of fruits or vegetables is a common post-harvest practice. Food grade waxes are used to replace some of the natural waxes removed during harvesting and sorting operations and can help to reduce water loss and respiration during handling and marketing. It also helps in sealing tiny injuries and scratches on surface of fruits and vegetables. It improves cosmetic appearance and prolongs the storage life of fruits and vegetables. The wax coating must be allowed to dry thoroughly before packing.

Hot Water Treatment

Immersing the produce in hot water before storage/marketing is known as hot water treatment. It is effective in minimizing fungal diseases. Anthracnose in fruit can be controlled by dipping the fruit in hot water at 51-55^{0}C for 30 minutes. This treatment helps in attaining uniform ripening within 5-7 days.

Hot water treatments for different fruits

Commodity	Pathogens	Temp.(°C)	Time (min)
Apple	*Gloeosporium sp.* *Penicillium expansum*	45	10
Grapefruit	*Phytophthora citrophthora*	48	3
Lemon	*Penicillium digitatum* *Phytophthora sp.*	52	5-10
Mango	*Collectotrichum gloeosporioides*	52	5
Orange	*Diplodia sp.* *Phomopsis sp.* *Phytophthora sp.*	53	5
Papaya	*Fungi*	48	20
Peach	*Monolinia fructicola* *Rhizopus stolonifer*	52	2.5

Source: Lisa Kitinoja and James Gorny, 1998

Radiation Treatment

Subjecting the produce to ionizing radiation is referred to as radiation. It acts in pasteurization of surface. Hence, the technique is also known as radurization. As it works without raising temperature of produce, it is known as cold sterilization. It has its role in surface pasteurization, sprout inhibition and retardation of senescence process. Radiation can destroy pathogen/pest without raising the temperature of the produce.

Government of India approvals for Irradiation dose requirements for fruits and vegetables

Commodity	Irradiation dose (KGy)		
	Minimum	Maximum	Purpose
Onion	0.03	0.09	Sprout inhibition
Potatoes	0.05	0.15	Sprout inhibition
Raisins	0.25	0.75	Insect disinfestations
Dried fruits	0.25	0.75	Insect disinfestations

Mango	0.25	0.75	Shelf life extension and quarantine treatment, Fruit fly and stone weevil disinfestations
Ginger	0.03	0.15	Sprout inhibition
Garlic	0.03	0.15	Sprout inhibition
Small onions (shallots)	0.03	0.15	Sprout inhibition

Vapour heat treatment (VHT)

This treatment proved very effective in controlling infection of fruit flies in fruits after harvest. The boxes are stacked in a room, which are heated and humidified by injection of steam. The temperature and exposure time are adjusted to kill all stages of insects (egg, larva, pupa and adult), but fruit should not be damaged. A recommended treatment for citrus, mangoes, papaya and pineapple is 43^0C in saturated air for 8 hours and then holding the temperature for further 6 hours. VHT is mandatory for export of mangoes.

Fumigation

In this technique place the boxes of fruit in a gas (SO_2) tight room and introducing the gas from a cylinder to the appropriate concentration. However, special sodium metabisulphite pads are also available which can be packed into individual boxes of a fruit to give a slow release of SO_2. The primary function of treatment is to control the *Botrytis Cinerea*. The SO_2 fumigation is also used to prevent discolouration of skin of litchis.

Fumigation with 1.2% sulphur dioxide for 10 minutes was shown to be effective in reducing skin discolouration in fresh litchis, especially if it is combined with a 2 minute dip in HCl acid directly afterwards. Immediately after sulphur dioxide treatment litchi fruit may appear a uniform yellow colour and then turn red again after 1 or 2 days.

Chemical Treatment

- The fungicide, chemical and growth regulators are used to extend shelf life of fruits.
- Pre harvest treatment of Maleic Hydrazide (200 ppm) reduces sprouting of onion and potatoes during storage.
- Potassium permanganate is used as ethylene absorbent in packaging of fruits which delay ripening.
- Post harvest dip with Diphenylamine (0.1-0.25%) for 30 seconds controle superficial scald.
- Ripening of banana and tomato can be delayed by post harvest treatment with Gibberellic acid.
- Pre harvest spray of N-Benzyladenine(BA) 10-20 ppm prolong shelf life of vegetables.
- Maleic hydrazide @ 1000-2000 ppm delays ripening of mangoes.
- Pre-harvest spray of calcium chloride (0.6%) and calcium nitrate (1%) resulted in enhancement of shelf life of mangoand guava fruits.

- Treatment of mature green guava fruit with GA_3 at 100-200 ppm help extends the storability of fruits.
- Pre harvest treatment of ber with Calcium compounds (1.7%) solution is useful in delayed fruit ripening.
- Storage life of leafy vegetables can be extended following post harvest application of Cytokinin.
- Treatment of legumes vegetables with Indol Acetic Acid (IAA) solution is useful in maintaining green colour.
- Pre harvest spray of 0.2% Difolatan control post harvest diseases of tomato and onion.

Storage

Proper marketing of perishable commodities such as fruit and vegetables often requires some storage to balance day-to-day fluctuation between harvest and sale or for long term storage. Storage of horticulture produce is attempeted with a view to extend period of availability. Storage controls shelf life of produce by controlling rate of respiration, transpiration, ripening and biochemical changes all of which are responsible for shelf decomposition/deterioration of produce. Further, different types of storage have different attributes in minimizing microbial infection and thus add to better storability of produce.

Objective of storage

- Slow the biological activity and micro-organism growth.
- Avoid glut and distress sale in the market, thus prolonging the market period.
- In long-term storage, making the food available in off-season.
- Regulate the market in an orderly manner.
- Reduce the transpirational, respiration, and ethylene production rate.

Tips for storage of high quality horticultural produce

- Store only high quality produce, free of damage, decay and of proper maturity (not over-ripe or under-mature).
- Knowledge of the appropriate storage conditions.
- Avoid lower than recommended temperatures in storage, because many commodities are susceptible to damage from freezing or chilling.
- Do not over load storage rooms or stack containers closely.
- Provide adequate ventilation in the storage room.
- Keep storage rooms clean.
- Storage facilities should be protected from rodents by keeping the immediate outdoor area clean, and free from trash and weeds.
- Containers must be well ventilated and strong enough to with stand stacking. Do not stack containers beyond their stacking strength.
- Avoid storing ethylene sensitive commodities with those that produce ethylene.
- Avoid storing produce known for emitting strong odors (apples, garlic, onions, turnips, cabbages and potatoes) with odor-absorbing commodities.
- Inspect stored produce regularly for signs of injury, water loss, damage and disease.
- Remove damaged or diseased produce to prevent the spread of problems.

Factors Affecting of Storage

1. Temperature
2. Relative Humidity
3. Ventilation
4. Air Velocity
5. Atmospheric gases composition
6. Light
7. Commodities
8. Post Harvest Treatment

Storage Method

1. Traditional Storage
2. Advanced Storage

Traditional Storage

a) Pit Storage
b) Clamp Storage
c) Barns Storage
d) Cellars Storage
e) Sand and Coir Storage
f) High Altitude Storage
g) Zero Energy Cool Chamber

Zero Energy Cool Chamber

The zero energy cool chamber used to enhance the shelf life of fresh fruit and vegetables by maintaining the temperature and relative humidity during summer and winter suasion naturally with the application of water. It is based on the principle of direct evaporation cooling and hence, does not require any electricity or power to operate, and all the material (Brick, sand, bamboo, khaskhas, etc.) required to make the cool chamber are available easily and are reusable. For zero energy cool chamber construction upland is selected where there is a lot of aeration and should be near to the source of water supply and floor (165 cm x115cm) is made by bricks. A double wall is erected upto a height of 67.5 cm and leaving a cavity with approximately 7.5 cm space between the inner and outer brick walls. The cavity (7.5 cm) between the double walls is filled with sand and drenched with water. A lid (165cmx115cm) is made using straw/ dry grass on bamboo frame. The shed is made over the chamber in order to avoid direct sun or rain.

