1. Direct and Indirect freezing.

-) Food Freezing is defined as processing of food by lowering the temp^r so that almost all of the water inside becomes frozen.

Direct Freezing.

In direct freezing, the substance to be frozen comes into direct contact with a cooling medium (refrigerant, gases, cold surface). These systems will operate more efficiently since there are no barriers to heat transfer b/w refrigerant and product.

1. Air blast Freezer :- This method uses forced cold air circulation to freeze products quickly.

* Food items or other substances are placed in a freezer room (Velocity 3-7m/s) or on conveyor belts, and cold air is blown over or around them.
* ABF is commonly used in the food industry to freeze fruits, vegetables, and various packaged goods.

2. Fluidized bed Freezer :- In FBF products are put on trays and suspended in a cold air stream, creating a fluid-like bed.

* The rapid movement of cold air around the items ensures even and quick freezing.
* This method is often used for freezing items like vegetables, shrimp and berries.

3. Immersion Freezing :- IF is used for small items like seafood or berries.
* The item are immersed in a cold liquid, typically a refrigerant or brine soln, until they reach the desired temp^{r}.

4. Contact freezing :- CF involves placing the product in direct contact with a cold surface.
* This surface can be a cold plate or a conveyor belt that passes through a low-temp^{r} environment.
* It's commonly used for freezing meat or bakery prdts

Indirect Freezing.

IF, also known as brine freezing, involves using an intermediate medium (brine soln) to transfer cold temp^{r} to the substance to be frozen

1. Plate Freezing :- In IPF the product is placed on shelves or trays, and the shelves r cooled by a brine soln or refrigerant.
* The cold shelves transfer their low temp^{r} to the prdt causing it to freeze.
* pF can be used for various products including meat, seafood and vegetables

2. Contact belt freezing :- This method involves passing the product through a refrigerated conveyor belt that is in contact with a cold brine soln
* The product's contact with the cold belt

leads to freezing.

* contact belt freezers r often used for freezing products like meat patties or seafood.

3. Brine Freezing :- It involves immersing the product in a cold brine soln, typically made by dissolving salt in water.

* The brine soln is cooled to temp^r below the freezing point of the product, which causes it to freeze.

* This method is used for freezing fish, seafood, and some types of meat.

EXPERIMENT 5 PRIMARY AND MINIMAL PROCESSING

Structure

5.1 INTRODUCTION

In India, perishable fresh fruit and vegetables are marketed immediately after harvesting without primary processing and adequate packaging. On the other hand, in the developed countries, most of the fruits and vegetables after harvesting are transported to packing stations for primary processing. They are then trimmed, sorted, graded, unit packed and marketed. In our country, because of the absence of primary processing, a lot of inedible material is transported to the market and finally to the homes of consumers where they end up in the garbage bin. Primary processing is therefore, necessary to streamline the marketing of fresh horticultural produce to urban markets. The solid wastes originating from horticultural crops in metro cities can create drainage problems and cause water logging, as well as invite stray animals near garbage dumps. These bio wastes also deteriorate very rapidly causing unhygienic conditions and increasing atmospheric pollution and provide a breeding ground for insects, pests and rodents. Minimally processed fruits and vegetables are cleaned, peeled, cut, sliced, packaged and/or lightly processed. These foods are in great demand because of their convenience. All fruits and vegetables need not be minimally processed. It is very often not convenient for the consumer with a small family to purchase commodities like pineapple, jackfruit, watermelon, pumpkin, ashgourd, yam, etc. Therefore if it is suitably sliced, peeled and packed consumer will be more inclined to buy it. In metro cities minimally processed vegetables like primary processing can solve one of the greatest problems of garbage disposal.

All fruits and vegetables need not be minimally processed. It is very often not convenient for the consumer with a small family to purchase commodities like pineapple, jackfruit, watermelon, pumpkin, ashgourd, yam, etc. If the vegetables are available in ready to cook form a large number of workingwomen in metro cities will be greatly benefited.

Objectives

After studying and performing this experiment, you should be able to:

- demonstrate the techniques of primary processing of fruits and vegetables and show how the solid wastes originating from fruits and vegetables can

be utilized in the farmers field thereby reducing cost of transport and the city garbage; and

- explain with practical demonstration of techniques of minimally processed fruits and vegetables and highlight its advantages.

5.2 EXPERIMENT

5.2.1 Principle

There is little difference in principle between primary and minimal processing. Primary processing is applicable in some fruits and vegetables, which carries lots of inedible/unmarketable part from the field to the market. Therefore, the main principle of primary processing is to eliminate the inedible parts without inflicting any damage to the main edible part. While minimally processed fruits and vegetables are cleaned, peeled, cut, sliced, packaged and/or lightly processed. One should keep in mind that while supplying minimally processed vegetable the maintenance of quality and hygiene must be of topmost priority.

5.2.2 Requirements

- Preparation table having stainless steel sheet or aluminum top.
- Stainless steel peeling, coring and pitting knives.
- Stainless steel washing tanks, constant supply of potable water.
- Electric fan / blower / drying arrangement.
- Packaging in polyethylene pouches, small plastic crates, CFB boxes.
- Pouch sealing machine.
- Shrink wrap/cling films, small cardboard tray/bamboo basket/perforated plastic container.
- Refrigerated storage/ walking coolers.
- Stainless steel pretreatment tanks.
- Laboratory facilities.

5.2.3 Procedure

Both the primary processing and minimal processing can be explained properly by giving example of a particular fruit or vegetables.

Primary processing

Cauliflower

- Procure cauliflower immediately after harvest
- Remove the inedible outer leaves and stems by cutting them with sharp knife without inflicting any damage to the edible curd
- The curds can be either wrapped in plastic film or kept as such in plastic crates for shipment in the market.
- The leaf and stem portions eliminated can be used as cattle feed or any other value added products.

