UNIT 10 LOSS OF FOOD VALUE IN FRESH PRODUCE AND PROCESSED PRODUCTS

Structure

10.0 OBJECTIVES

After reading this unit, you should be able to:

- describe the protection and preservation techniques;
- explain biochemical changes after harvesting and slaughter; and
- discuss the handling, transport and safe storage of fruits and vegetables.

10.1 INTRODUCTION

Fruits and vegetables are highly perishable commodities. These are affected by a number of factors leading to post harvest spoilage and hence, post harvest losses are the major source of food loss. Besides, packaging, transportation, and marketing of these perishables also contribute to post harvest losses. These are passed through a long channel before their use, which may lead to a number of undesirable physico-chemical changes in their composition. The losses may take place further, if the produce is not processed following the scientific methodology. In order to reduce the losses and maintain the quality to a maximum extent, effective post harvest management of fruits and vegetables during handling, transportation, marketing, and storage of fresh and processed products is of great importance.

10.2 ASSESSMENT OF LOSS

Fruits and vegetables respire even after harvesting and undergo biochemical changes. Their condition and marketable life are affected by temperature, humidity, composition of the atmosphere which surrounds them, level of

damage that has been inflicted on them before, during and after harvest, and the type and degree of infection with microorganisms, insects etc. Fruits and vegetables will deteriorate during storage through loss of moisture, loss of nutrients, physical loss through pest and disease attack, loss in quality from physiological disorders, fibre development, greening (potatoes), shoot growth, seed germination etc.

Various loss assessment methods have been used in practice for perishable commodities. In a study of apples arriving at a central market in Mexico over a period of one year, various measurements were made using European Community (EC) Standards (Table 10.1).

Table 10.1: Quality standards and losses of apples at wholesale market level in Mexico

Quality rating	Reasons for being unmarketable	Percentage
Extra		0.2
1		11.0
2		29.6
3		25.7
Below 3		15.5
Unmarketable		18.0
	Physiological (dehydration, over-maturity, physiological disorders)	9.0
	Fungal diseases (Penicillium, Gloeosporium, Phytophthora)	10.0
	Insect infestation	2.1
	Bitterpit	1.4
	Freezing injury	0.2
	Mechanical damage	6.8

Source: Noon R.A. (1979). Report on an assignment as Plant Pathologist to CONAFRUTA, Mexico City, March 1977-September 1979. Tropical products Institute Report R923, 34 pp.

The factors in the life cycle of fresh fruits and vegetables, which can influence their post-harvest losses, are crop production factors (temperature, nutritional status, light, day length, chemical treatments, infections or infestations etc.), maturity level at harvesting, method of (manual or mechanical) harvesting, removing crops from the field, treatments (pesticides, heat, sprout suppressants, curing), storage and transport conditions, packaging, type of transport, type of store, temperature (pre-cooling, store temperature), humidity, and atmospheric gases.

Losses occur at different times during the production and post harvest cycle of crops, and have a variety of causes. If it is clear that the losses are due to infections caused by microorganisms the control measures will depend on the type of microorganism, the time of infection, the reason for the success of infection and permissible control measures. It follows that effective and

sustainable control of post harvest losses should be an integrated approach taking into account health, economics and practicality of the situation. It is important to know the time in marketing chain when losses occur. Losses are usually higher when the crop enters the marketing chain (particularly during wholesale marketing) than in crops consumed by the producer.

10.3 FACTORS CAUSING SPOILAGE: PHYSICAL, PHYSIOLOGICAL, THERMAL, MICROBIAL, CHEMICAL, INSECTS, PESTS, DISEASES

Factors causing spoilage often do not operate in isolation. At one time, many forms of deterioration may take place, depending on the type of food and the environmental conditions that its exposed to.

Physical Factors

Storage conditions like temperature, oxygen, light, duration of storage etc are the important factors that influence the type of microbial growth and spoilage.

The rate of a chemical reaction doubles itself for every 10^0 C rise in temperature. Excessive heat brings about protein denaturation and destruction of vitamins. Several fruits and vegetables deteriorate even at refrigeration temperature (4^0 C) resulting in disclouration, changes in texture etc. Freezing may also cause deterioration of liquid foods e.g. separation of fat particles from a food emulsion.

Atmospheric oxygen brings about undesirable changes in foods such as discolouration, flavour changes and loss of vitamin A and C. Light destroys riboflavin, vitamin A and C and also many food colours. All the other food deterioration factors are time-dependent. The longer the storage time, greater the deterioration of food.

Physiological Factors

Rate at which the stored product respires is a major factor in determining the pace of physiological ageing. Deterioration in fruits and vegetables occurs mainly through the process of physiological ageing and water loss.