The whole structure is made wet by sprinkling water daily twice (morning and evening) in order to achieve desired temperature and relative humidity or fix a drip system with plastic pipes and micro tubes connected to an overhead water source. The horticultural produce is kept in perforated plastic crates covered with a thin polyethylene sheet. Maximum and minimum thermometer and hygrometer are placed in the chamber to note temperature and relative humidity, respectively

Shelf life of fruits and vegetables in zero energy chamber (days)

Produce	Time of storage	Outside	Cool chamber
Leaf vegetables	Summer	<1	3
Leaf vegetables	Winter	3	8-10
Potato	Spring/Summer	40	97
Mango	Summer	4	8

Orange	Winter	8-10	20-30
Tomato	Summer	7	15
Pointed gourd	Summer	2	5
Bitter gourd	Summer	2	6
Okra	Summer	1	6
Carrot	Spring	5	12
Cauliflower	Spring	7	12
Green chilli	Summer	3	6

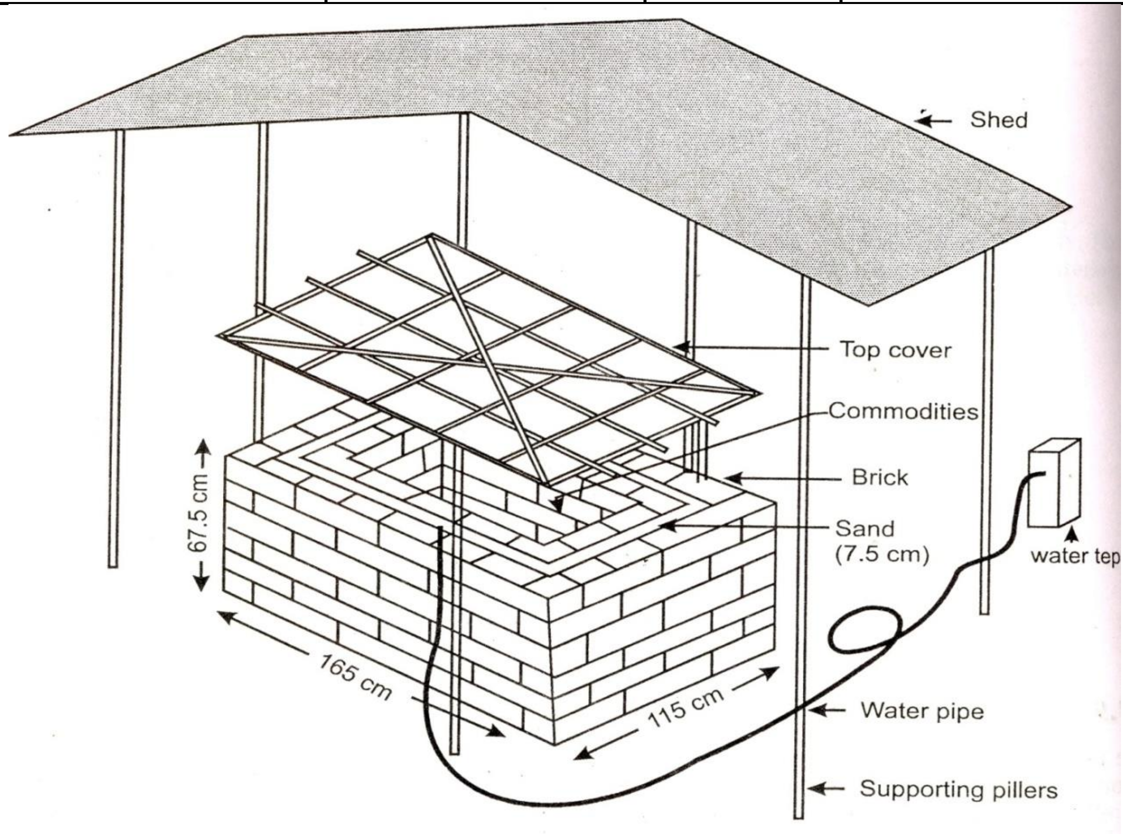


Fig. . . Zero Energy Cool Chamber

Advanced Storage

A. Cold Storage

It maintains low temperature and humidity throughout the storage period. Temperature which is just sufficient to lower down metabolic activity of produce is maintained. Care is taken that the inside temperature may not cause chilling injury to the produce. Depending upon type of produce different temperature and humidity are maintained under cold storage.

Recommended temperature and relative humidity conditions for fruits storage

Name of commodity	Temp (^{O}C)	RH (%)	Approximate Shelf-Life
Acid lime,	8-10		6-8 weeks
Apple	-1-0	90-95	4-8 months

Apricot	0-1	90-95	1-2 weeks
Asian pear	0-1	90-95	2 months
Avocado	8-12	85-90	1.5 weeks
Banana	13	90-95	1-4 weeks
Ber	3	90-95	4 weeks
Fig	0-1.7	85-90	7weeks
Date	6.7	85-90	2 weeks
Grape	0-1	90-95	2-8 weeks
Guava	8-10	90-95	2-3 weeks
Kiwi, Chinese gooseberry	0	90-95	3-5 months
Lemon	10-13	85-90	1-6 months
Loquat	11	90	3 weeks
Lychee, Litchi	5.7	90-95	3-5 weeks
Mandarin (Kinnow)	8-10	90-95	2 months
Mango	8-9	85-90	2-4 weeks
Mangosteen	4-6		2-3 weeks
Nectarine	-0.5-0	90-95	2-4 weeks
Papaya	9-10	90-95	1-3 weeks
Passion fruit	5.6-7.2	85-90	3 weeks
Peach	0-0.3	90-95	2-4 weeks
Pear	-1.5-0.5	90-95	4-5months
Persimmon	0-1.7	85-90	7 weeks
Pineapple	7-13	85-90	2-4 weeks
Plum and prunes	0-1	90-95	2-5 weeks
Pomegrante	5	90-95	2 months
Strawberry	0	90-95	7-10 weeks
Sweet cherries	-1-0.5	90-95	2-3 weeks
Sweet Orange	2-5		2-3 month

Recommended temperature and relative humidity conditions for vegetables storage

Name of commodity	Temp (^{o}C)	RH (%)	Approximate Shelf-Life
Asparagus, green	1-2	95-100	2-3 weeks
Beans	4-7	90-95	7-10 days
Bell Pepper	7-10	90-95	2-3 weeks
Bitter gourd	10-12	85-90	2-3 weeks
Brinjal	10-11	92	3-4 week
Broccoli	0	95-100	10-14 days
Cabbage	0	90-95	3-6 weeks
Carrots	0.4-4	93-99	6-8 months
Cauliflower	0	90-95	3-4 weeks
Eggplant	10-12	90-95	1-2 weeks
Garlic	0	65-70	6-7 months
Ginger	13	65-70	6 months
Lettuces	0	90-95	2-3 weeks
Mushrooms	0	90	7-14 days

Okra	8.9	90-95	7-10 days
Onion	0	65-70	20-24 weeks
Peas	0	90-95	1-2 weeks
Potato	3-4.4	85	34 weeks
Radish	0	90-95	1-2 months
Tomato (Ripe) (Unripe)	7.2 8.9-10	90 85-90	1weeks 4-5 weeks
Turnip	0	90-95	4-5 months
Watermelon	10-15	90-95	2-3 weeks

Hypobaric Storage

In such type of storage, the produce is storage under low pressure atmosphere, vacuum tight and refrigerated condition. The pressure of 1.3 to 13 kPa is maintained under storage. The due to lowering of pressure under storage, the pressure of individual gases are lowered. The CO_2 and other volatiles like ethylene produced during respiration in course of storage are removed and controlled level of O_2 is maintained. Many time flavour of the produce is affected.

Controlled atmosphere (CA) storage

Storage of commodities under gaseous atmosphere condition, like gas storage, where the composition of atmosphere is controlled accurately. Thus the levels of carbon dioxide, oxygen, nitrogen, ethylene, and metabolic volatiles in the atmosphere may be manipulated. Controlled atmosphere storage generally refers to keeping produce at decreased oxygen and increased carbon dioxide concentrations and at suitable range of temperature and RH. The modified atmosphere and controlled atmosphere differ only in degree of control and CA is more exact. This storage method in combination with refrigeration markedly enhances storage life of fruit and vegetables.

