Lecture 34: Food Technology

34.1 Introduction

Food technology has evolved into an interdisciplinary area of applied science and engineering based on chemical engineering and food science. India is primarily based on agriculture. The demand for uniform and high quality food round the year even at remote places from production centre has led to improved food processing technologies. Food industries are almost double the size of chemical industries.

34.2 Food industries can be divided into following sections:

- Consumer food industry (confectionaries, cocoa products, bakery products, soft drinks etc.)
- Grain processing
- Marine products
- Dairy products
- Poultry and meat products
- Fruit and vegetable processing
- Fats and oils
- Sugar

34.3 Emphasis of food industries

Food industries emphasize on four different operations namely food storage, food processing, food transport and food preservation.

(i) Food storage

Food storage includes improved storage of food such as refrigeration cycles, refrigerants, and better insulation. Food industries process the raw materials as soon as they are recovered. Sometimes due to unavoidable circumstances such as early arrivals, non-availability, market price considerations which change according to time, the raw materials have to stored before processing.
The storing area should be well ventilated, shaded, should use water baths, and if necessary, cold storage must be used. Before storage, all bruised, shriveled, discolored or soured portions should be removed.

(ii) **Food Processing**

Food processing involves conversion of raw plant and animal tissues into edible ingredients and separation of inedible and hazardous components, extraction or concentration of nutrients, flavors, colors and other useful components and removal of water.

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| Mass Transfer Operations | Drying  
|--------------------------|--------|
|                          | Extraction, Distillation  
|                          | Absorption, Adsorption  
|                          | Crystallization from Solution  
|                          | Ion Exchange  
| Membrane Separations     | Ultrafiltration  
|                          | Reverse Osmosis  
| Non-Thermal Preservation | Irradiation  
|                          | High Pressure  
|                          | Pulsed Electric Fields  
| Packaging                | Filling, Closing  
|                          | Metallic, Plastic Packages  
|                          | Aseptic Packaging  

**Types of food processing:**

(a) Refining and Milling  
(b) Canning  
(c) Concentration  
(d) Freezing  
(e) Drying  
(f) Pasteurization and sterilization  
(g) Fermentation  
(h) Irradiation  
(i) Packaging  

(a) **Refining and Milling:**

- Sugar obtained from sugar cane is converted to final sugar by refining process.  
- Milling is the process of converting grain into powder (flour) by mechanical means.  
- In milling operation, grain is cleaned and crushed between two steel rolls.
(b) Canning:

- Fresh food like fruits, vegetables, meat, fish etc. are preserved for long time storage by heat treatment and sealing into air-tight containers.
- These cans may be made by tin, untinned steel, which is often plastic-lined, aluminium or glass.
- Heat treatment is given to the container by placing them in a steam pressure vessel at a temperature of 121°C depending on container size and nature of food.
- The toxin produced by microorganism is clostridium botulinum. Therefore processing must be done to destroy this organism.

(c) Concentration:

- Foodstuff which naturally contains high percentage of water is concentrated before preservation.
- Milk is evaporated from 8.6% solid content to 45% solid content.
- Fruit juices are also concentrated before marketing.
- Usually the volume is reduced to one-third of the original volume.
- For food concentration three processes are available- evaporation with evaporators, reverse osmosis and freeze concentration.

(d) Freezing:

- Freezing does not kill the microorganisms which cause spoilage, but freezing inactivate microorganisms.
- Nutrients are not destroyed by freezing.
- Inactivation of enzymes by heat treatment (blanching) is done before freezing to prevent unwanted changes.
- To improve the quality of final product, the amount of water in food is reduced before freezing.
(e) **Drying:**
- Cereal grains, fruits, pastas, milk, coffee, tea, some vegetables and meats are dried.
- After drying volume is reduced to one tenth of the original volume.
- Dried foods are easy to transport and store.
- The nutritive value of dried food is usually unchanged but vitamin content is reduced.
- Microbial growth is controlled.

(f) **Pasteurization and sterilization:**
- Heat treatment inactivates the microorganisms but changes the taste of food and its appearance.
- The high temperature short time (HTST) method exposes the milk to 73°C for not less than 16 sec, followed by rapid cooling. This process is called pasteurization.
- Pasteurization kills pathogenic (disease causing) microorganisms, eliminates food borne disease and inactive enzymes.
- Milk can be stored for several months at room temperature.