The characteristics of a food influence the type of microorganisms that can grow in it and thus determine the changes in its appearance, flavour and other qualities. Proteins are degraded by proteolytic organisms. Fats are digested by relatively few microorganisms, mainly moulds. Fats become rancid due to hydrolytic decomposition to mal-odourous fatty acids. Carbohydrates are affected by carbohydrates fermenting microorganisms; particularly yeasts and moulds.

Moisture is required both for chemical reactions and microbial growth. Foods with a high percentage of moisture deteriorate fast. Variation in surface moisture due to change in relative humidity can lead to lumping and caking, surface defects, crystallization and stickiness in foods. Condensation of even small amounts of moisture can result in multiplication of bacteria.

Acidity- Due to low pH, most of fruits are mainly spoiled by yeasts and moulds. Nonacid foods (vegetables, meat, fish, milk) are particularly subject to bacterial spoilage, but also support growth of moulds under favourable conditions.

Thermal Factors

Inappropriate temperature during food processing and storage are one of the main causes of food deterioration. At high processing temperature proteins get denatured and browning takes place (Maillard reaction). Water soluble vitamins particularly vitamin C, thiamine and riboflavin are heat sensitive and destroyed at high temperatures. Oxidative rancidity is accelerated by heat, metallic tins and light. The rate of oxidation of fat is doubled for each degree increase in temperature. Sugars and starches are degraded by prolonged heating at high temperature.

Microbial Factors

Bacteria, yeasts and moulds often cause food spoilage after harvesting, during handling, processing and storage. They attack all the food components – sugar, starche, cellulose, fat and protein. Depending on the food and the microorganisms, the action on food could be to produce acids, making the food sour, or produce alcohol. Some microorganisms produce gases, making the food foamy; still others produce unwanted pigments or toxins.

Chemical Factors

Pesticides can leave residues on plant produce much more than safe limits and make them unfit for consumption. Poisonous chemicals may enter foods from utensils, e.g., from cadmium plated ware or cheap enamelled ware containing antimony. Lead and arsenic residues from fruit sprays may be on fruit surface, but usually in harmless amounts, especially after washing. Indiscriminate use of all plastic packaging material like polyvinyl and polyethylene material can be a health hazard, e.g., it may lead to the reaction of acid and oil of pickles with plastic packaging as observed in some cases.

Insects, Pests, Diseases

Insects, worms, bugs and fruit flies may damage foodstuffs such as grains, fruits and vegetables and render them unfit for consumption. Apart from losses due to food eaten, insects cause greater damage due to bruises and cuts they make in foods exposing them to microbial attack resulting in total decay. Pests such as rodents introduce high degree of filth in form of excreta, bodily secretions and spoilage microorganisms. For example, rats can transfer the bacteria S*almonella* to the food, may cause salmonellosis.

Several types of pathogenic fungi are able to initiate an infection on the surface of floral parts and on, developing fruits. Many fungi that cause considerable wastage of produce are unable to penetrate intact skin of the produce, but readily invade broken skin. In addition, the cut stem is a frequent point of entry for microorganisms, and stem-end rots are important forms of post harvest wastage of many fruits and vegetables.

Table 10.2: Major post harvest diseases of some fresh fruits and vegetables

Crop	Disease	Pathogens
Apple, pear	Lenticel rot Blue mold rot	*Phlyctaena vagabunda* *Penicillium expansum*
Banana	Crown rot Anthracnose	*Colletotrichum musae Arx, Fusarium roseum, Verticillium theobromae, Ceratocystis paradoxa* *Colletotrichum musae*
Citrus fruits	Stem end rot Green mould rot Blue mould rot Sour rot	*Phomopsis citri Faw, Diplodia natalensis, Alternaria citri Penicillium digitatum Sacc.* *Penicillium italicum Wehmer* *Geotrichum candidum*
Papaya, mango	Anthracnose	*Colletotrichum gloeosporiodes*
Pineapple	Black rot	*Ceratocystis paradoxa,*
Potato, leafy vegetable	Bacterial soft rot Dry rot	*Erwinia carotovora* *Fusarium species*
Leafy vegetables, carrot	Watery soft rot	*Sclerotinia sclerotiorum*

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you understand by spoilage?

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2. What are different factors that can deteriorate the quality of fresh and processed products? Explain in brief.

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3. How the pests can make the food unfit for consumption?