Benefits of CA storage

- Slow down respiration and ethylene production rates, softening and retard senescence of horticultural produce.
- Reduce fruit sensitivity to ethylene action
- Alleviate certain physiological disorders such as chilling injury of various commodities, russet spotting in lettuce and some storage disorders including, scald of apples.

Harmful effects of CA storage

- Initiation or aggravation of certain physiological disorders can occur, such as blackheart in potatoes, brown stain on lettuce and brown heart in apples and pears.
- Irregular ripening of fruits, such as banana, mango, pear and tomato, can result from exposure to O_2 levels below 2% or CO_2 levels above 5% for more than 2 to 4 weeks.
- Off- flavors and off-odours at very low O_2 or very high CO_2 concentration may develop as a result of anaerobic respiration and fermentative metabolism.

Modified Atmospheric Storage (MA)

Storage in which inside atmosphere is modified in such a way that its composition is other than that of air constitutes MA storage. The modification is achieved by manipulating O_2, CO_2 and N_2 is storage atmosphere. It favoures extension in self life of produce owing to reduced respiration and ethylene production, minimize water loss and nutrient decomposition, reduced microbial growth and spoilage and inhibition of ripening and senescence.

POST-HARVEST MANAGEMENT OF FLOWERS

Flowers are highly perishable unlike other horticultural or agricultural crops. Owing to poor keeping quality the post-harvest losses in floriculture are significantly higher than any other sector. Although there has been significant increase in the area, production and productivity of flower crops in the last two decades, there is an urgent need to minimize the huge post-harvest losses in terms of the value of the produce which are estimated to be 30-40 per cent of farm value. The post-harvest behavior of flowers is an outcome of the physiological processes, occurring in leaves, stem, flower bud, leafless peduncle or scape connecting bud to the stem. Some of these processes may act independently to affect the senescence and vase life of cut flowers but most of them are inter-related. The nature and extent of post-harvest damage is typical for each crop or cultivar. The post-harvest losses become important especially when dealing with the export of fresh flowers to distant and foreign market. Therefore, patient, soft and expert handling of flowers is of utmost importance after harvest.

The post-harvest quality of flowers depends upon mainly three factors.

1. Pre harvest factors
2. Harvest factors
3. Post-harvest factors

Pre-Harvest Factors

Genetic or inherent makeup

Post-harvest lasting quality of flower species and cultivars vary considerably due to differences in their genetic make-up. Gladiolus varieties White Prosperity, Sancerre, Suchitra, Eurovision, Nova Lux, Rose Supreme and Trader Horn possess the better vase-life.

Growing conditions

Most cut flower crops require well-lighted conditions. On the contrary, too high light intensities cause scorching and dropping of leaves and abscission of petals. Flower crops are also specific in their temperature requirements. Flowers also require adequate nutrients for good longevity. High nitrogen doses should be avoided as they increase susceptibility to diseases. For example, iron deficiency is commonly observed in gladiolus in north India, causing heavy yield losses. Flowering crop should also be grown away from the industries which release toxic effluent, gases, damaging the foliage as well as flowers. Flowers damaged by pathogens, insects and pests also show high ethylene production resulting in poor vase-life.

Harvest Factors

The most important factors for harvest are when, how and where, “when” the plant material will reach the optimum stage of development and “when” during the day to harvest. Each plant material has its own best harvest stage and this can vary depending on the use of, and market for, the plant material. Materials for preserving usually are harvested more mature than those for fresh, wholesale markets. Some general rules of thumb for when to harvest are, spike type flowers harvest when one-fourth to one-half of the individual florets are open; daisy type flowers- harvest when flowers are fully open. The other “when” is, the best time of day for harvesting flowers is coolest part of the day and when there is no surface water from dew or rain on the plants.

Right stage, method and time of harvesting of flowers are of considerable importance to ensure their long vase-life. The stems should be cut with sharp knives or secateurs. Hardwood stems should always be given slanting cut to expose maximum surface are to ensure rapid water absorption. The flowers of dahlia and poinsettia release latex upon cutting. To overcome such problem, stems should be given a dip in hot water (80-90^{0}C) for a few seconds.

The flowers of rose, carnation, gladiolus, tuberose, daffodils, lily, iris, freesia and tulip should be harvested at bud stage since their buds continue to open in water. The flowers of snapdragon, Harvesting of flowers at bud stage is always preferred as their buds have long vase-life, are less sensitive to ethylene, easy to handle during storage and transport and are less prone to diseases and pests.

Harvesting stages for important Flowers

S.no.	**Flower**	**Harvesting stages**
1.	Rose	For local market: when outer one/two petals start unfurling For distant market: fully coloured tight buds Loose flower: fully open flower
2.	Carnation (standard)	For local market: when flower are half opened or at paint brush stage or outer petal is perpendicular to stem For distant market: cross is developed on buds and colour is visible
	Carnation (spray)	For local market: when two flowers have opened and other heve shown colour For distant market: when 50% flower have shown colour. Loose flower: fully open flower
3.	Chrysanthemum (standard)	For local market: half opened flowers For distant market: when outer row of florets start unfurling
	Chrysanthemum (spray)	For local market: when two flowers have opened and other shown colour For distant market: when 50% flowers have shown colour
	Chrysanthemum (loose flower)	Fully open flower
	Pot mums	50% buds have developed colour
4.	Gladiolus	For local market: lower most 1-2 florets are opened

		For distant market: lower most 1-2 florets show coloure
5.	Oriental lily	For local market: when 1-2 florets are opened For distant market: when 1-2 florets show coloure
6.	Asiatic lily	For local market: when 1-2 florets are opened For distant market: when 1-2 florets show coloure
7.	Gypsophilla	25-30% flowers are fully open in the inflorescence
8.	Tuberose	Single: buds are fully developed but yet not open Double: basal 3-4 buds start to open
9.	Orchids	Most species: fully open flowers Dendrobium: 75% inflorescence is open
10.	Anthurium	When one thred to one half of the spedix shows change in colour (mature)
11.	Alstroemeria	For local market: when 4-5 florets have opened For distant market: when first floret has started opening and other have developed 50% colour
12.	Gerbera	Before outer row of ray florets show pollen or when outer row of petals is perpendicular on stalk
13.	Marigold	Fully open flowers
14.	Calendula, pot marigold	Fully open flowers
15.	China aster, annual aster	Fully open flowers
16.	Cockscomb	One-half florets open
17.	Daffodil, narcissus, jonquil	“goose neck” stage
18.	Dahlia	Fully open flowers
19.	Delphinium	One-half florets open
20.	Freesia	First bud beginning to open
21.	Goldenrod	One-half florets open
22.	Larkspur, annual delphinium	

23.	Lily-of-the-valley	One-half florets open
24.	Nasturtium	Fully open flowers
25.	Pansy	Almost open flowers
26.	Snapdragon	One-third florets open
27.	Sweet pea	One-half florets open
28.	Sweet William	One-half florets open
29.	Zinnia	Fully open flowers

Post-Harvest Factors

Water relations

The termination of life of the harvested flowers depends on water uptake and transport, water loss and the capacity of the flower tissue to retain its water. A water deficit and wilting develop, when the transpiration exceeds absorption of water. The rate of water uptake of cut flowers depends on transpiration pull, temperature and composition of solutes . Disruption of water columns in stem vessels by air embolism and resistance to water flow in stems, also develop water deficit. Acidification of water and addition of wetting agent and flower food in the holding solution markedly improve water uptake of cut flowers.

Respiration

The rate of respiration depends on quantity of carbohydrates available in the harvested flowers, temperature and the use of certain chemicals to regulate it. With higher temperature, there is faster rate of respiration and burning of the tissue. Consequently, the life of flowers is shortened.

Relative humidity

It has, bearing on the transpiration rate. Higher the humidity in the air, less is the transpiration rate and vice-versa.

Growth regulators

Postharvest life of flowers can be controlled by growth regulators. Water relation changes associated with flower senescence are also influenced by growth regulators. Cytokinins delay senescence of some cut flowers. Depending upon the concentrations, GA in some cases promotes longevity of flowers, while this is also used in bud opening solution. The IAA promotes ethylene production of isolated carnation petals. In contrast, the senescence and abscission of poinsettia flowers is delayed by auxin.

