LECTURE 14: Principles and methods of processing and preservation

The Green Revolution, better management practices and subsequent efforts through the application of science and technology for increasing food production in India have brought self reliance in food. The nation become self reliance but available produce could not reach to the consumer so we are, still facing the problem of use of under nutrition and malnutrition. Properly planned agri-produce if process, it can reduce the waste, enhances employability and can contribute to the economic development of rural population at large.

The fruits and vegetables are comparative higher value than cereals and more perishables. Losses in the fruits and vegetables are high and chances to reduce the waste and enhancing the employability through post harvest processing are more. The processing includes pre-processing of fruits and vegetables before these are fit to final conversation into processed foods. The food preservation and processing industry has now become of a necessity than being a luxury. It has an important role in conservation and better utilization of fruits and vegetables. In order to avoid the glut and utilize the surplus during the season, it is necessary to employ modern methods to extend storage life for better distribution and also processing techniques to preserve them for utilization in the off season on both large scale and small scale.

Food processing therefore refers to the application of techniques to foods in a systematic manner for preventing losses through preservation, processing, packaging, storage and distribution, ultimately to ensure greater availability of a wide variety of foods which would help to improve the food intake and nutritional standards during the periods of low availability. The main objective of fruits and vegetables processing is to supply wholesome safe, nutritious and acceptable food to consumers throughout the year.

Prerequisites of preservation are cleaning, grading and sorting as per maturity.

1. Cleaning: It is a unit operation in which contaminating materials are removed from the food material and separated to leave the surface of the food in a suitable condition for further processing. In vegetable processing, blanching also helps to clean the product. In addition, the early removal of small quantities of food contaminated by micro-organisms prevents the subsequent loss of the remaining bulk by microbial growth during storage or delays before processing.

Wet cleaning: Wet cleaning is more effective than dry methods for removing soil from root crops or dust and pesticide residues from soft fruits or vegetables. It is also dustless and causes less damage to foods than dry methods.

Dry cleaning: Dry cleaning procedures are used for products that are smaller, have greater mechanical strength and possess lower moisture content (for example grains and nuts). After cleaning, the surfaces are dry, to aid preservation or further drying. The main groups of equipment used for dry cleaning are;

- air classifiers
- magnetic separators

- separators based on screening of foods

Removing contaminants and foreign bodies: Physical separation of contaminants from food is possible when the food has regular well defined shape. e.g. round foods are separated from contaminants by exploiting their ability to roll down in inclined, upward moving conveyor belt.

2. Sorting: Sorting is the separation of foods into categories on the basis of a measurable physical property. Like cleaning, sorting should be employed as early as possible to ensure a uniform product for subsequent processing. The four main physical properties used to sort foods are size, shape, weight and color.

Shape and size sorting: The particle size distribution of a material is expressed as either the mass fraction of material that is retained on each sieve or cumulative percentage of material retained. Size sorting is the separation of solids into two or more fractions on the basis of differences in size.

Color sorting: Small particulate foods may be automatically sorted at high rates using microprocessor controlled color sorting equipment. Particles are fed into chute one at a time. The angle, shape and lining material of chute are altered to control the velocity of pieces as the pass a photo detector. Photo detectors measure the reflected color of each piece and compare it with preset standards, and defective foods are separated by a short blast of compressed air.

Weight sorting: Weight sorting is more accurate than other methods and is therefore used for more valuable foods. Aspiration and flotation sorting use differences in density to sort food and are similar in principle and operation to aspiration and flotation cleaning.

3. Grading: This term is often used interchangeably with sorting but strictly means 'the assessment of overall quality of a food using a number of attributes'. Grading is carried out by machines or operators who are trained to simultaneously assess a number of variables.

The basic principles of preserving bio materials and their respective methods are given in the following table.

Sr. No.	Principle	Method
1	Reducing temperature so that deteriorating reactions occurring within the bio materials are minimized	Evaporating Cool ChamberRefrigerated StorageCold storageFreezing
2	Creation of an environment of gases such deteriorating bio chemicals reduce their activities.	Hermetic StorageControlled Storage and Modified Packaging
3	Reduce chemical potential of water (water activity reduction) 1. Application of heat 2. Addition of solute so that water is	Drying and Dehydration, Convective microwave drying, pasteurization and sterilizationOsmo-dehydration

	strongly bound	
4	Production of chemicals through fermentation which will be detrimental to the microbes causing food spoilage	PicklingControlled fermentationAerobic, Anaerobic
5	Innovative methods	Irradiations, Dielectric, infrared and Ohmic heating

The methods and principles can further classify based on food preservations. These are;

1. Control of Water Activity

Water activity of the food can be control the different methods which are explained hereunder.

a. Evaporation: Frequently in the food industry a raw material or a potential foodstuff contains more water than is required in the final product. When the foodstuff is a liquid, the easiest method of removing the water, in general, is to apply heat to evaporate it. Evaporation is thus a process that is often used by the food technologist. The basic factors that affect the rate of evaporation are;

- Rate at which heat can be transferred to the liquid
- Quantity of heat required to evaporate each kg of water
- Maximum allowable temperature of the liquid
- Pressure at which the evaporation takes place
- Changes that may occur in the foodstuff during the course of the evaporation process

b. Dehydration: It is defined as the application of heat under controlled conditions to remove the majority of the water normally present in a food by evaporation. The main purpose of dehydration is to extend the shelf life of foods by reduction in water activity.

c. Osmo-dehydration: In osmo-dehydration, the prepared fresh material is soaked in a thick liquid sugar solution and or a strong salt solution and then the material is dried. During osmotic treatment, the material loses some of its moisture. The syrup or salt solution has a protective effect on colour, flavor and texture. This protective effect remains throughout the drying process and makes it possible to produce dried products of high quality.

d. Drying: Drying is the process to remove the moisture content from the food material and thereby reduce the water activity and extend the shelf life. Several types of dryers and drying methods are commercially used. This is depending upon the form of material and its properties, desired physical form and characteristics of dried products, operating cost, etc. Sun drying, solar drying, atmospheric drying (batch type) like, kiln, tower, cabinet and (continuous type) like tunnel, belt, fluidized bed, puff, foam mat, spray, drum and microwave, etc.