Banana

- Harvest mature banana bunches carefully without causing any damage to banana fingers.
- Separate the banana hands from the bunch with help of a sharp knife.
- If facilities available wash the hands wax and dry them.
- Put the banana hands individually in plastic bag and place them in the crates for shipment.
- The banana stems left out can be used as value added product.

Minimal processing

- Select good quality fruits and vegetables for this purpose.
- Peel the fruits and vegetables and cut them into convenient pieces.
- Place them into appropriate containers or pouches for marketing.
- Some pre-treatments are recommended varies from commodity to commodity should be followed strictly.
- Transport and store the minimally processed under refrigerated condition.

5.2.4 Observations

It is advisable to maintain strict hygienic condition of the place and equipment. Strict vigil on the quality of primary and minimally processed fruits and vegetables are to be carried out. Yield of primary and minimally processed fruits and vegetable is to be recorded.

Shelf life or marketable life can be observed by determining the quality both in terms of microbial and organoleptic quality.

5.2.5 Calculations

The yield of the finished product and weight loss during storage should be determined.

$$\text{Primary processed produce \%} = \frac{\text{Weight of primary processed produce}}{\text{Weight of the original fresh produce}} \times 100$$

$$\text{Minimally processed produce \%} = \frac{\text{Weight of minimally processed produce}}{\text{Weight of the original fresh produce}} \times 100$$

$$\text{Waste \%} = \frac{\text{Weight of waste}}{\text{Weight of the original fresh produce}} \times 100$$

Sensory evaluation = Experienced assessors randomly selected should evaluate overall acceptability, colour, texture and flavour/odour. Attributers are to score on five point hedonic scale of excellent, 1; good 2; fair 3; poor, 4; and very poor, 5.

5.2.6 Result

Yield and wastage expressed as Percent (w/w).

Quality assessment is reported on Hedonic scale.

5.3 PRECAUTIONS

- Handle only freshly harvested horticultural produce for this purpose.
- Care must be taken to see that surface moisture from the finally prepared material before packaging should be removed.
- Once the primary/minimally processed fruits and vegetables are prepared and packed it should straight away go to refrigerated store.
- Keep rejects such as peel, seeds/stones or any other vegetable parts carefully for processing into a value added products and not thrown as garbage.

- **Freezer burn** is a condition that occurs when frozen food has been damaged by dehydration and oxidation due to air reaching the food. It is generally caused by food not being securely wrapped in air-tight packaging.

- **Freezer burn** is a condition that occurs when frozen food has been damaged by dehydration and oxidation due to air reaching the food. It is generally caused by food not being securely wrapped in air-tight packaging.

- Freezer burn appears as greyish-brown leathery spots on frozen food and occurs when air reaches the food's surface and dries the product. Color changes result from chemical changes in the food's pigment. Freezer burn does not make the food unsafe; it merely causes dry spots in foods. The food remains usable and edible, but removing the freezer burns will improve the flavor.
- Freezer burn is the result of moisture loss. It can happen to any food that's been frozen for a long time.
- All foods contain water, which forms thousands of ice crystals when frozen. These crystals migrate to the surface of food and eventually to the coldest part of your freezer through a process called sublimation
- **Sublimation** is similar to evaporation, but it doesn't involve liquid. Instead, a substance changes directly from a solid into a gas. It's the reason why ice cubes become smaller if you don't use them for a long time.
- This loss of water molecules causes dehydration, making the frozen food shriveled, dry, and tough. Additionally, water loss allows oxygen to cause changes in flavor and color, especially in meats, poultry, and fish that was not wrapped well.

Freezer burn food products

Causes Freezer Burn

Freezer burn is caused by improper freezing practices and/or exposure to air. All foods are susceptible to this effect, but foods with higher moisture content (meats, fruits, ice cream, etc.) will develop it more quickly. Even if something is frozen perfectly, though, it will likely develop freezer burn over time.

Identifying freezer burn

- Any food stored in a freezer is subject to freezer burn. Yet, because it's caused by dehydration, foods with a higher water content like produce, meats, poultry, fish, or ice cream tend to be more affected than foods with a low water content, such as nuts, seeds, or flour.
- Meat, poultry, and fish may develop dark brown or greyish-white leathery areas. When cooked, the texture may be dry and tough.
- You can easily recognize freezer burn on fruits and vegetables, as they become dry and shriveled. They might also be covered in ice crystals because of their high water content, and if you cook them, they'll likely have a woody texture.
- Starchy foods like cooked grains, rice, or pasta, as well as baked goods like bread or cake, will develop a rougher texture. Meanwhile, grains may be coated with ice crystals, and baked goods will be dry and less voluminous.
- When ice cream gets freezer burnt, it loses its creaminess and gains ice crystals instead.

Preventions of freezer burn

- It's also important to package your food properly to minimize oxygen exposure. For example, wrap meat, poultry, or seafood in freezer paper or plastic wrap, then in foil, and then in a freezer bag.
- Minimize freezer burn by keeping your freezer at 0°F (-18°C) or lower. Food freezes faster at this temperature, allowing smaller ice crystals to form. These are less likely than larger crystals to significantly change the quality of your food.
- Remove as much air as possible from the packaging of frozen fruits and vegetables, and use small containers to minimize any empty space when freezing leftovers. Cover the top of ice cream with freezer paper or plastic wrap before replacing the lid.
- Opening your freezer frequently causes the temperature inside to fluctuate, and more ice crystals form when foods start to thaw. Thus, only open it when necessary.
- The best way to avoid freezer burn is to use your frozen food faster

UNIT -10 INTRODUCTION TO FOOD PROCESSING

Structure

10.1 INTRODUCTION

We are all aware that delay in the use of fresh foods, alters its freshness, palatability and nutritive value. Therefore, it becomes very important that we transform the fresh raw material and ingredients into wholesome, safe, nutritious and acceptable foods to be used by the consumers throughout the year. This process of transforming fresh, raw material into wholesome, safe, nutritious and acceptable foods for the consumers is referred to as food processing. Food processing is as old as the human hunger. Thousands of years ago, hunters and gatherers cured meat, dried fruits and berries, and cooked meals for their families. From the simple foods for ancient peoples to the foods created for astronauts, food processing has been intimately linked with human endeavors.