Preservative solutions

Preservatives in the form of tablets or powder are prepared from a mixture of chemicals-sugars, germicides, salts and growth regulators. Various types of conditioners are sugar and biocide, antiethylene compound, and hydrated compound. The flowers like gladiolus, carnation, chrysanthemum and freesia are benefited most by the pretreatment.

Antiethylene compounds in preservative solutions reduce the action of ambient ethylene as well as autocatalytic production of ethylene by fresh cut flowers. Fresh cut flowers responding to silver thiosulphate are carnation, orchids, gypsophila, gladiolus, gerbera, snapdragon, alstromaeria, agapanthus, anemone and sweet pea. Greatest improvement in cut flower quality and longevity is obtained when DICA or DDMH were combined with sucrose.

Pre-cooling and storage

Precooling is essential for removing field heat from flowers. This is done either by forced air cooling or hydrocooling to bring down temperature from 20^0-30^0C to 1^0C in a relatively short period. Other methods are room cooling and vacuum cooling. Flowers can be stored for a longer period at low temperature. There are two methods of cold storage-wet and dry. Wet method is short-term storage, in which cut stems are dipped in water. Dry storage is more labour-intensive method and costly. The controlled atmosphere based on reduction of respiration rates, conservation of respirable substrates during, storage, and delay in ethylene-triggered changes cause senescence. It involves the use of increased level of CO_2 and decreased levels of O_2 in the atmosphere, low storage temperature and prevention of the build-up of endogenous ethylene.

Packing and transporting

Lower rate of transpiration, respiration and cell division during transportation, are essential for long storage life and keeping quality. Before packing, flowers should be dried. They should be treated with systemic insecticides and miticides. Packing must ensure protection of flowers against physical damage, water loss and external conditions detrimental to transported flowers. Boxes made of corrugated fibre boards are good. Flowers sensitive to geotropic bending must be transported in an upright position. The flowers should be transported at an optimal low temperature. The relative humidity of the air during precooling and shipment of cut flowers should be maintained at the level of 95-98%. Lack of light during prolonged transportation particularly at high temperature causes yellowing of leaves in many flowers. Shipment of flowers is usually done by road, air and sea. For short distance and time period shorter than 20 hr, cut flowers may be transported in insulated trucks without refrigeration after precooling and proper packing. Air shipment is quickest and usually the temperature is not controlled during the flight the flowers should be pulsed with STS prior to air shipment

Post harvest treatment of cut flowers for improve shelf-life

Pre-cooling

Precooling is a treatment given to flowers to remove the field heat immediately after harvest. It can be done with ice cold water, cold water or forced air. Pre-cooling reduces respiration rate and decreases breakdown of nutritional and other stored material in the steam, leaves and patals, delays bud opening and flower senescence. It also delays rapid water loss and decreases flower sensitivity to ethylene.

Pre-cooling temperature of some important flowers

S.no.	Flower	Pre-cooling Temperature
1.	Alstroemeria,	4^0C

	Gladiolus	
2.	Anthurium	13^0C
3.	Dendrobium	5-7^0C
4.	Carnation	1^0C
6.	Rose	1-3^0C
7.	Chrysanthemum	0.5-4^0C
8.	Cymmbidium	0.5-4^0C

Conditioning/ hardening

It restores the turgor of flowers wilted after harvest, storage or transport. Conditioning is done with dematerialized water supplemented with germicides and acidified with citric acid to pH 4.0-5.0. Some wetting agents like tween 20 @ 0.01-0.10% can be used for this purpose. Some chemical like STS, 8-HQC, sucrose etc can also be used for conditioning.

Impregnation

Loading of flowers with high concentration of silver nitrate or nickel chloride of cobalt chloride for a short period of time is known as impregnation. It protects the blockage of the water vessel in stem by microbial growth and decay and synthesis of ethylene. It is generally practice in crops like Gerbera, Carnation, Chrysanthemum and Gladiolus cut flowers.

Pulsing

Treating the flowers with high concentration of sucrose and germicide for a short period of time, in order to improve the shelf life and to promote flower opening. Pulsing is beneficial especially for flowers destined for long storage period or long distance transportation. The addition of sucrose in the vase water alone, may encourage increased growth of micro-organisms in the vase medium. Hence, the antimicrobial agents eg 8-HQ, 8-HQS, 8-HQC, silver salts, citric acid etc should also be incorporated to enhance better solution uptake that would suffice maximum effects of the supplied sugar.

- Sucrose is the main ingredient of pulsing solutions providing additional sugar, and the proper concentration range from 2 to 20%, depending on the crop. The solution should always contain a biocide appropriate for the crop being treated.
- Ethylene-sensitive flowers are pulsed with silver thiosulphate (STS). Treatments can be for short periods at warm temperatures (e.g. 10 minutes at 20^0C) or for long periods at cool temperatures (e.g. 20 hours at 2^oC).
- Alstroemeria and lilies can be pulsed in a solution containing gibberellic acid to prevent leaf yellowing, and this is often a useful pre-treatment.
- Short pulses (10 seconds) in solutions of silver nitrate useful for some crops. China asters and maidenhair fern respond well to solutions containing 1000 ppm silver nitrate. Other flowers are damaged by these high concentrations, but respond well to 100-200 ppm (e.g. gerberas). The function of the silver nitrate is not fully understood. In some cases it seems to function strictly as a germicide (e.g. chrysanthemums). In

all cases, residual silver nitrate solution should be rinsed from the stems before packing.

- Generally for rose and carnation, 5-8% sucrose solution is sufficient while for multi-floret spike like gladiolus and tuberose, high concentration of 10-20% is needed.

Bud opening

Use of germicides, sucrose and hormonal solution to promote the opening of immature buds in crops like chrysanthemums, rose, carnation, gladiolus, snapdragon, etc.

Grading, bunching and packaging

After harvesting the flowers should be graded according to various grades as per specification for local and distant market. Then these should be pulsed and made into bunches of 5, 10, 20, 50, 100. Cut flower should be packed in corrugated cardboard boxed or sleeves. Packaging must ensure protection of flowers against physical damage and for this cotton or news paper can be used as cushion material.

Storage

After pre-cooling and pulsing the flowers can be stored at low temperature i.e. in cold store to regulate the flower market or to avoid the glut in the market. Controlled atmospheric (CA) modified atmospheric (MA) or hypobaric (LP) storage method can be used to enhance the post harvest life of flower.

Recommended temperature and RH conditions for flowers storage

Name of commodity	Temp (^{o}C)	RH (%)	Approximate Shelf-Life
Alstroemeria	1	90-95	1 week
Anthurium	13	80	1 week
Asparagus	0-1	95-100	7-10 days
Aster	0-1	90-95	1 week
Asiatic lily, Oriental Lily	0-1		
Baby's Breath, Gypsophila	0-1	90	3 week
Bird-of-Paradise	8	85-90	14 days
Carnation	1	90-95	2-4 weeks
Chrysanthemum	0.5-2	85-90	12-15 days
Crossandra	15-20		
Daffodil	0-1	90	2 weeks
Delphinium, Larkspur	0-1	90-95	7 days
Freesia	0-1	90-95	2 weeks
Gladiolus	7	90-95	7-15 days
Gerbera	2-4	90-95	1week
Leatherleaf Fern	1-6		2 weeks
Iris	0	90-95	1 week

Marguerite Daisy, Boston Daisy	0-1	90-95	3-7 days
Marigold	8-12	90-95	1 - 2 weeks
Rose	0.5-2	90-98	7-10days
Snapdragon	0-1		10 days
Statice	0-1	90-95	6 weeks
Stock	0-1	90-95	3-5 days
Sunflower	0-1		
Sweet Pea	0-1		1 week
Sweet William	2-3		
Orchid	5-7		2 weeks
Torch Ginger	12.5-15		10-17 days
Tuberose	7-10	80 – 90 %	5-10-days
Tulip	1	85	7 week

Transport

Flower should be transported in corrugated cardboard boxes. The flowers which are sensitive to ethylene, ethylene scrubbers containing $KMnO_4$ should be added to those boxes. Some of the flowers are like gladiolus and snapdragon are sensitive to geotropic bending, so these should be transported in upright position. Some of the flower crops show yellowing during transportation due to lack of light, therefore there should bwe a provision of light inside the transporting vehicle.