2. Cold Treatment

Cold treatment is the treatment like, fermentation, irradiation, di-electric, ohmic, infrared heating, freezing, super cooling, refrigeration, etc. given to the food materials for increasing the shelf life.

a. Fermentation: During food fermentations, the controlled action of selected micro-organisms is used to alter the texture of foods, preserve foods by production of acids or alcohol, or to produce subtle flavors and aromas which increase the quality and value of raw materials. Main advantages are;

- The use of mild conditions of pH and temperature which maintain the nutritional properties and sensory characteristics of the food.
- The production of foods which have flavors or textures that cannot be achieved by other methods
- Low energy consumption due to the mild operating conditions
- Relatively low capital and operating costs
- Relatively simple technologies

b. Irradiation: Ionizing radiation takes the form of Υ-rays from isotopes or, commercially to a lesser extent, from X-rays and electrons. Main advantages are;

- There is little or no heating of the food and therefore negligible change to sensory characteristics.
- Packaged and frozen foods may be treated.
- Fresh foods may be preserved in a single operation, and without the use of chemical preservatives
- Energy requirements are very low
- Changes in nutritional value of foods are comparable with other methods of food preservation
- Processing is automatically controlled and has low operation costs.

Applications of Irradiation;

- Sterilization
- Reduction of pathogens
- Prolonging shelf life
- Control of ripening
- Disinfestations
- Inhibition of sprouting

c. Dielectric, Ohmic and Infrared heating: Dielectric energy and infrared energy are two forms of electromagnetic energy. They are both transmitted as waves which penetrate food and are then absorbed and converted to heat. In contrast, ohmic heating uses the electrical resistance of foods to directly convert electricity to heat. Dielectric and ohmic heating are direct methods in which heat is generated within the product, whereas infrared heating is an indirect method that relies on heat that is generated externally being applied to the surface of the food mostly by radiation, but also by convection and to a lesser extent conduction.

d. Freezing: Freezing is the reduction in temperature generally by super cooling followed by crystallization of water, nucleation and finely crystal growth.

Methods of quick freezing

- Freezing by indirect contact with a refrigerant
- Freezing in a blast of cold air
- Freezing by direct immersion in a refrigerating medium

Freezing by indirect contact with refrigerant: Food may be frozen by being placed in a contact with a metal surface which is cooled by a refrigerant or packaged or packed in a can and cooled by immersion in a refrigerant. Also food packaged in paper boxes may be frozen by contact with refrigerated metal plate which may be moving or stationary.

Air Blast freezing: To obtain very cold air, a blast of air is directed through refrigerating coil. For greater effect, the cold air blast is confined in an insulated tunnel. The material to be frozen may be placed on a moving belt within variable of moved countercurrent and the air blast.

Freezing by direct immersion (FBDI): FBDI in low temperature drying was the beginning of quick freezing. Since liquid are good heat conductors, a product can be frozen rapidly by direct immersion in low temperature liquid for example brine and sugar solutions.

Freezing time: The definition of freezing time is a function of two instances i.e. when freezing starts and when it stops. It is very difficult to determine the freezing time (q) since freezing will occur at different rate and at different point in a piece of food. The freezing will be faster at some point on the surface and in the body of the piece of food, there is a point which cools slowest. The highest temperature at which ice crystals have a stable existence in a food material is known as the freezing point of that material and this signals the starts of freezing time. Because of the nature of materials of food and the presence of water soluble constituents, all water does not crystallize at this temperature, this is known as cryoscopy effect.

e. Super Cooling: Occurs when temperature of water is lowered below the freezing point and crystallization does not occur. The super cooling provides the means of determining the in depth effect of a reduction in temperature relative to the initial freezing point.

f. Refrigeration: This is the process by which heat is removed from a confined place and material for the purpose of maintaining a lower temperature. The standard unit of generating heat capacity is 1 tone of refrigeration. This is derived on the basis of removal of latent heat of fusion of 1 tone of water at 32^{o} F or 0^{o}C to produce 1 tons of ice.

3. Control of Microbial Activity

Food materials can be stored for longer period by controlling the microbial activities by pasteurization and sterilization methods.

a. Pasteurization: Pasteurization is a relatively mild heat treatment, in which food is heated to below 100^{o}C. In low acid foods it is used to minimize possible health hazards from pathogenic micro-organisms and to extend the shelf life of foods for several days. In acidic foods it is used to extend the shelf life for several months by destruction of spoilage micro-organisms and or enzymatic inactivation.

b. Heat sterilization: It is the unit operation in which foods are heated at a sufficiently high temperature and for a sufficiently long time to destroy microbial and enzyme activity. As a result, sterilized foods have a shelf life in excess of six months at ambient temperatures provided they are aseptically packed after sterilization to avoid post sterilization

contamination. Severe heat treatment of sterilization causes damage to the nutrition and it can be avoided by development of suitable processing technology.