In this unit, we shall study about all the different aspects of processing i.e. its historical developments, what are the basic concepts and principles of food processing and preservation, why is food processing necessary, what are the different food processing techniques to prevent the food from the spoiling agents.

Using this knowledge of food processing, we shall then learn about how to transform the food into a more palatable form with a prolonged shelf-life. But, before we learn about

processing we need to understand food spoilage and its causes. We begin this unit by first defining food spoilage and discussing the main causes of food spoilage.

Objectives

After studying this unit, you will be able to:

- discuss the concepts and aims of food processing
- describe the historical developments in food processing and preservation
- identify the factors that are responsible for food spoilage and
- describe the traditional methods of food preservation and their principles.

10.2 FOOD SPOILAGE AND CAUSES

Foods gradually undergo deterioration or spoilage from the time they are harvested, caught, slaughtered or manufactured. Therefore, delay in the consumption or processing of fresh foods alters its freshness, color, texture, palatability and nutritive value, organoleptic desirability, aesthetic appeal and safety. Essentially, all foods undergo varying degrees of deterioration during handling and storage. Some foods spoil rapidly, others keep for longer but for a limited period of time. Therefore, spoilage of food refers to *the alterations in foods or the food undergoes some physiological, chemical and biological changes, which renders it inedible or hazardous to eat.* Hence, such food is essential for processing or preservation after it is harvested or slaughtered.

Why and how does the food get spoiled? There are several causes of food spoilage. These include:

- *Growth of Microorganisms*, such as bacteria, molds and yeasts, which can spoil food very fast.
- *Action of Enzymes,* present in all raw food, promotes chemical changes affecting especially the food texture and flavor.

- *Atmospheric oxygen* can react with some food components, which may cause rancidity or color changes (oxidative reaction).
- *Damage due to pests (insects, rodents etc),* which account for huge losses in food stocks (Infestations).
- *Others*: moisture, light, time, temperature (heat and cold), mechanical damage, etc.

At any one time, many forms of spoilage may take place depending upon the food and environmental conditions. Food processing involves the development of preservation techniques to slow down or stop the food spoilage caused by the above factors and finally result in the preservation of food.

In the next section(s), we will learn about the processing concept, principles and methodology.

10.3 FOOD PROCESSING

Food processing, as you learnt earlier, involves the conversion of raw materials and ingredients into an acceptable food product for the consumer. It encompasses every aspect necessary to transport raw materials from the "harvest site" through packaging and merchandising. It involves the application of scientific principles to slow down or stop the natural processes of food decay caused by micro-organisms, enzymes in the food or environmental factors such as heat, moisture and sunlight and so preserve the food. Much of this knowledge is known traditionally and put into practice by experience and information handed down through the generations. Food scientists strive to improve the methods of storing, processing and manufacturing food through the scientific understanding of mechanisms involved.

The term 'processing' is very broad and encompasses many techniques. These include primary processing like threshing, dehusking, polishing and grinding in case of food grains, and preliminary operations such as cleaning, washing, sorting, grading, peeling,

blanching and cutting in case of fruits and vegetables, and others to produce secondary processed products like breads, biscuits, confectionery, dehydrated and canned products like jams, jellies, pickles, sauces, frozen meals etc. This diverse range of operations means that the majority of foods are processed in one way or another before being consumed. What are the reasons for processing foods? Well, the reasons for food processing may vary, but the main objectives are discussed in the next section.

10.3.1 Aims of Food processing

The reasons for food processing may vary, but the main objectives are to:

- preserve the nutritive quality of food by preventing them from spoilage due to microbes and other spoilage agents,
- prolong the shelf-life (e.g. preservation). This is because the processed food is usually more stable than the raw food,
- enhance the quality (e.g. cooking),
- ensure that food is safe for future consumption,
- ensure the availability of many food products throughout the year,
- ease for storage, transportation and distribution systems, and
- create employment and to generate additional income.

Food processing, you would have realized, is practiced in some form or the other in most of our homes. Have you ever thought about its origin? How did it start? How did it develop? The next section presents the historical development of food processing. You will find this discussion interesting.

10.3.2 Historical development of Food processing

Food processing began thousands of years ago to help people keep food through the lean seasons. Various methods of preserving food have been around for a long time. The processes of smoking, drying (dehydration) and using salt and spices to prevent spoilage have been used for thousands of years. All of these methods were based on desiccation or dehydration. Grains and nuts were the first foods to be dried using the naturally available sunlight and air. Mechanical methods of drying were developed in the late 1700s. Dried

foods are popular because they are compact, lightweight and last much longer than the fresh foods. Cheese-making was an accidental discovery, which became established as a method for increasing the longevity of milk.

The process of canning was pioneered in the 1790s when Nicolas Appert, a French Confectioner, discovered that the application of heat to food in sealed glass bottles preserved the food from deterioration. Napoleon-I gave Appert 12,000 Francs to make his invention public. Napoleon was highly interested in Appert's invention because of its potential to supply food to the armed forces who were many miles away from home. Appert published several books for canning and started the canning industry. Around 1806, the French Navy had undertaken successful training of Appert's principles on a wide range of foods including meat, vegetables, fruit and milk.