Fresh flower preservatives

Fresh flower preservatives are chemicals added to water to make flowers last longer. They contain a germicide, a food source, a pH adjuster, water, and sometimes surfactants and hormones. Germicides are used to control bacteria, yeasts and molds. These microorganisms harm flowers by producing ethylene, blocking the xylem, producing toxins and increasing sensitivity to low temperatures. Bacterial counts of 10 to 100 million per 1 milliliter impairs uptake, while counts of 3 billion per 1 milliliter causes wilting. Some common germicides are listed in table:

Germicide Types	**Common Name**	**Recommended Concentration**
8-hydroxyquinoline sulphate	8-HQS	200–600 ppm
8-hydroxyquinoline citrate	8-HQC	200–600 ppm
Silver Nitrate	$AgNO_3$	10–200 ppm
Silver Thiosulfate	STS	0.2–4 ppm
Thiobendazole	TBZ	5–300 ppm
Quarternary ammonium salts	QAS	5–300 ppm
Slow-release chlorine compounds	50–400 ppm of Cl	
Aluminum sulphate	$Al_2(SO_4)_3$	200–300 ppm

8-HQC is the most common one used in commercial floral preservatives. Sucrose is the most common food source used in floral preservatives. It provides energy to sustain flowers longer and to open flowers in the bud stage. 1 to 2 percent sucrose is the standard amount in preservatives. Never use sucrose without a germicide, as it is the primary food source for microorganisms, too. Acids or acid salts are added to adjust the pH of the water to 3.5 to 5.0. At this pH, less microbes can grow and water is taken up by the flowers more easily. Surfactants and wetting agents reduce water tension so water is taken up more easily, also. Tween 20 and Triton are examples of surfactants.

Commercial Fresh Cut Flower Preservative

- Floralife
- Rogard/Silgard
- Chrystal
- Prolong
- Oasis
- Vita Flora

Holding

After pulsing and storage flowers are held in a solution containing sucrose, germicide ethylene inhibitor and growth regulator, that type of solution is called preservative or vase solution. The flowers can be kept in holding solution either at wholesaler, retailer or consumer level. Basically, the concentration is much lower than pulse solution. The anti-microbial agents like 8-HQC (8-hydroxy quinoline citrate), 8-HQS (8- hydroxy quinoline synthesis), aluminium sulphate, anti-ethylene agents like STS (Silver thiosulphate), $AgNO_3$ and acidifuing agents like citric acid are widely used as vase solution. Even plant growth regulaters like gibberellic acid, benzyl adenine, are also reported to improve vase life and quality of gladiolus and chrysanthemum. Growth retardants like CCC (cycocel), SADH (Succinic acid dimethyl hydraride) and MH (malic hydrazide) have also been reported to improve vase life of some cut flowers. Ethylene inhibitor like Amino ethoxy vinyl glycine (AVG), Methoxy vinyl glycine (MVG) and Amino oxyacetic acid (AOA) are beneficial in ethylene sensitive flower. Recently, chemicals like 1-MCP (1-methyl cyclopropene) and 1-OCP (1-octacalcium phosphate) have been found to be highly effective especially for ethylene insensitive flowers.

POST-HARVEST MANAGEMENT OF CEREAL CROPS

Each type of cereal requires a specific post-harvest treatment, however, there are certain general principles that apply to most of them.

Cereals undergo a number of processing stages between harvest and consumption. This chain of processes is often referred to as the total post-harvest system. The post-harvest system can be split into three distinct areas.

The first is the preparation of harvested grain for storage. The second, which is referred to as primary processing, involves further treatment of the grain to clean it, remove the husk or reduce the size. The products from primary processing are still not consumable.

The third stage (secondary processing) transforms the grains into edible products.

Primary processing involves several different processes, designed to clean, sort and remove the inedible fractions from the grains.

Primary processing of cereals includes cleaning, grading, hulling, milling, pounding, grinding, tempering, parboiling, soaking, drying, sieving.

Secondary processing of cereals (or 'adding value' to cereals) is the utilisation of the primary products (whole grains, flakes or flour) to make more interesting products and add variety to the diet. Secondary processing of cereals includes the following processes: fermentation, baking, puffing, flaking, frying and extrusion.

1. **Puffing:-** Puffed grains are often used as breakfast cereals or as snack food. During puffing, grains are exposed to a very high steam pressure which causes the grain to burst open. The puffed grains can be further processed by toasting, coating or mixing with other ingredients.
2. **Flaking:-** Flaked cereals are partially cooked and can be used as quick-cooking or ready to eat foods. The grains are softened by partially cooking in steam. They are then pressed or rolled into flakes which are dried. The flakes are eaten crisp and should have a moisture content of below 7%.
3. **Fermentation:-** Doughs made from cereal flour can be fermented to make a range of products.
4. **Baking:-** Doughs and batters made from cereal flours are baked to produce a range of goods.
5. **Extrusion:-** Extrusion involves heating and forcing food (usually a dough) through a small hole to make strands or other shapes. The extruded shapes then undergo further processing such as frying, boiling or drying. Extruded products include pastas, noodles, snack foods and breakfast cereals.

- **The Post-Harvest Cereal System**

Post-harvest treatment for storage

a. **Harvesting:-** There is an optimum time for harvesting cereals, depending on the maturity of the crop and the climatic conditions. This has a significant effect on the quality of the grain during storage.

Harvesting often begins before the grain is ripe and continues until mould and insect damage are prevalent. Grain not fully ripened contains a higher proportion of moisture and will deteriorate more quickly than mature grains because the enzyme systems are still active.

If the grain remains in the field after maturing, it may spoil through wetting caused by morning dew and rain showers. There is also an increased risk of insect damage.

Cereals are traditionally harvested manually.There are three main types of harvesting equipment for the small scale producer: manual, animal powered and engine powered.

A range of mechanised harvesting equipment suitable for the small-scale farmer has been developed. Some of it is more efficient and cost effective than others.

Harvested crops are left in the field for a few days to dry before further processing.

b. Threshing:- Threshing is the removal of grains from the rest of the plant. It involves three different operations: Separating the grain from the panicle; sorting the grain from the straw; winnowing the chaff from the grain.

Separation of the grain from the panicle is the most energy-demanding of the three processes. It is the first process to have been mechanised. Sorting the grain from the straw is relatively easy, but is difficult to mechanise. Winnowing is relatively easy, both by hand and by machine.

Most manual threshing methods use an implement to separate the grain from the ears and straw. The simplest method is a stick or hinged flail that is used to beat the crop while it is spread on the floor.

A range of engine powered threshers are available.

c. Winnowing:- Winnowing is the separation of the grains from the chaff or straw. It is traditionally carried out by lifting and tossing the threshed material so that the lighter chaff and straw get blown to one side while the heavier seeds fall down vertically.

Hand-held winnowing baskets are used to shake the seeds to separate out the dirt and chaff. They are very effective, but slow.

There is a range of winnowing machines that use a fan to create artificial wind. This speeds up the winnowing process.

Some of these contains sieves and screens that grade the grains as well.

d. Drying:- Prior to storage or further processing, cereal grains need to be dried. The most cost-effective method is to spread out in the sun to dry. In humid climates it may be necessary to use an artificial dryer.