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10.4 POST-HARVEST/ SLAUGHTER – BIOCHEMICAL CHANGES

10.4.1 Post-Harvest Biochemical Changes

The perishable foods like fruits and vegetables continue to undergo chemical changes even after harvest. The changes of fruits after harvest are numerous. Some of the very important changes include changes in (i) rate of respiration, (ii) water content, (iii) carbohydrates and (iv) organic acids and pH.

i) A major metabolic process which takes place in harvested produce or in any living plant is respiration. Respiration rate per unit weight is highest for the immature fruits or vegetables and then steadily declines with the age.

ii) When fruit and vegetables are picked from the plants, water no longer flows into the foods although the loss continues. In dry atmosphere and at high temperatures, water loss is rapid. For e.g., apples rapidly cooled after delivery to the storage area have a much smaller water loss than those cooled slowly. During the ripening period of bananas, the water content in the pulp increases and in the peel decreases. Water loss in bananas (and probably in other fruits) is checked by waxy layer of the skin.

iii) Many changes occur in the carbohydrate fraction of fruits during ripening. This alters both taste and texture of the produce. The green fruits usually contain an abundance of starch, but are short on the soluble sugars that give ripe fruit its sweetness. On ripening, however, starches decrease and sugars increase in concentration.

One of the most obvious changes in fruit is the alteration in texture. The breakdown of polymeric carbohydrates, especially pectic substances and hemicelluloses, weakens cell walls and the cohesive forces binding cells together. In the initial stages, the texture becomes more palatable, but eventually the plant structures disintegrate. Protopectin is the insoluble parent form of pectic substances. During ripening and maturation, protopectin is gradually broken down to soluble pectin. The rate of degradation of pectic substances is directly correlated with the rate of softening of fruit. For e.g. pears are picked in the hard stage and held at low temperatures until required for ripening. On return to room temperature they rapidly ripen and soften due to increase in soluble pectin. Fruits like banana, peaches, plums and tomatoes also show loss of protopectin and rise in soluble pectins on ripening.

10.4.2 Post-Slaughter Biochemical Changes

There are a series of biochemical changes occurring after slaughter. When an animal dies, the skeletal muscles stiffen in rigor mortis and remain in this

condition for a period after which they soften and become flexible again. The onset of rigor is quickened by high temperatures and delayed by low temperature. Rigor mortis is important in meat products since muscles cooked while still in rigor are much tougher than if it is allowed to soften before cooking. The stiffness, that develops when muscles pass into rigor, is the result of changes in the proteins. Living muscle fibres contain protein in a soft, pliable gel. During rigor this gel stiffens, but when rigor passes, the muscle again becomes soft and pliable. After the passing of rigor mortis, meat becomes progressively more tender, juicier, and more flavourful. The speed with which this ripening or aging occurs, depends on the time and temperature of keeping the carcass. Changes occur quite rapidly at room temperature but more slowly at refrigerator temperatures.

10.5 HANDLING AND TRANSPORT

Fruits and vegetables continue to respire even after harvesting. We cannot improve the quality of the harvested commodities but it can be retained till consumption if the rate of metabolic activities is reduced by adopting the appropriate post harvest handling operations (Fig. 10.1).

Pre-cooling

Pre-cooling (prompt cooling after harvest) is important for most of fruits and vegetables because they may deteriorate as much in 1 hour at 32^0C as they do in 1 day at 10^0C or in 1 week at 0^0C. In addition to removal of field heat from commodities, pre-cooling also reduces bruise damage from vibration during transit. Cooling requirement for a crop vary with the air temperature during harvesting, stage of maturity, and nature of crop. Different methods of cooling are given commodity-wise in Table 10.3.