Before 1860, changes in food were explained on the theory of spontaneous generation. Pasteur demonstrated that ferments, molds and some other forms of putrefaction were caused by the presence of microorganisms widely distributed in the environment. Since these microorganisms are the main cause of food spoilage, food preservation depends on rendering conditions unfavorable for their growth.

The evolution of food processing is listed in Table10.1.

Table-10.1 Evolution of food processing

- 8000 - 7000 BC. Mankind first began farming, growing crops and raising animals for food instead of hunting and gathering for food.
- 4000 B.C. Salt, chemicals in smoke, drying, use of snow and ice were used for storing food for long times.
- 3000 B.C. Yeast was used to make alcoholic drinks by fermentation.
- 200 A.D. Bacteria were used to make yogurt by fermentation.
- 1810 Nicolas Appert (1752-1841) discovered a way of preserving food in sealed containers. Canning industry is developed from his discovery.
- 1860s Louis Pasteur (1822-95) invented a way of killing harmful microbes in wine and beer.

- 1920s Clarence Birdseye (1886-1956) developed a method of quick freezing food.

Today, food processing allows food from other parts of the world to be transported to our local market, so that we can enjoy a great variety of things to eat all through the year. Let us now study the methods and principles that are involved in the food preservation technique.

10.3.3 Methods and Principles of Food preservation

Food preservation is one of the oldest technologies used by human beings. The perishable food materials like fruits, vegetables, milk, meat, fish and others deteriorate or decay easily, so quite a lot of such commodities are wasted in various stages of food supply chain unless special methods are used for their preservation. Therefore, the process in which, the perishable food materials are given a suitable physical or chemical treatment to prevent their wastage, spoilage and to retain their nutritive value for long periods, is called food preservation. The principles of food preservation refer to *the processing techniques that are used to prevent food from spoilage*. The different preservation techniques commonly used today are given in the Table 10.2.

Table 10.2: Methods of food preservation

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1. Asepsis, or keeping out microorganisms
2. Removal of microorganisms (filtration, centrifugation, washing, trimming)
3. Maintenance of anaerobic conditions, e.g., in a sealed, evacuated container
4. Drying (drying under the sun, mechanical drying, freeze drying, smoking)
5. Use of high salt or sugar content (sugaring, pickling, curing etc)
6. Use of acids
7. Fermentation
8. Use of low temperatures (refrigeration, chilling, freezing)
9. Use of high temperatures (pasteurization, boiling, canning)
10. Mechanical destruction of microorganisms, e.g., by grinding, high pressure, etc

11. Chemical preservatives
12. Carbonation
13. Irradiation
14. Combination of the two or more of the above methods.

All food preservation methods listed in Table 10.2 are based upon the general principle of preventing or retarding the causes of spoilage caused by microbial decomposition, enzymatic and non-enzymatic reaction, chemical or oxidative reactions and damage from mechanical causes, insects and rodents etc. The basic principles of the different preservation methods are given in Table 10.3.

Table 10.3: Principles of food preservation

1. *Prevention or delay of microbial decomposition:*
   a. By keeping out microorganisms (asepsis)
   b. By removal of microorganisms e.g. by filtration.
   c. By hindering the growth and activity of microorganisms e.g. by low temperatures, drying, anaerobic conditions or chemicals.
   d. By killing the microorganisms e.g. by heat or radiations.
2. *Prevention or delay of self-decomposition of the food:*
   a. By destruction or inactivation of food enzymes e.g. by blanching.
   b. By prevention or delay of chemical reactions e.g. prevention of oxidation by means of an antioxidant.
3. *Prevention of damage* because insects, animals and mechanical causes.

A detail discussion on the traditional methods of food processing is presented in section 10.4. Before you go on to read about these methods, look up the points to remember listed below. This will help you sum up what you have learnt so far.

POINTS TO REMEMBER

1. Conversion of raw materials and ingredients into acceptable consumer products is referred to food processing, which comprises of all the steps right from the time the raw materials are procured to the time it arrives on consumer tables, including preservation.

2. Most of the foods we buy are processed in some way or another. These processes help to make the products that are safe, of consistent quality and convenient for the consumers, prolonged shelf-life and available round the year.

3. Food spoilage or deterioration refers to the alterations in the foods or undergoing some physiological, chemical and biological changes, which render the food inedible or hazardous to eat. Food spoilage may affect: safety, nutritional value, organoleptic desirability, aesthetic appeal and change in color, texture, flavor and other quality attributes of the food.

4. Major causes of food deterioration: Growth of microorganisms (bacteria, yeasts, molds); activities of food enzymes and other chemicals within the food itself; infestation by insects, parasites, rodents; oxidation; time, temperature and light; physical stress or abuse.

5. The principles of food preservation refer to the processing techniques that are used to prevent food from spoilage caused by the above agents.

6. The origin of food processing goes all the way back to 8000 B.C. Smoking, drying, and salting were some of the most frequently used processes of preservation during ancient period.

Check Your Progress Exercise 1

1. Define food processing and food preservation.

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2. List the major causes of food deterioration/spoilage.

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3. What are the effects of food deterioration?

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4. Mention the major advantages of food processing.

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5. Different preservation techniques commonly used today, include:

……

……

……

6. What do food manufacturers particularly aim to achieve when they preserve a food? (Choose the correct answer)

(i) To improve its vitamin C content.

(ii) To extend its shelf life.

(iii) To reduce the amount of cooking time it will require.