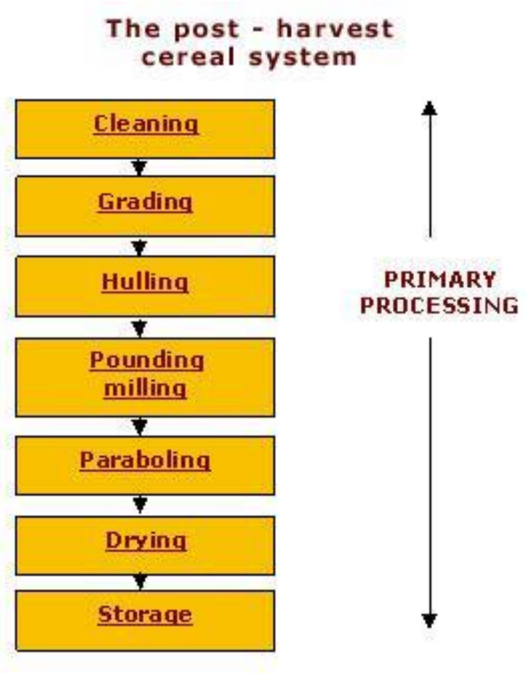
Simple grain dryers can be made from a large rectangular box or tray with a perforated base. The grain is spread over the base of the box and hot air is blown up through a lower chamber by a fan.

The fan can be powered by diesel or electricity and the heat supplied by kerosene, electricity, gas or burning biomass.

Cereal grains should be dried to 10-15% moisture before storage.

e. **Storage:-** Dried grains are stored in bulk until required for processing. The grains should be inspected regularly for signs of spoilage and the moisture content tested. If the grain has picked up moisture it should be re-dried. Grains are often protected with insecticides and must be stored in rodent-proof containers.

Primary processing



a. **Cleaning and Grading:-** Before further processing, grains are cleaned and graded according to size. Winnowing machines can be used to separate out the chaff, soil and dirt. Some machines have integral sieves that combine cleaning with grading.

b. **Hulling:-** Several grains have an unpalatable husk or shell that needs to be removed by a decorticator. A range of specialised machines are available for this task. A range of small rice hullers (both manual and powered) is available. Less rice is broken during hulling if the rice is parboiled first. Rice polishers are available for removing the rice bran after hulling.

c. **Pounding/Milling:-** Three main types of grain mill are available: Plate mill; Hammer mill; Roller mill. The choice of mill depends on the raw material and the scale of production. Hammer mills are almost universally used throughout the developing world. Roller mills are not used at the small scale because of their high cost and maintenance requirements.

The plate mill is usually limited to about 7kW and is derived from the stone mill or quern. Two chilled iron plates are mounted on a horizontal axis so that one of the plates rotates and the grain is ground between them. The pressure between the two plates governs the fineness of the product and is adjusted by a hand screw.There are manual versions of the plate mill available, though they are arduous and hard work to use.

Small-scale hammer mills range in size from 2kW to 20kW. They consist of a circular chamber in which beaters whirl at a high speed. The milled grain is filtered out through a perforated plate that runs around the edge of the mill chamber. The size of the holes in the perforated plate determines the fineness of grinding of the particles. Most grains can be ground in a hammer mill. Grain for human food is ground to a 1mm particle size while animal food is ground to a 3mm particle size.

Hammer mills cannot be used for wet milling. Roller mills crush the grains rather than milling them into smaller particles. Roller mills are usually used for animal food. It is important to ensure that the grains have the optimum moisture content before milling. If the grain is too dry and hard, it is difficult to break down and requires more energy to convert it into flour. If the grain is too moist, the material sticks to the mill. The optimum moisture content varies between cereal types and with the particular mill being used. Dry grain can be conditioned by soaking in water. Moist grain can be dried before grinding. Different cereal grains have different milling and grinding requirements.

d. **Paraboiling:-** Parboiling rice is an optional step, but one that improves the quality of hulling as it results in fewer broken grains. About 50% of all rice grown is parboiled.

Parboiling involves soaking and heating the rice which pre-cooks the grains, loosens the hull, sterilises and preserves the rice.At the village level, parboiling is carried out in large pans over an open fire. Rice parboilers, that improve the efficiency of cooking, are available.

e. Drying:- Prior to storage or further processing, cereal grains need to be dried. The most cost-effective method is to spread out in the sun to dry. In humid climates it may be necessary to use an artificial dryer.

Simple grain dryers can be made from a large rectangular box or tray with a perforated base. The grain is spread over the base of the box and hot air is blown up through a lower chamber by a fan.

The fan can be powered by diesel or electricity and the heat supplied by kerosene, electricity, gas or burning biomass.

Cereal grains should be dried to 10-15% moisture before storage.

f. Storage- Dried grains are stored in bulk until required for processing. The grains should be inspected regularly for signs of spoilage and the moisture content tested. If the grain has picked up moisture it should be re-dried. Grains are often protected with insecticides and must be stored in rodent-proof containers.

SECONDARY PROCESSING

Raw materials: - The quality of raw materials has an influence over the quality of the products. High quality raw materials should be used.

Small-scale bakers do not normally have facilities for flour analysis and rely on information supplied by the miller or wholesaler. There are a few simple tests that they can carry out which give useful information about the flour quality.

a. Flour:- Flour can be milled from a variety of cereals. The type available in each country or region may depend upon the types of cereal grown, although wheat flour tends to be available in most places.

1. Wheat flour:- Wheat flour contains proteins known as glutens. These are capable of forming a strong elastic network within the dough, which is very useful when making leavened bread.

The protein network traps the gas that is given off by the yeast during fermentation. This causes the dough to increase in volume and produces a bread with a light texture.

If flours that are low in gluten are used to make leavened bread, the gas escapes and the bread is flat and heavy.

Wheat flour is available in different grades according to the degree it is extracted from the whole wheat grain. Flours of different extraction rates include the following:

- Wholemeal flour - 100% extraction
- Wheatmeal flour - 90-95% extraction
- Straight run flour - 70-72% extraction
- Patents - 20-40% extraction

2. **Non-wheat flours:-** There are a variety of non-wheat flours available that can be mixed with wheat flour to make bread.
    - **Cassava flour** is a fine white powdery flour that has a shelf life of up to one year. It is widely used as a staple food and for the production of a range of fried and baked goods including bread, cakes and biscuits.
    - **Cereal flours**, especially from maize and sorghum, which are both staple crops, are used to make breads and snackfoods. Sorghum is mainly used to make bread or porridge. Maize is used to make tortillas, snacks and for the production of cornflour and thickeners.
    - **Soy/composite flour** is a fine creamy flour that is combined with maize flour or other cereal flours to increase the protein content and balance the amino acid composition of the composite flours. In this form it is used as a breakfast porridge and as a weaning food.

Different types of wheat flour -

Different types of wheat flour are available in each country. Wholemeal flour is used for the production of brown bread, rolls and other high fibre products.

- Atta is a wheat flour that is suitable for making chappatis. It is also available as a wheatmeal flour.
- Special bakers flour (bread making flour) is a strong flour that is used for bread, rolls and pastry. Bakers flour should contain a good quality gluten so that it can produce a light bread.
- Biscuit flour. This is a special blend of flour that is made for mechanical biscuit plants.
- Self-raising flour. This flour is a soft flour that is fortified with a chemical aerating additive similar to baking powder. It is used for making chemically aerated breads such as soda bread. Soft flour is used for cake making.

Cereal	**Crude protein**	**Crude fat**	**Ash**	**Crude fibre**	**Available carbohydrate**
Brown rice	7,3	2,2	1,4	0,8	64,3
Sorghum	8,3	3,9	2,6	4,1	62,9
Rye	8,7	1,5	1,8	2,2	7108
Oats	9,3	5,9	2,3	2,3	62,9
Maize	9,8	4,9	1,4	2,0	63,6
Wheat	10,6	1,9	1,4	1,0	69,7
Barley	11,0	3,4	1,9	3,7	55,8
Pearl mil	11,5	4,7	1,5	1,5	63,4

Maize

Maize can either be wet or dry milled. In dry milling, maize is ground between stones or by using a hand-powered plate mill or at a larger scale, using a hammer mill or powered plate mill.

In wet milling, the grain is soaked and allowed to ferment slightly to improve the flavour before milling with a hand or pwered plate mill.

Maize is sometimes soaked in alkaline water to facilitate removal of the bran before it is milled. If the maize meal is not used whole, it is transferred to a flat basket and shaken so that the bran is separated from the floury endosperm.

The flour is sometimes ground again to make a finer product. The bran is often used to feed chickens.

Maize has a relatively high fat content and tends to go rancid quickly. Ground maize meal therefore has a short shelf life.