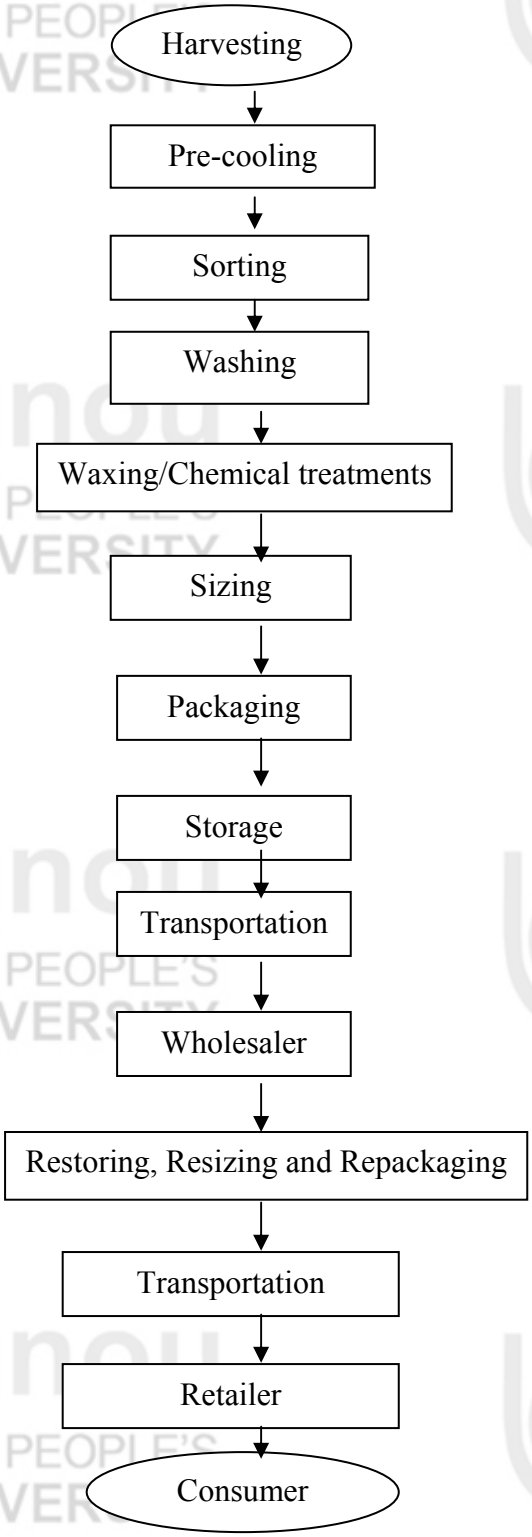
Table 10.3: Commodity-wise cooling methods

Cooling method	Commodity
Room cooling	All fruits and vegetables.
Forced air cooling (pressure cooling)	Fruits and fruit type vegetables, tubers and cauliflower.
Hydro cooling	Stem, leafy vegetable, some fruits and fruit type vegetables.
Package icing	Roots, stem, some flower type vegetables, green onions and brussel sprouts.
Vaccum cooling	Some stem, leaf and flower type vegetables.
Transit cooling Mechanical refrigeration Top icing and channel icing	 All fruits and vegetables Some roots, stems, leafy vegetables

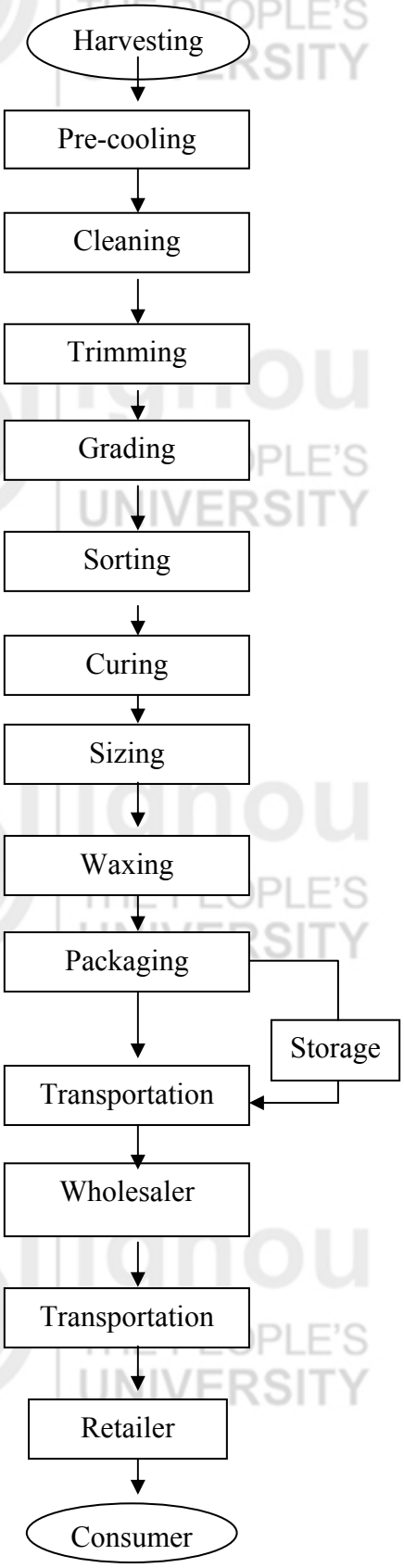
Washing, Cleaning and Trimming

Before fresh fruits and vegetables are marketed various amounts of cleaning are necessary which typically involves the removal of soil, dust, adhering debris, insects and spray residues. Chlorine in fresh water is often used as disinfectant to wash the commodity. Some fungicides like Diphenylamine (0.1-0.25%) or ethoxyquin (0.2-0.5%) may be used as post-harvest dip to control an important disorder of apple known as superficial scald. Many

vegetables need trimming, cutting and removal of unsightly leaves or other vegetables parts.