(g) **Fermentation:**
- All organisms are not detrimental.
- Fermentation produces carbon dioxide but no putrid odor.
- Fermentation is decomposition of carbohydrate.
- These industries produce vinegar, wine, beer and other alcoholic beverages. It is also used in making bread, cheese, salting of food etc.

(h) **Irradiation:**
- Irradiation is required to kill microorganism present in food.
- Irradiation is used to preserve proteinous food such as meat, fish, fresh fruits, vegetables, flour, spices etc.
- Irradiation does not denaturate protein, does not alter taste and does not leave any radioactive residue in the food.
• Loss of vitamins is less as compared to canning, freezing or drying.

(i) Packaging:

• The objective of packaging is to store and transport safely without deterioration of food.
• Containers are sealed so that no outside contaminant can enter and cause food spoilage.
• Cardboard boxes, cans, glass bottles, polythene, plastic coated paper, finely woven cloth are commonly used for packing.

References:

Dryden C. E., Outlines of Chemical Technology, East-West Press, 2008
Lecture 35

35.1 Food Processing Equipments

(a) Sanitary Design and Material of construction

- Hygienic or sanitary design of food processing equipment is based on proper selection of material of construction and fabrication techniques.
- Chemical and biological properties also play an important role in designing of equipments in food industries.
- The major problem is corrosion and toxicity of food products due to corrosion.
- pH of food products should also be considered for material selection.
- Stainless steel is widely used for being corrosion resistant.

Three A have set standard special features for design of equipment to ensure sanitary conditions. These are as follows:

- Material, in general, should be 18-8 stainless steel, with a carbon content of not more than 0.12%, or equally corrosion-resistant material.
- The gage of metal should be sufficient for various applications.
- Product surfaces fabricated from sheets should have a No.4 finish or equivalent.
- Square corners should be avoided. Minimum radii are often specified. For example a storage tank must have inside corners of 6.4mm for permanent attachments.
- No threads should be in contact with food. Acme threads should be used.
- Surfaces should be sopped to provide drainage.
- Designs should permit interchangeability of parts.

(b) Cleaning

- Cleaning is an integral part of food processing operation.
- The process should ensure the microbiological safety of final products.
- After cleaning, the surface should be washed with hot water and left to dry.
Three –A standards for cleaning in place are as follows:

- Using alkali or acid solutions appropriate for the product and equipment surface.
- Providing a time of exposure of 10 to 60 min to remove substances without damage to the metal.
- Utilizing a velocity of flow of 1.5m/s (1 to 3m/s).
- Maintaining a slope of surface and tubing to provide for drainage (5 to 10mm/m).
- Avoiding dead ends for flows.
- Using connections and joints that are cleanable (welded joints, clamp-type joints, appropriate gaskets).

(c) Controls:
- Continuous processes are better than batch operation to save processing cost and for better uniformity.
- Quality control is greatly improved by computer control.
- Cheese plant uses process control computer to regulate process.

(iii) Food transport:

It involves chemical engineers in designing refrigerated container, for transporting food products from the place of production to the consumers by rail and road carriers.

(iv) Food preservation

It means preserving final food products for longer use and storage with the help of chemical additives, freezing, drying, inert gas blanketing etc. Preservation operation reduce or eliminate food spoilage.
35.2 Tomato-paste processing plant

Tomato processing plant produces tomato paste. It includes various processing equipments and many unit operations and processes such as washing, inspecting, pulping, finishing, evaporation, sterilization, aseptic packaging and finally storage of tomato paste. A simplified process block diagram is shown in figure. Due to seasonal variability of raw tomato, material and energy balance are required periodically, during the operation of the food processing plant.

35.3 Potato chips processing plant

Solar energy is basically used for frying potatoes. The rising energy cost has necessitated using solar energy. Solar energy is collected through parabolic trough collectors to heat pressurized water. In steam flash heated water is converted to steam. The produced steam and steam from a gas-fired boiler is used to heat the fryer through a heat exchanger. To conserve energy, cogeneration of electricity with process steam is done to save about 20% of total energy.