10.4 TRADITIONAL METHODS OF FOOD PROCESSING

Because food is so important to survival and most foods remain edible for only a brief period of time, people since the earliest ages have experimented with the methods for successful food preservation. Among the products of early food conservation, were cheese and butter, raisins, pemmican, sausages, bacon and grains. Therefore, food preservation is one of the oldest technologies used by human beings. Often, in the way of many traditional technologies, the ideas and methods are passed down through the generations, from mother to daughter. Look around and everywhere you will see people processing food, wherein food is being dried, crushed, milled, canned, bottled, cooked and sweetened.

Various methods of preserving food have been around for a long time. The methods like drying, pickling, salting, smoking, canning and freezing have been with us for the times immemorial. But all of these traditional methods are being updated and are in use today in some form. The methodology and principles of some of the preservation methods are discussed here:

- *Asepsis:* Food is a living system and it has natural protection mechanisms in its raw agricultural state. Once removed from the field or protective skin or peel (e.g. banana, coconut, vegetables, shell of nuts, husks of grains etc), it begins to deteriorate. Asepsis deals with the prevention of microbial contamination (keeping out microorganisms) of fresh or processed foods. Packaging of foods is a widely used application of asepsis.

- *Drying:* Drying is the oldest and probably the simplest way of preserving food. It is usually accomplished by the removal of water. Dried foods are preserved because the available moisture level is so low that the microorganisms cannot grow and enzyme activity is controlled. Moisture from food may be removed by a number of methods: drying by the Sun's rays and by the modern artificial ones. Grains and nuts were the first foods to be dried under the sun and air. However, sun-drying is a slow process, risk of contamination and spoilage and is limited to climates with a hot Sun and a dry atmosphere and to certain fruits such as grapes (raisins), figs, dates, apricots, raw mangoes (*amchur*), pears and peaches. Vegetables like beans, peas, cabbage, cauliflower, lady fingers, garlic, onions, chillies, turmeric and all leafy vegetables can also be dried by sun-drying. Drying of fruits and vegetables involves washing, peeling, preparing and spreading on flat bottom trays and drying under Sun. Fish (Bombay duck) and shrimps are dried by exposing them to the Sun on the seashore. The word dehydration usually implies *the use of controlled conditions of heating, with the forced circulation of air or artificial drying (mechanical drier)* as compared with the use of sun-drying. Using mechanical driers, fruits, fruit leathers, banana chips, tea, coffee, milk, soups, fish, meat, eggs and vegetables can all be dried year-round. Dried foods are compact and lightweight; do not require refrigeration and last much longer than

the fresh foods. Dried foods should be stored in airtight containers to prevent moisture from rehydrating the products and allowing microbial growth.

- *Salting:* Salting, especially of meat, is an ancient preservation technique. Food is treated with salt or a strong salt solution. Due to high concentration of salt, water from the food is tied up and made unavailable for microbial growth and enzyme action and hence, preserved the food. Salt has the following effects: (a) it causes high osmotic pressure and hence, plasmolysis (shrinking) of cell; (b) it dehydrates foods by drawing out and tying up moisture as it dehydrates microbial cells; and (c) it ionizes to yield the chloride ion, which is harmful to organisms. Dry salting is used in India for the preparation of tamarind, raw mango, amla, fish and meat. Salted meat and fish can last for years. In meat salting, the prepared meats were soaked in 10% salt-water brine for several weeks. In fish salting, fresh fish were gutted on a cement slope and washed with the water. Coarse salt was then rubbed into their gills, mouth and scales. Layers of fish were alternated with layers of salt and covered with dry matting. They were then left to stand for 3 to 5 days, after which the pile was turned over and left for an additional 3 to 5 days.

- *Sugaring:* Water is withdrawn from the microbial cells when they are placed in a strong sugar solution (about 68%) and thus result in an adverse effect on microorganisms. Therefore, sugars such as glucose or sucrose, owe their effectiveness as preservatives to their ability to make water unavailable to organisms and to their osmotic effect. Examples of food preserved by high sugar concentrations are sweetened condensed milk, fruits in heavy sugar syrup (preserve or murraba), jams, jellies, marmalades and candies. Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar (about 55 % by wt), acid and pectin to a reasonably thick consistency.

- *Pickling:* Pickling was widely used to preserve meats, fruits and vegetables in the past, but today it is used almost exclusively to produce "pickles" or pickled cucumbers or pickled onions and sauces. Pickling uses the salt combined with the acid, such as acetic acid (vinegar). Microorganisms do not grow well in acidic solutions. Some of the fruits and vegetables, which lend themselves to pickling,

are raw mangoes, limes, amla, ginger, turmeric and green chillies. To make pickles, the fruits or vegetables are washed, cut into halves or quarters, the seeds are removed and then either dry salted or soaked in a 10-15% salt water brine for several days or months, then rinsed and mixed with spices, oils etc. and stored in glass bottles or jars.

- *Fermentation:* In contrast to other preservation methods, multiplication of microorganisms and their metabolic activities are encouraged. In this, microorganisms break down complex organic compounds into simpler substances either in aerobic or anaerobic conditions. The chemicals excreted by the microorganisms cause the preservative effect of fermentation. The principal chemicals involved are the acids (especially, lactic acid) and alcohol. These inhibit the growth of common pathogenic organisms in foods. Examples of food preserved by fermentation are yogurt, cheese, beer, wine and other alcoholic beverages.

- *Cheese-Making:* Cheese is a way of preserving milk for long periods of time. In this process, the milk in cheese becomes something completely unlike milk, but cheese has its own interesting and delicious properties. Cheese-making is a long and involved process that makes use of bacteria, enzymes and naturally-formed acids to solidify milk proteins and fats and preserve them. Cheese can be stored for months or years.