Paddy rice

In some countries paddy is parboiled before the husk is removed. Parboiling is the partial cooking of the rice to gelatinise the starch, which makes the grain tougher. There is also a slight change in flavour which some people prefer.

The toughening process makes the seed more resistant to insect attack and to shattering during husking. It also helps to prevent absorption of moisture from the air during storage. The parboiling process involves three stages:

(i) Soaking or steeping of the paddy in cold or hot water to increase its moisture content
(ii) Steaming to gelatinise the starch in the kerneldrying.

The rice should be dried carefully after parboiling to minimise losses. Husking paddy, which is sometimes referred to as de-husking or milling is the process of removing the outer husk.

Husked paddy is referred to as brown rice, whereas de-husked (or polished) rice is white rice. Brown rice is nutritionally superior to white rice as it contains some of the bran which contains protein and vitamin B1 (thiamine).

Millet

The outer layers of some varieties of sorghum seed (usually the red seed varieties) contain tannins that are slightly toxic, have a bitter taste and inhibit the digestion of proteins. For this reason, sorghum is generally hulled before grinding into a flour.

Traditionally sorghum and millet is ground by hand using querns or hand plate mills.

The seed is winnowed to remove foreign matter, then put into a large mortar and wetted. It is then pounded to strip the bran or shell from the grain, followed by winnowing to get rid of the bran, Pounding and winnowing are repeated several times to get a good quaity milled seed.

The milled seed is washed to remove any small pieces of bran and soaked in water for 24 hours to condition or temper it. The grain is dried to the correct moisture content then re-ground using a pestle and mortar.

2 IMPORTANT GOVERNMENT SCHEME FOR FOOD SECTOR

1. **Scheme for Infrastructure Development:-** To fulfil the need for creation of integrated and holistic infrastructure for food processing sector, Ministry of Food Processing Industries (MOFPI) had launched new Schemes in 11th FYP with strong focus on creation of modern enabling infrastructure to facilitate growth of food processing and creation of an integrated cold chain mechanism for handling perishable produce. Under the initiatives of MOFPI for strengthening infrastructure in agro and food processing sector, it had launched the Mega Food Parks Scheme, Scheme for Cold Chain, Value Addition and Preservation Infrastructure and Scheme for Modernization of Abattoirs in the 11th Five Year Plan.
2. **Mega Food Parks Scheme:-** The Mega Food Parks Scheme (MFPS) is the flagship program of the Ministry of Food Processing Industries (MFPI) during the 11th five year plan. The scheme aims to accelerate the growth of food processing industry in the country through facilitating establishment of strong food processing infrastructure backed by an efficient supply chain.

   The Mega Food Parks Scheme provides for a capital grant of 50 percent of the project cost in difficult and ITDP notified areas (with a ceiling of Rs 50 crores). The grant shall be utilized towards creation of common infrastructure in CPC and PPCs in the park. Such facilities are expected to complement the processing activities of the units proposed to be set up at the CPC in the Park. Each Mega Food Park may take about 30-36 months to be completed.

   Out of 30 Mega Food Parks proposed during the 11th five year plan, the Ministry has taken up 15 projects under the Scheme so far. Of this, Final approval has been accorded to 8 Mega Food Parks in the States of Andhra Pradesh, Punjab, Jharkhand, Assam, West Bengal, Uttarakhand, Tamil Nadu and Karnataka. The cumulative project cost of these 8 Parks is Rs. 930 crore which includes total grant assistance of Rs.500 crore under the Scheme. In-principle approval has been accorded to remaining 7 projects. In addition to these, 15 new Mega Food Parks are in the process of Government approval.

3. **Scheme for Cold Chain, Value Addition and Preservation Infrastructure**

   The Task Force on Cold Chain set up by the Ministry of Agriculture has identified a huge gap of 9 to 10 million tonnes of cold storage capacity in the country.

   Ministry of Food Processing Industries through its Scheme for Cold Chain, Value Addition and Preservation Infrastructure has been successfully addressing the above issue. The Scheme was approved in 2008 with an objective to provide integrated and complete cold chain, value addition and preservation infrastructure facilities without any break, for perishables from the farm gate to the consumer. The assistance under the Scheme includes financial assistance (grant-in-aid) of 50% the total cost of plant and machinery and technical civil works in General areas and 75% for NE region and difficult areas subject to a maximum of Rs 10 crore.

In the first phase, the Ministry has approved 10 integrated cold chain projects in 2008-09, which are already being implemented in different parts of the country. Out of the 10 projects, 8 have started commercial operation. Substantive value addition, reduction in wastage and enhancement in farmers' income is evident from concurrent evaluation of the projects.

In the 2nd phase, 39 projects have been approved. The approved projects envisage a total investment of about Rs. 850 crore which would be creating cold chain capacity of about 1.60 lakh MT.

Taking note of the high demand and the gap in the requirement of cold storage, processing, preservation and cold logistics facilities in India, the Ministry is planning to upscale the Scheme and Planning Commission has already accorded 'In-principle' approval for the same.

Modernization of abattoirs

Ministry has approved 10 projects in 1st phase which are at various stages of progress. Two projects have been completed. A proposal for up-scaling the scheme is under consideration.

4. **Scheme for Technology Upgradation/Establishment/ Modernization of Food Processing Industries.**

Under the Scheme for Technology Upgradation/ Establishment/ Modernization of Food Processing Industries, financial assistance is provided in the form of grants-in-aid for setting up of new food processing units as well as Technological Upgradation and Expansion of existing units in the country. Ministry extends financial assistance in the form of grant-in-aid to entrepreneurs @ 25% of the cost of Plant & Machinery and Technical Civil Works subject to a maximum of Rs. 50 lakhs in general areas or 33.33% subject to a maximum of Rs. 75 lakhs in difficult areas.

The implementation process of the Scheme has been made more transparent and decentralized from 2007 onwards.

Earlier all the applications for such grants were received by the Ministry through the State Nodal Agencies. These applications were then centrally processed and grants disbursed directly by the Ministry. From 2007-08, the receipt of applications, their appraisal, calculation of grant eligibility as well as disbursement of funds has been completely decentralized. Under the new procedure, an entrepreneur/applicant can file application with the neighborhood Bank branch/Financial Intuition (FI). The Bank/FIs would then appraise the application and calculate the eligible grant amount as per the detailed guideline given to them by the Ministry. The Banks/ FIs appraise project and its recommendation for the release of grant is transmitted to the Ministry through e-portal established for this purpose. After the recommendation and requisite documents are received from the Bank/FIs, the Ministry sanctions the grant and transfer the funds through the e-portal itself. This has resulted in faster sanction procedure and enlarged outreach of the Scheme.

In the 11th Five Year Plan a total allocation of Rs. 600 crores was provided. Out of total allocation, an amount of Rs 488.51 crore has been received so far including Rs.98 crore BE of 2011-12. Ministry has utilized almost the entire budget allocated under this scheme (except NER) and has assisted 2532 Food Processing Units so far. Ministry has taken initiatives to create awareness in the industry/entrepreneurs by advertisements, organizing investors meet and special meetings in NER. In so far as general areas are concerned, the Ministry has been continuously reviewing the status and organizing meetings with the focal point banks on a quarterly basis. Ministry has also engaged an agency (CMI) to maintain the data and to monitor the scheme closely. Under this arrangement, the details of all the pending applications along with their present status has been put in the public domain on the website of the Ministry. Any applicant can find out current status of his application by clicking on to "http://www.mofpi@nic.in" e-portal-status of applications OR "http://cmi/mofpi/status".

This scheme has added huge processing capacity to the food processing industry which in turn has resulted in significant reduction of wastages.

5. **Quality Assurance, Codex Standards and Research & Development and Promotional Activities**

In today's global market quality and food safety gives a competitive edge for the enterprises producing processed foods and providing services. Apart from domestic standards for food products, processes and management practices, Codex prescribes international standards for safety and quality of food as well as codes of good manufacturing practices, which are accepted worldwide. Further, equal emphasis is required to be accorded to R&D activities for development of innovative products, cost effective processes and efficient technologies for food processing sectors. The scheme for food safety, codex and R&D has been successful in making a dent in this area in the country. The scheme comprises of following components.