35.4 Food Additives

Food additives improve nutritional compositions, flavor and storage stability in food products. It is used in small quantities. Food additives may be categorized with some of their examples. These are categorized according to functional and nutritional benefits provided to food rather than chemical identity of additives. Some of these are summarized as below.

**Acidulants:** eg. adipic acid, citric acid, fumaric acid, lactic acid, malic acid, phosphoric acid, tartaric acid.

**Anticaking and free flow agents:** eg. Calcium silicate (CaSiO₃), Calcium stearate (C₃₆H₇₀CO₄), Magnesium silicate, Magnesium carbonate.

**Antifoaming agents:** eg. Polydimethylsiloxane
Antioxidants: eg. Butylatedhydroxyanisole (C\textsubscript{11}H\textsubscript{16}O\textsubscript{2}), Propyl gallate (C\textsubscript{10}H\textsubscript{12}O\textsubscript{5}), Ascorbic acid, Erythorbic acid

Bulking agents: eg. Polydextrose

Coloring agents: eg. Beet powder, caramel, saffron titanium dioxide and FDA certified chemicals

Dietary fibres: eg. Cellulose, hemicellulose, pentosans, pectins

Emulsifiers: eg. Glycerol monostearate, succinylated monoglyceride, propylene glycolmonostearate, sodium stearoyl-2-lactylate, polyoxethylenesorbitan, monooleate, lecithin, sucrose esters.

Enzymes: eg. Amylase, glucoamylase, lactase, pectin methylesterase, lysozyme, lipase, trypsin, glucose isomerase, glucose oxidase.

Fat replacer: eg. Protein, caprenin, caprylic acid.

Firming agents: eg. Calcium chloride, acidic aluminium salts.

Flavors: eg. Essential oils, fruit juices, aroma chemicals.

Flavor enhancers: eg. Monosodium L-glutamate, ammonium glycyrrhizinate.

Flour bleaching agents and bread improvers: eg. Benzoyl peroxide

Formulation aids: eg. Starches, dextrins, maltodextrin, mineral oils.


Gases: eg. Nitrogen, carbon dioxide


Leavening agents: eg. Sodium bicarbonate

Non – nutritive sweeteners: eg. Aspartame, saccharin.
Nutrient supplements: eg. Riboflavin, niacin, iron.

Preservatives: eg. Benzoates, sorbates, propionates, sulfur dioxide, sulfites.

Processing aids: eg. Gelatin, lime

Solvents: eg. Ethanol, glycerin, propylene glycol.

Stabilizers and thickeners: eg. Gaur gum, carrageenan, cellulose.

35.5 Technical Questions

1. What are the byproducts of food industries?

Ans: Leather, gelatin and adhesives.

2. How is effective pasteurization and sterilization processing carried out?

Ans: Heating alters the odor and taste of food and other chemical changes also take place. Short time-high temperature treatment causes less deterioration than long-time low temperature processes. To provide adequate heat penetration using a short time treatment, agitated cookers are used. Agitation increases the rate of heat transfer from container to food product.

3. How effectively is freezing processing carried out?

Ans: For preservation of fresh food, food should be frozen very quickly (supercooled) and maintained at enough low temperature to prevent appreciable ice crystal formation. By this way, quality of food does not deteriorate and microorganisms do not increase to great extent. Generally slow freezing produces large ice crystals in the cells of the food which rupture the cells and cause a breakdown of the structure of the food and allows undesirable enzyme reactions even at a very low temperature (-18°C).
4. Why is vacuum evaporation preferred for juice concentration rather than evaporation at atmospheric pressure?
Ans: Vacuum evaporation involves evaporation of water from fruit juices at lower pressures. It is well known that the boiling point of a liquid increases with increasing temperature and hence processing at higher temperature would damage heat sensitive biological compounds in the juice. Therefore, vacuum evaporation will contribute towards achieving the boiling point of juice at temperatures close to the room temperature and thereby safeguard the nutritional content of the fruit juices.

5. What characterization methods are applicable for food process technologies?
Ans: Food chemistry and biotechnology related characterization methods need to be applied for the analysis of the concentration of various species contributing towards flavors and nutrition. Other than this, food process technologies also need to assess upon the toxicity of the processed food along with the maximum allowable shelf time, before the processed food is dangerous for human consumption.

References:

Dryden C. E., Outlines of Chemical Technology, East-West Press, 2008