- *Smoking:* Smoking was known as a method of food preservation at an early date. Foods are exposed to smokes by burning some special kinds of wood. It has two main purposes, adding desired flavoring and preserving. In the earlier times, many households had smokehouses, which were used to smoke beef, ham and bacon. Smoking is still used to preserve fish and meat. Most meat is smoked after curing to aid their preservation. Preservative action is provided by such bactericidal chemicals in the smoke as formaldehyde and creosote, and by the dehydration that occurs in the smokehouse. The smoke is obtained by burning hickory or a similar wood like oak, maple, walnut and mahogany under low breeze/wind.

- *Cold Preservation:* The metabolism of a living tissue is a function of the temperature of the environment. Low temperatures are used to retard chemical reactions and action of food enzymes and slow down or stop growth and activity of microorganisms in the food. Lower the temperature, the slower will be the above natural activities. Freezing and refrigeration are among the oldest methods of preservation. Mechanical ammonia refrigeration systems invented during 1875 allowed development of commercial refrigerated warehousing and freezing. Low temperatures employed can be:

  (a) Cellar storage temperatures (about 15° C): It is usually used for the storage of surplus foods like root crops, potatoes, onions, apples, etc. for limited periods.

  (b) Refrigerator or chilling temperatures (0℃ to 5℃): Foods kept at this temperature slows down the microbial activities and chemical changes resulting in spoilage. Mechanical refrigerator or cold storage is used for this purpose. Examples of this include meats, poultry, eggs, fish, fresh milk and milk products, fruits, vegetables, etc. can be preserved for 2-7 days by refrigeration.

  (c) Freezing (-18℃ to - 40℃): In freezing, water in food turns into ice and makes unavailable for reactions to occur, and for microorganisms to grow. Most perishable foods like poultry, meats, fish, ice-creams, peas, vegetables, juice concentrates, etc. can be preserved for several months at this temperature. In vegetables, enzyme action may still produce undesirable effects on flavor and texture during freezing. Heating, like blanching, therefore, must destroy the enzymes before the vegetables are frozen.

- *Heat Preservation:* The process of heating was used centuries before its action was understood. Food is heated up or cooked. Heat kills microorganisms, alters the protein structure and destroys enzyme activity of microorganisms in food. The examples include all forms of cooked food, pasteurization, milk sterilized by UHT (ultra high temperature), canning, etc. One of the most important modern

applications of the heat principle is the pasteurization of milk. Heat treatment of food may be in different ways:

(a) Pasteurization (temperature below 100° C)

Pasteurization is a heat treatment that kills a part but not all the microorganisms present and usually involves the application of temperatures below 100° C. Milk, for example, is usually heated to 63° C for 30 min or 71° C for 15 seconds or in UHT, 138° C for 2-4 seconds. Examples are: milk, wine, beer, fruit juices and aerated waters are routinely pasteurized. The heating may be by means of steam, hot water, dry heat or electric currents and the products are cooled promptly after the heat treatment. Pasteurization is usually supplemented by other methods to prolong shelf-life.

(b) Boiling (temperature at 100° C)

Cooking of rice, vegetables, meat, fish etc. at home is usually done by boiling the food with water and involves a temperature around 100° C.

(c) Canning (temperature above 100° C)

Canning is the process in which *the foods are heated in hermetically sealed (airtight) jars or cans to a temperature that destroys microorganisms and inactivates enzymes that could be a health hazard or cause the food to spoil.* The vacuum seal formed after heating and cooling in the process ensures that no microorganism can get into the product. The degree of heat and the length of time of heating vary with the type of food and the kinds of microorganisms that are likely to occur in it. High-acid foods such as fruits and tomatoes can be processed or "canned" in boiling water, while low-acid vegetables and meats must be processed in a pressure canner at 121 °C (15 psi pressure). Most canning is in ‘tin cans’ which are made up of tin-coated steel or in glass containers, but increasing use is being made of containers that are partially or wholly of aluminum, plastics such as pouches or solid containers. Examples of food preserved by canning are-

all kinds of tinned foods, such as soup, meat, beans, cereal grains, legumes, nuts, and other various dried food products such as fruit, coffee, milk, soups, fish, meat and vegetables.

- *Food concentration:* Relatively few liquid foods are preserved by concentration, mainly because of the reduction in water activity (a_w) and development of osmotic pressure, which retard the microbial growth and enzymatic reactions. Concentration of food is usually done for many reasons: reduction in volume and weight; reduction in packaging, storage and transport costs; better microbial stability; and convenience. Examples of food preserved by concentration are tomato paste, fruit juice concentrate, soup and condensed milk. The main requirement to improve processing of these products is to control the rate of heating to prevent localized burning of the product, particularly when it has become thickened towards the end of boiling.

- *Carbonating:* Carbonated water is the water in which carbon dioxide gas has been dissolved under pressure. By eliminating oxygen, carbonated water inhibits bacterial growth. Carbonated beverages (soft drinks), therefore, contain a natural preservative.

- *Use of food Additives:* Food additives may be defined as *substances added intentionally to food, generally, in small quantities to improve its appearance, flavour, texture or storage properties*. These may be classified into different broad groups as listed in Table 10.4.

  Those food additives, which are specifically added to prevent the deterioration or decomposition of a food, have been referred to as *chemical preservatives*. In food preservation, the added substances may be grouped into two. The first one includes the use of sugar, salt, spices, acetic acid (vinegar) and alcohol, and is referred to as class I preservatives and is considered to be relatively safe to humans. The second group includes the use of benzoic acid, sulfur dioxide,

nitrates and nitrites and a variety of neutralizers, firming agents and bleaching agents and referred to as class II preservatives and is considered to be relatively safe to humans, but within the permissible doses prescribed by the Food Regulatory bodies because higher concentrations can be a health hazard. Preservation of foods by the chemicals is effected by interfering with the cell membrane of the microorganism, their enzyme activity and genetic mechanism; by acting as antioxidants.