(i) Setting up/Upgradation of Food Testing Laboratories (maximum grant Rs. 2.50 crore per project). (22 projects assisted in XI Plan so far)
(ii) Implementation of HACCP / ISO / GMP / GHP / Safety Management System in food processing units (maximum grant Rs. 15.00 lakh / Rs. 20.00 lakh per project in general area / difficult area). (18 Projects assisted in XI Plan so far).
(iii) Research & Development in food processing sector. (40 projects assisted in XI Plan so far)
(iv) Promotional activities including advertisement & publicity. (Rs. 46.78 crore spent in XI Plan so far)

6. **Human Resource Development:**

The Food Processing Industry is critical to India's development as it establishes a vital linkage and synergy between the two pillars of the economy –Industry and Agriculture. Demand for trained manpower including entrepreneurs, managers, technologists, skilled workers to cater to the growing needs of the food processing industry is increasing day-by-day. Besides latest technology & diversification and new ways of managing and marketing is required by the existing food processing industry to face global competition.

(i) Creation of infrastructural facilities for running degree/ diploma courses in food processing (maximum grant Rs. 75.00 lakh per project). (33 projects approved in XI Plan so far)

(ii) Entrepreneurship Development Programmes (EDP) (maximum grant Rs. 2.00 lakh per programme). 846 EDPs assisted during 11th Plan so far.

(iii) Setting up of Food Processing Training Centres (FPTC) (maximum grant Rs. 6.00 lakh / Rs. 15.00 lakh per project for single line/multi line products). (140 Centres assisted in XI Plan so far)

(iv) Training at recognized national / state level institutes etc. sponsored by MFPI or other training programme.

During 11th Five Year Plan, the Ministry is expected to provide assistance for setting up of about 270 FPTCs, organize 750 EDPs and facilitating need based professional development training programmes. In addition about 55 Universities/Colleges/ Institutions would be assisted for creating infrastructure facilities for degree/diploma courses in food processing.

Strengthening of Institutions

7. **Indian Institute of Crop Processing Technology - A National Institute with International Repute**

Indian Institute of Crop Processing Technology is a world class R&D and Educational Institute under the Ministry of Food Processing Industries, Government of India. The mandatory activities of IICPT are teaching, research and outreach activities in post harvest processing, preservation and value addition of agricultural and horticultural produces. IICPT and its scientists are experts in their own fields of research. IICPT has created in its main campus at Thanjavur world class research laboratories for conducting research in different areas of food processing technologies.

IICPT focuses research in major theme areas to address problems like: development of indigenous technology knowledge based food, composite grains foods, energy saving in parboiling, improving milling techniques of cereal grains, pulses, oil seeds and millets, food processing effluent treatment, creating ready to use dry mix fermented batter for idly and other Indian foods, new food product development based on grains, fruits and vegetables, fortification of processed foods for making health foods at affordable prices, development of new equipments for puffing, multipurpose yard drying, parboiling, for producing hand pound rice, reducing storage losses, economic utilization of biomass, food industries by-product and waste utilization.

To encourage new entrepreneurs to participate in the business of food processing and value addition, they have to be technically trained by providing hands-on experiences. They need to see and work for themselves on processing and value addition of foods. To fulfill all the basic needs, IICPT has created a Hi-tech, state of the art food processing incubation cum training center in its campus with the different product lines. It has also been offering consultancy services for the industry.

Considering the necessity for the growth of food processing sector and food processing industries and the future demands for trained manpower in the areas of food processing, the Institute began offering formal degree courses at bachelors, masters and doctoral levels in food process engineering from 2009 – 10 academic year.

Some of the major achievements of IICPT in the last four years have been as under:-

(i) Filed 11 patents and got 4 patents approved.
(ii) Developed Mobile Processing Unit for Tomatoes.
(iii) Conducts approx 320 one day outreach programme for farmers all over the country.
(iv) Developed 10 new products and done their commercial testing.
(v) Established a Food Testing Lab of International Standards at Thanjavur.

8. **National Meat and Poultry Processing Board**

The Government of India established the National Meat and Poultry Processing Board on 19th Feb 2009.

The Board is an autonomous body and would initially be funded by the Government of India for 3 years and would be managed by the industry itself. The Board has 19 Members including CEO of the Board. The Chairman is from the industry.

This industry driven institution has been launched to work as a National hub for addressing all key issues related to Meat and Poultry processing sector for the systematic and proper development of this sector. The Board serves as a single window service provider for producers/manufacturers and exporters of meat and meat products, for promoting the meat industry as a whole and it would result in large number of employment opportunities.

Some of the major achievements of the Board in last two and half years are:

(i) Establishing a world class Meat Products testing lab.
(ii) Conducting nearly 40 one day training progammes every year for meat workers (Butchers) all over the country.
(iii) Developing a model for a modern meat shop.
(iv) Arranging two National Conferences and five experts meet.

9. **Indian Grape Processing Board**

The Union Government in 2009 gave its approval for the establishment of the Indian Grape Processing Board (IGPB) at Pune, Maharashtra which is close to the principal grape growing/processing areas in the country. The 15 member Board that is led by an eminent professional from the Industry has been registered under the Societies Registration Act, 1860 at Pune.

- The important functions and objectives of the Board are as under:
- To focus on Research & Development, Extension, and Quality up gradation, market research and information, domestic and international promotion of Indian wine.

- To foster sustainable development of Indian Wine Industry
- To formulate a vision and action plan for the growth of Indian Wine Sector including research and development for quality upgradation in new technologies/processes.

During the two years of its existence, the Board has focused on the promotion of "Wines of India" in the domestic as well as international market by participating in important and relevant exhibitions/fairs, consumer awareness & training programmes, undertaking advocacy work with the various State Governments/ Central Ministries on various issues related to taxes/levies and promotion aspects.

10. **National Institute of Food Technology, Entrepreneurship & Management (NIFTEM)**

The Government in 2006 approved setting up of NIFTEM at an estimated cost of Rs. 244.60 crore including foreign exchange component of US $ 8.1 million. Further, Government in April, 2011 approved revision of the estimated cost for setting up of NIFTEM from Rs. 244.60 cr to Rs. 479.94 cr.

Since the legal status of NIFTEM as a Company was creating hurdles in obtaining statutory recognition as a Deemed University from UGC for running its Academic courses, the government has approved:

- Registering NIFTEM as a Society.
- Transfer all assets & liabilities from the Company to the Society
- Winding up of NIFTEM Company.

In pursuance of above decision NIFTEM Society has been incorporated on 19.05.2010. Its Assets & Liabilities have been transferred from the Company to the Society w.e.f 11.11.2010. The winding up process of the Company has been initiated.

NIFTEM's Mandate

NIFTEM would work as ―Sector Promotion Organisation/ Business Promotion Organisation of the food processing sector. The other major objectives of NIFTEM are:

- Working as a ―One Stop Solution Provider to all the problems of the sector.
- Working for ―Skill Development and Entrepreneurship Development for the sector.
- Facilitating business incubation services with its ultra modern pilot plant for processing of fruits and vegetables, dairy, meat and grain processing.
- Conducting Frontier Area Research for development of the Sector.
- Developing world class managerial talent with advanced knowhow in food science and technology.
- Providing intellectual backing for regulations which will govern food safety and quality and at the same time foster innovation.

- Functioning as a knowledge repository on various aspects of food processing such as product information, production and processing technology, market trends, safety and quality standards, management practices among others.
- Working for upgradation of SME food processing clusters.
- Facilitating business incubation services with its ultra modern pilot plans for fruit and vegetables, dairy, meat and grain processing.
- Promoting cooperation and networking among existing institutions within India and as well as with international bodies.

Construction of the campus, recruitment of faculty and other steps to make the Institute fully functional from the next year are being taken.

Skill Development: Short term Training Programmes

NIFTEM started its activities under Skill Development by conducting the short term training programmes from 20th -22nd July'2011 and 19th -21st September, 2011.

Outreach programmes: NIFTEM has also been conducting nearly 20 outreach progammes every year all over the country with the help of its knowledge partners.