(a)



(b)

Figure 10.1: Post-harvest handling operations of a) fruits, and b) vegetables

Sorting, Grading and Sizing

Sorting is done by hand to remove the fruits, which are unsuitable to market or store due to damage by insects, diseases or mechanical injuries. The remainder crop products are separated into two or more grades on the basis of the surface colour, shape or visible defects. For example, in an apple packing house in India 3 grades viz. extra fancy, fancy and standard may be packed for marketing. After sorting and grading, sizing is done either by hand or machine. Sizing on the basis of fruit shape and size are most effective for spherical (oranges, tomato, certain apple cultivars) and elongated (delicious apples, European pears or of non-uniform shaped commodities, respectively. Grading-packing line machines with facilities of washing, waxing and drying in addition to sizing are now days available in the market.

Curing

Curing is an effective operation to reduce the water loss during storage from hardy vegetables viz. onion, garlic, and other root vegetables. The curing methods employed for root crops are entirely different than that from the bulbous crops (onion and garlic). The curing of root and tuber crops develops periderm over cut, broken or skinned surfaces for wound restoration. It helps in the healing of harvest injuries, reduces loss of water and prevents the infection by decay and attack by pathogens. Onion and garlic are cured to dry the necks and outer scales. For the curing of onion and garlic, the bulbs are left in the field after harvesting under shade for a few days until the green tops; outer skin and roots are fully dried.

Waxing

Waxing generally reduces the respiration and transpiration rates, but other chemicals such as fungicides, growth regulators, preservative can also be incorporated specially for reducing microbial spoilage, sprout inhibition etc. However, it should be remembered that waxing does not improve the quality of any inferior horticulture product but it can be a beneficial adjunct to good handling. Some of the commonly used waxes are paraffin wax, carnauba wax, bees wax, wood resins, shellac, etc.

The majority of quality contributing factors as affected by wax application includes reduction in the physiological loss in weight (PLW), delay in respiration rate, reduction in post-harvest spoilage and maintenance of improved quality of commodity intended for storage to increase the shelf life. The principal disadvantage of wax coating is the development of off flavour if not applied properly. Adverse flavour changes have been attributed to O_2 and CO_2 exchange, thus resulting in anaerobic respiration and elevated ethanol and acetaldehyde contents.

Packaging

Proper or scientific packaging of fresh fruits and vegetables reduces the wastage of commodities by protecting them from mechanical damage, pilferage, dirt, moisture loss and other undesirable physiological changes and pathological deterioration during the course of storage, transportation and subsequent marketing. For providing uniform quality to packed produce, the commodity should be carefully supervised and sorted prior to packaging. Packaging cannot improve the quality but it certainly helps in maintaining it as it protects the produce against the hazards of transportation.

Transportation

Mechanical damage to packages occurs particularly during handling and transportation. Rail, road, sea and air transport may all be used to move produce to its destination. Air-transport relies on short journey time to maintain produce quality. The packaging requirement during surface transport are generally greater than by air owing to longer time taken for the journey, higher humidity and usually greater stack heights. The use of pallets and mechanical aids can reduce handling damage to the package considerably. It is very important that the package maintains its integrity throughout the journey.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Explain briefly the important changes take place in harvested fruits and vegetables.

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2. Why pre-cooling is important for harvested fruits and vegetables?

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3. Discuss the unit operations, which are important for handling of fruits and vegetables.

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10.6 COLD STORAGE

Fresh produce changes in quality and quantity between harvest and consumption. These losses have been observed to the tune of 20-50 per cent particularly in developing country depending upon the commodity. Fresh produce like fruits and vegetables and ornamentals are living tissues, which are subjected to continuous change after harvest due to inadequate handling, packaging, transport and storage. Deterioration in fruits and vegetables occur mainly through the process of physiological ageing and water loss. The rate at which the stored product respires is a major factor in determining the pace of physiological ageing.

The deterioration in the agricultural produce of high value (milk, meat, fish, fruits, and vegetables) depends largely on storage temperature. One way to minimize deterioration reduce losses consists of lowering their storage temperature to an appropriate level. The storage of foods for extended periods at lowered temperatures is called as cold storage.

Refrigeration or Chilling

Chilling temperatures are obtained by means of ice or mechanical refrigeration. Fruits, vegetables and their products and other high value foods can be stored for a few days to many weeks when kept at chilling temperature. It is necessary to refrigerate fruits and vegetables as soon as they are harvested, fish as soon as they are caught and meat as soon as slaughter has taken place under good hygienic conditions, eggs recently laid, etc. to maintain the quality of the foods. It is important to cool the produce before refrigeration, maintain RH conditions for the food, and carry out renewal of air.