Table 10.4: Food Additives

Preservatives	Sodium benzoate in fruit drinks, potassium meta bisulphate in fruit products, sorbic acid in cheese, sodium and calcium propionates in breads and cakes, nitrates and nitrites in meats.
Antioxidants	Butylated hydroxy anisole (BHA), Butylated hydroxy toluene (BHT), propylgallate (PG), tocopherols in oily or fried foods; Ascorbic acid, SO_2 in fruit products.
Sequestrants (chelating agents)	Polyphosphates, citric acid – to remove elements from the food.
Surface-active agents (emulsifiers)	Lecithin, mono-and di-glycerides and bile acids-to stabilize oil in water.
Stabilizers and thickeners	Gums, gelatin, carboxy methyl cellulose, pectin, egg yolk, etc. in jellies, chocolate milk drinks, pie fillings and cake toppings.
Bleaching and maturing agents	Oxides of nitrogen, chlorine dioxide in bleaching and maturing flour.
Food colors	Natural sources: annatto, caramel, carotene, saffron, Synthetic: coal tar dyes.
Non-nutritive sweeteners	Saccharin, cyclamates, etc.
Flavouring agents and flavor enhancers	Monosodium glutamate (MSG), 5'-nucleotides

- *Food Irradiation:* Food irradiation is another sterilizing technique in which the foods are bombarded by high-energy rays called *gamma rays* or by fast-moving electrons to kill bacteria, fungi and insects and in some cases, to delay fruit ripening. It has been used in pasteurizing or sterilizing perishable foods such as meat, fish and fruits and extending their storage lives for long periods. It is also used for sprouting inhibition in onions, potatoes etc. Sterilization can be effected at room temperature and hence, the technique is also called as *cold sterilization* process. A major benefit of irradiation is that it can occur after the food is packaged and sealed. Cobalt-60 or Cesium-137 or electrons producing machines are the principal sources of ionizing radiations used for food irradiation. The unit of radiation is in terms of rads (and kilorad or megarad).

POINTS TO REMEMBER

1. The traditional food preservation methods like drying, pickling, salting, smoking, canning and freezing have been with us from the times immemorial. But all of these methods are being updated and are in use today in some form.

2. Dried foods are preserved, because the available moisture level is so low that microorganisms cannot grow and enzyme activity is controlled.

3. Fruits like grapes (raisins), figs, dates, apricots, raw mango (amchur), pears and peaches and vegetables like bean, peas, cabbage, cauliflower, lady finger, garlic, onion, chilli, turmeric and all leafy vegetables including fish can be dried under Sun.

4. Dried foods are compact, lightweight, do not require refrigeration and last much longer than fresh foods, retaining to wholesomeness.

5. Effects of salt in food preservation: (i) it causes high osmotic pressure and hence shrinking of cell, (ii) it dehydrates foods by removing moisture and

making it unavailable for the microbial cells; (iii) it ionizes to yield the chlorine ion, which is harmful to organisms.

6. Foods preserved by high sugar concentrations are sweetened condensed milk, preserves, jams, jellies, marmalades and cadies.

7. Foods preserved by fermentation are yogurt, curd, cheese, beer, wine and other alcoholic beverages.

8. Cheese making is a long and involved process that makes use of bacteria, enzymes and naturally formed acids to solidify milk proteins and fat and preserve them.

9. Preservative action of smoking is due to the bactericidal chemicals like formaldehyde and creosote present in the smoke and dehydrating effect.

10. Low temperature preservation of food may be at (i) Cellar storage temperatures (about 15° C); (ii) Refrigerator or chilling temperatures (0° C to 5° C); (iii) Freezing temperatures (-18° C to –40° C).

11. High temperature preservation of food may be at (i) Pasteurization temperature (below 100° C); (ii) Boiling temperature (at 100° C); (iii) Canning temperature (at or above 100° C).

12. Advantages of concentration of foods are- reduction in volume and weight hence, reduction in packaging, storage and transport costs; better microbial stability and convenience.

13. Chemical preservatives are referred to as those food additives, which are specifically added to prevent the deterioration or decomposition of a food.

14. Cobalt-60 or Cesium-137 or electrons producing machines are the principal sources of ionizing radiations used for food irradiation.

Check Your Progress Exercise 2

1. State whether the following statements are correct or incorrect. Correct the false statements.

(i) Asepsis deals with killing of microorganisms.

(ii) Food in its agricultural state has natural protection mechanism from deterioration.

(iii) Dried foods are more susceptible to microbial spoilage.

(iv) Preservation of food by high sugar and salt solution is based on the principle that water from food is tied up and made unavailable for microbial growth and enzyme action.

(v) The heat developed during the process causes the preservative effect of fermentation.

(vi) Cheese making is a process to preserve the milk into solid form for months and years.

(vii) Smoking is a method of food preservation mainly used for milk and milk products.

(viii) Preservation of food by cold temperature is due killing of spoilage microorganisms and inactivation of enzymes present in the food.

(ix) Pasteurization is the process of heat treatment to kill all the microorganisms present in milk or fruit juice.

(x) In canning preservation, high acid foods are processed at temperature above 100 C.

(xi) Sugar, salt, spices, vinegar and alcohol are considered as class I food preservatives relatively safe to humans.

(xii) Ionizing radiations are measured in terms of Kcal.

10.5 LET US SUM UP

In this unit you studied about the basic fundamentals of food processing. Food processing, you learnt, refers to the transformation of raw materials and ingredients into a more palatable, readily usable form, nutritious and convenience food product with a prolonged shelf-life.