Freezing

Freezing method is most harmless method of storage of food for longer duration. At temperature below the freezing point of water (-18^0 to -40^0 C) growth of microorganisms and enzyme activity are reduced to a minimum. Most perishable foods can be preserved for several months if the temperature is brought down quickly (quick freezing) and the food is kept at these temperatures. Quick frozen foods maintain their quality and freshness when they are thawed because only very small ice crystals are formed when foods are frozen in this manner.

Table 10.4: Practical storage life of some frozen products

Product	Practical storage Life (in months)		
	-18^0C	-25^0C	-30^0C
Fruits			
Peaches, apricots or cherries (sweet or sour) in sugar	12	18	24
Raspberries or strawberries in sugar	18	<24	>24
Citrus or other fruit concentrates	24	>24	>24
Vegetables			
Broccoli	15	24	>24
Carrots	18	>24	>24
Cauliflower	15	24	>24
Peas	18	>24	>24

Raw meat and meat products			
Beef carcass	12	18	24
Veal carcass	9	12	24
Pork carcass	6	12	15
Poultry, chicken and turkeys eviscerated (packaged)	12	24	24
Fried chicken	6	9	12
Whole eggs, liquid	12	24	>24
Marine products			
Fatty fish	4	8	12
Lean fish	8	18	24
Milk products			
Butter from pasteurized and matured cream	8	12	15
Cream	6	12	18
Ice-cream	6	12	18
Bakery and confectionery			
Cakes-cheese, sponge, chocolate, fruit, etc	12	24	>24

10.7 PROTECTION AND PRESERVATION TECHNIQUES

Foods are perishable and hence cannot be stored at ordinary temperatures for any length of time. So there comes the need of protection and preservation. It becomes necessary to take the preventive measures to increase the shelf life, or to treat these commodities with some life enhancer or processing them to various products. In the preservation of food, the following methods are involved:

I. Prevention or delay of microbial decomposition

   a) by keeping out microorganisms (asepsis- packaging prevents entry of microorganisms in food, e.g. canned peas);

   b) by removal of microorganisms, e.g. filtration;

   c) by hindering the growth and activity of microorganisms, e.g., by low temperature, drying, anaerobic conditions, chemicals or antibiotics; and

II. By killing the microorganisms, e.g., by heat or irradiation.

III. Prevention or delay of self-decomposition of food

   a) by destruction or inactivation of enzymes, e.g., by blanching or boiling;

   b) by prevention or delay of chemical reactions, e.g., prevention of oxidation by means of an antioxidant.

IV. Prevention of damage by insects, animals, mechanical causes, etc.

Various methods generally used for preservation of foods are as under:

I. Preservation by High Temperature: Two common methods of preservation by high temperatures are preservation are usually: pasteurization and sterilization.

a) Pasteurization

Pasteurization destroys pathogenic microorganisms and extends shelf life of the product by decreasing the microbial population and inactivation of enzymes, for example, pasteurized milk and other dairy products, beer, fruit juices and aerated drinks. Dried fruits like raisins, apricots and dates can also be pasteurized in the package.

b) Sterilization

Sterilization means the destruction of all viable microorganisms. The time and temperature necessary for sterilization vary with the type of food. Vegetables like green peas, beans, okra etc being non acidic contains more starch than sugar, require higher temperature to kill the spore forming organisms. Continuous heating or 30 to 90 minutes at 116^0 C is essential for their sterilization. Temperature above 100^0 C can only be obtained by using steam pressure sterilizers such as autoclaves.

Aseptic Canning

Aseptic Canning is a technique in which food is sterilized outside the can and then aseptically placed in previously sterilized cans, which are subsequently sealed in an aseptic environment, e.g., fluid and semi fluid products. The temperature employed may be as high as 149^0 C and sterilization takes place in 1 or 2 seconds.

Hot Pack or Hot Fill

Hot pack refers to the filling of previously pasteurized or sterilized food while still hot, into clean but not necessarily sterile containers under clean but not necessarily aseptic conditions, e.g. filling of hot jams in jars. Heat of the product and some holding time before cooling render the container sterile.

II. Preservation by Low Temperature

Microbial growth and enzymatic recitations are retarded in foods stored at low temperatures. Low temperatures can be obtained by (a) refrigeration or chilling ($0\text{-}5^0$C) suitable for storage of potatoes, apples and other perishables, and (b) freezing (-18 to -40^0 C) suitable for storage of most of the perishables.

III. Preservation by Chemicals

Certain chemicals when added in small quantities can hinder undesirable chemical reaction in food by interfering with cell membrane and enzymatic activity of microorganisms or their genetic mechanisms and acting as antioxidants. Benzoic acid, potassium metabisulphite, sorbic acid, calcium propionate are some of the chemicals used as preservative.

The development of off flavours (rancidity) in edible oils is prevented by the use of butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT) or lecithin, which act as antioxidants.

IV. Preservation by drying

When the moisture content of food is brought down below a certain level, microorganisms are unable to grow. Moisture can be removed by heat application as in sun drying or by mechanical drying (dehydration), e.g. dried green peas, cauliflower and raw mango, and fruit juice powder, etc.

V. Preservation by filtration

In this method, the juices are clarified by settling or by using ordinary filters and then passed through special filters, which are capable for retaining yeasts and bacteria. Various types of germ proof filters are used for this purpose.

VI. Preservation by Carbonation

Carbonation adds to the life of a beverage and contributes in some measures to its tang. Another advantage of carbonation is the removal of air thus creating an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning.

VII. Preservation by Salt or Sugar

Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products by: (i) causing high osmotic pressure resulting in the plasmolysis of microbial cells, (ii) dehydrating food as well as microorganisms by drawing out and tying up the moisture (iii) ionizing to yield the chloride ion which is harmful to microorganisms, (iv) reducing the solubility of oxygen in water, sensitizing the cells against carbon dioxide, and interfering with the action of proteolytic enzymes. Sugar absorbs most of the available water resulting very little water for microbial growth hence their multiplication is inhibited and even those already present die out gradually. Thus sugar acts as preservative by osmosis as in case of jam, jelly, candy, marmalade, etc.

VIII. Preservation by Fermentation

Decomposition of carbohydrates by microorganisms or enzymes is called 'fermentation'. By this method, foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of the alcoholic beverages (wine, beers), vinegar and fermented pickles depends upon the presence of alcohol, acetic acid and lactic acid, respectively. About 2 per cent acetic acid prevents spoilage in many products.

IX. Preservation by Acids

Acidic conditions inhibit the growth of many microorganisms hence organic acids are added to or allowed to form in foods to preserve them. Acetic acid in pickles, citric acid in squashes, jam and jellies, lactic acid are commonly used for preservation.

X. Preservation by oil and spices

A layer of oil on the surface of any food produces anaerobic conditions, which prevents the growth of moulds and yeasts. Thus pickles in which enough oil is added to form a layer at the top can be preserved for long

periods. Spices like turmeric, pepper, and asafoetida have very little bacteriostatic effect but their primary function is to impart their characteristic flavour to food.

XI. Preservation by Antibiotics

Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics. Nisin, an antibiotic used in canning of mushrooms, tomatoes and milk products. Subtilin is used for the preservation of asparagus, corn, and peas. *Pimaricin* can be used for treating fruits and fruit juices. At present these three antibiotics are permitted only in such foods. Residual antibiotics are expected to be destroyed during cooking as these foods are expected to cook prior to consumption.

XII. Preservation by irradiation

The ionizing radiations (gamma rays or electro beams) can be used for sterilization of foods in hermetically sealed packs, reducing the spoilage flora on perishable foods, elimination of pathogens in foods, control of infestation in stored cereals, prevention of sprouting of potatoes, onion etc. The irradiation of food can be considered to a method of 'cold sterilization', i.e. food is free of microorganisms without high temperature treatment. This method has not yet gained general acceptance due to the unacceptable flavour of some irradiated food and fear of hazard.

10.8 EVAPORATIVE COOLING AND STORAGE

Temperature and moisture content are two most important parameters, which control the rate of decay of food commodities during storage. The higher the temperature the more is the rate of respiration and other biochemical processes, and the food is more likely to develop abnormalities with resultant loss of quality and nutritive value. The vital activities of the tissues such as transpiration, respiration and ripening etc. continue even after harvest. The high moisture content of the horticultural commodities accelerates these reactions making them highly perishable. Very low humidity in the storage space causes undesirable moisture loss from the commodity leading to desiccation and shrivelling. Thus, the principal aim of storage in fresh form is to control wilting and shrinkage alongwith the above undesirable physiological and biochemical changes and infections. This can be achieved by maintaining lower temperature and high humidity conditions through evaporative cooling.

Evaporative cooling is the adiabatic saturation of moist air. It is a thermodynamic process, where a part or all of the sensible heat of moist air is converted to latent heat, thereby, producing a reduction in temperature. Evaporation of water produces a considerable cooling effect and the effect increases with increase in the amount of evaporation. Theoretically, the lowest temperature that can be achieved by the evaporation of water is the wet bulb temperature of the moist air. Evaporative cooling has been extensively utilized for creating a modified atmosphere in an enclosure for crop growing, livestock housing or storage of horticultural produce. Evaporative cooling has also been recommended for removal of field heat from produce on the farm and for short duration storage after it is removed from the cold stores before distribution.