We have also identified the several agents or factors responsible for food spoilage. To prevent the food from spoilage, we have discussed some of the traditional food processing methods like drying, salting, smoking, sugaring, fermentation, use of

preservatives and use of heat treatment. In all of these methods discussed, the common basic principle is to slow down or stop the natural process of food spoilage caused by the various factors and so preserve the food. As a result, availability of food round the year, easy storage, transportation and distribution, retention of nutritive value of the food, creation of employment and generation of additional income are ensured by the technique of food processing. You also studied about the development of food processing. We have recorded that during ancient period, smoking, drying and salting were some of the most frequently used process of food preservation.

10.6 GLOSSARY

Acetic acid **:** Active ingredient in vinegar; used in food preservation.

Acid foods **:** Foods which contain enough acid to result in a pH of 4.5 or lower. Includes all fruits except figs; most tomatoes; fermented and pickled vegetables; relishes; and jams, jellies and marmalades.

Anearobic fermentation **:** Fermentation in the absence of air (secondary fermentation)

Antioxidants **:** Antioxidants are scavengers of particles called oxygen-free radicals. Vitamins A, E, C, and many of the carotenoids and phytochemicals are thought to be antioxidants.

Asepsis **:** keeping out microorganisms from food.

Blanching **:** The process of exposing a food product to either steam or hot water for a short time, before being placed in packages and frozen or dried.

Canning **:** A method of preserving food in air-tight vacuum-containers and heat processing sufficiently to preserve the food.

Cereals : Rice, wheat, millets and their products

Contaminant : an undesirable substance that is considered to make something impure or dirty.

Curing : a method of food preservation that involves soaking the food in a strong salt solution.

Dehydrating : a method of food preservation that involves removing the water from the food. (Drying food)

Dhals : decorticated, split products from pulse.

Drying Food : Drying is a method of food preservation that is simple, safe and easy to learn. Drying also creates new food products such as fruit leather, banana chips, pumpkin seeds and beef jerky.

Emulsifier : A substance that is used to prevent the liquids in an emulsion from separating into layers.

Enzymes : Protein molecules produced by living cells which act as catalysts in chemical reactions.

Fermentation : It is the transformation of sugars by intentional growth microorganisms (bacteria, yeast or mold). The fermentation of these sugars by yeast yields alcohol. This process takes place in big tanks, called fermenters.

Food additive : A substance added to food that enhance the palatability or preserve the foods.

Food spoilage : It occurs due to growth of microorganisms, action of enzymes present in the food, mechanical and insect damage to the food.

Freezer : A reach-in or walk-in food storage unit that maintains a temperature of 0°F (-18°C) or less.

Freezing : A method of food preservation involving low temperatures (-18° C), a change of state of a substance from liquid to solid.

Hermetic seal	**:** An absolutely airtight container seal, which prevents reentry of air or microorganisms into packaged foods.
Infestation	**:** invasion by insects and pests.
Irradiation	**:** The treatment of food with ionizing radiation to kill microorganisms.
Low-acid foods	**:** Foods, which contain very little acid and have a pH above 4.5. Vegetables, tomatoes, figs, all meats, fish, seafood and some dairy foods are low acid.
Oxidation	**:** Reaction with the oxygen in the air, causes food to go bad
Pasteurization	**:** A heating process designed to destroy the most heat-resistant pathogenic or disease-causing microorganism in a food product.
Perishable Food	**:** Food product that spoils readily without special processing or preservation techniques e.g. meats, poultry, fish, shellfish, eggs, dairy products, and most fruits and vegetables.
Pickling	**:** The practice of adding enough vinegar or lemon juice to a low-acid food to lower its pH to 4.6 or lower.
Preservative	**:** a substance used to prolong the shelf life of foods or to prevent the spoilage of food.
Pulses	**:** edible seeds of leguminous plants.
Rancidity	**:** Development of any off or disagreeable flavors in oil or fat due to enzymatic or oxidative reactions.
Sterilization	**:** A process that destroys virtually all microorganisms and their spores.
Yeast	**:** The one-celled microorganism that turns sugar into alcohol and carbon dioxide.

10.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Food processing refers to the transformation of raw materials and ingredients into wholesome, safe, nutritious, convenience and acceptable food to consumers throughout the year.

   Food preservation refers to the process in which the, perishable food materials are given a suitable physical or chemical treatment to prevent their wastage, spoilage and to retain their nutritive value for long periods.

2. The major causes of food deterioration/spoilage are bacteria, molds, yeasts; enzyme present in food itself e.g. polyphenolase, lipase, peroxidase, Catalase; insects, rodents; oxidation, hydrolysis; Physical damage.

3. The effects of food deterioration are spoilage by pathogenic microorganisms can be injurious to health, nutrient loss, loss of organoleptic quality (colour, texture, taste, aroma), loss of functionality.

4. The advantages of food processing are many. Processing can prevent food deterioration or spoilage; processing can extend shelf-life (e.g. preservation); processing can enhance quality (e.g. cooking); processing can generate employment; processing ensures the availability of food round the year, safety, convenience and quality food products.

5. Asepsis; filtration, centrifugation, washing, trimming; drying and smoking; sugaring; pickling; curing; fermentation; refrigeration, chilling, freezing; pasteurization, boiling, canning; chemical preservatives; carbonation; Irradiation and combination of the two or more of the above methods.

6. (ii)

Check Your Progress Exercise 2

(i) True.

(ii) False. It deals with keeping out microorganisms

(iii) True

(iv) False. More susceptible to browning etc

(v) True

(vi) False. Lactic acid and alcohol excreted by the microorganisms

(vii) True

(viii) False. Meat, fish and their products

(ix) False. At low temperatures, retard chemical reactions and action of food enzymes; slow down or stop growth and activity of microorganisms in food

(x) False. Kills part but not all the microorganisms present.

(xi) False. Low acid foods are processed at temperature above 100° C.

(xii) True

(xiii) False. Measured in rads (and kilorad or megarad)