Evaporative cool chambers maintain 10-15^0 C lower temperature compared to field temperature, depending on the season and also maintain around 90 per cent relative humidity. The fruits and vegetables can be stored in plastic crates in the chamber. The shelf life of some fruit and vegetables in the cool chambers have been observed to increase from 3 to 90 days as compared to storage at room temperature.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are different principles of food preservation? List out with examples.

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2. How the temperature effect the storage of fruits and vegetables, explain in brief.

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10.9 LET US SUM UP

Fruits and vegetables are highly perishable commodities. Fresh produce changes in quality and quantity between harvest and consumption. These changes depend upon a number of factors. The quantitative losses have been observed to the tune of 20-50 per cent mainly because of inappropriate handling, packaging, transport and storage of the fresh produce. Deteriorative changes in fruits and vegetables occur mainly due to the action of microorganisms, storage conditions like temperature, oxygen, light, duration of storage, characteristics of the food, insects, pest, diseases etc.

Post harvest handling is one of the major factors that affect the overall quality and losses during transport and marketing. Spoilage in fruits and vegetables depends largely on storage temperature. Deteriorative changes and quantitative

losses can be reduced significantly by lowering the storage temperature to an appropriate level. The storage of foods for extended periods at lowered temperatures is called as cold storage.

Most of the fruits and vegetables cannot be stored for too long. So there arises the need of protection and preservation. Fruits and vegetables can be preserved by high temperatures (as in case of pasteurization, sterilization, canning), low temperature (refrigeration or freezing), preservatives, removal of moisture, use of salt, sugar, acids, oils, antibiotics, and irradiation.

10.10 KEY WORDS

Canning : the process of preserving food by sterilization at $>100^0$ C and cooking in a sealed metal can, which destroys bacteria and protects from contamination.

Carbonation : is the process of dissolving sufficient carbon dioxide in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste, e.g. carbonated fruit beverages.

Maillard reaction : the reaction between lysine (an amino acid in protein) and sugars is known as Maillard reaction. This deteriorative change takes place on heating or prolonged storage.

Pasteurization : when food is heated in containers or by other method to a temperature below 100^0 C for a definite period of time, the process is known as pasteurization.

Respiration : oxidative breakdown of complex materials, present in cells, such as carbon dioxide and water, with the production of energy and other molecules that can be used by the cell for synthetic reactions.

Spoilage : is a condition produced by excessive growth of microorganisms leading gradually to decay or decomposition or by other physical and chemical causes.

10.11 ANSWER TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include the following points:

1. Undesirable changes in foods.

   Food spoiled due to action of microorganisms, insects, pests, enzymes and other factors. See sub-sec. 10.3.

2. Physical factor, physiological factors, thermal factors, microbial factors, chemical factors, insects, pests, diseases. See Sub-sec 10.3.

3. Rodents contaminate the food with their urine and droppings.

   Rats can contaminate the food with microorganisms. See Sub-sec 10.3.

Check Your Progress Exercise 2

Your answer should include the following points:

1. Respiration.

   Changes in water content.

   Organic acids and starch content decreases. Sugar content increases.

   See sub-sec 10.4.1.

2. Reduces field heat.

   Reduces the rate of deterioration. See sub-sec 10.4.

3. Pre-cooling, washing, cleaning, trimming, sorting, grading, curing, sizing, waxing, packaging. See sub-sec 10.4.

Check Your Progress Exercise 3

Your answer should include the following points:

1. Prevention or delay of microbial decomposition

   By killing the microorganisms.

   Prevention or delay of self-decomposition of food. See sub-sec. 10.7.

2. High temperature enhances decay.

   Low temperature reduces losses and enhances shelf life. See sub-sec. 10.7 and 10.8.

10.12 SOME USEFUL BOOKS

1. Srivastava, R.P. and Kumar Sanjeev (2002) Fruit & Vegetable Preservation (Principal and Practices 3rd Revised and Enlarged Edition), International Book Distributing Co.

2. Thompson, A.K. (1996) Post Harvest Technology of Fruit and Vegetables, Blackwell Science Ltd., London.

3. Wills, R., McGlasson, B., Graham, D. and Joyce, D. (1998) Post-harvest an Introduction to the Physiology and Handling of Fruit, Vegetables & Ornamentals, CAB International, Australia.

4. Wills, R.B.H., McGlasson, Graham D., Lee, T.H. and Hall, E.G. (1989) Post Harvest an Introduction to the Physiology and Handling of Fruit and Vegetables. CBS Publishers and Distributors, Delhi.