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UNIT V
PRESERVATION BY COOLING

Topic: Freezing Equipments

Freezing equipment: The equipment for freezing can be categorized in different ways, namely as equipment used for batch or in-line operation, heat transfer systems (air, contact, cryogenic), and product stability.

Three Types:

Air blast Freezer or Cooled air freezers

Contact Freezer

Cryogenic Freezer

A Air blast Freezer or Cooled air freezers

1. **Air blast freezer:** Air blast freezing refers to freezing of products in a powerful blast of circulating cold air at a temperature from -18 to -400C under forced circulation. The air blast freezer is one of the oldest and commonly used freezing equipment due to its temperature stability and versatility for several product types. Air is used as the freezing medium in the freezing design, either as still air or forced air. The air is re-circulated over food at a velocity of 1.5-6.0 m/s. The high air velocity reduces the thickness of boundary films surrounding food and thus improves the surface heat transfer co-efficient. For freezing in batch system the foods is stacked on trays in rooms or cabinets. While continuous system consists of trolleys stacked with trays of food or on conveyor belts which carry the food through an insulated tunnel. Multi-pass tunnels contain a number of belts and products falls from one to another. This action breaks up any clumps of foods and allows control over the product depth (for example a 25-50 mm bed is initially frozen for 5-10 minutes and then repiled to 100-125 mm on second belt). Air flow is either parallel or perpendicular to the food and is directed to pass evenly over all food pieces. Blast freezing is economical and highly flexible for different shapes and sizes of the food. The equipment is compact and has a relatively low capital cost and high throughput (200-1500 kg h-1).
2. **Fluidized bed freezer:** These are modified blast freezers in which air between -25^{o}C and -35^{o}C is passed at a high velocity (2-6m/s) through a 2-13 cm bed of food, contained on a perforated tray or conveyor belt. The shape and size of food pieces determines thickness of fluidized bed and air velocity needed for fluidization. The foodstuff is fluidized to form a bed of particle followed by freezing. Air is forced upward through belt o suspend the particles. In fluidized bed freezer, the food comes in to greater contact with the air than in blast freezer and thus all surfaces are frozen simultaneously and uniformly. The use of high air velocity is very effective for

freezing unpacked foods, especially when they can be completely surrounded by flowing air, as in the case of fluidized bed freezers. The product zone in the freezer is constructed with stainless steel and food grade plastic for easier maintenance. In some cases, the freezing is done in two stages; firstly the initial rapid freezing to produce ice glaze on food surface, followed by freezing on second belt in beds 10-15cm deep. Small vegetables, french-fried potatoes and fruits like strawberries are some of the products now frozen with this technology.

B. Contact Freezer

1. Immersion freezer: In immersion freezer, the food comes in direct contact with the refrigerant. For freezing, the food is passed through a bath of refrigerated propylene glycol, brine, glycerol or calcium chloride solution on a submerged mesh conveyor. In contrast with cryogenic freezing, the liquid in immersions freezer remains fluid throughout the freezing operation and change of state does not occur. Immersion freezer involves less capital cost and offers high rates of heat transfer. They are used commercially for concentrated orange juice in laminated polyethylene cans. Freezing of orange juice in cans and peas to -18^0C in immersion freezing generally takes 10-15 minutes and 30 seconds respectively. Direct immersion of a product into a liquid refrigerant is the most rapid way of freezing since liquids have better heat conducting properties than air. The solute used in the freezing system should be safe without taste, odour, colour or flavour and for successful freezing; products should be greater in density than the solution.

2. Plate freezer: These freezers consist of a vertical or horizontal series of hollow plates, through which refrigerant is pumped at -40oC temperature. In this case, the product is pressed between hallow metal plates, either horizontally or vertically, with a refrigerant circulating inside the plates. Vertical plate freezers are suitable for the viscous products like orange juice whereas, horizontal plate freezers are suitable for packaged products like vegetable or fish fillets. For freezing, flat and relatively thin foods are placed in single layers between plates and a slight pressure is applied by moving plates together. This improves contact between the food and plates and thus increases the rate of heat transfer.

Advantages: Plate freezers include advantages like good economy and space utilization, low operating costs, minimum defrosting of condenser and high rate of heat transfer.

C. Cryogenic Freezers

The Cryogenic freezers use solid or liquid carbon dioxide, liquid nitrogen directly in contact with the food and refrigeration is obtained as a pre-cooled substances. Cryogenic freezers used are carbon dioxide, liquid nitrogen or Freon. Cryogenic freezers are characterized by a change of state in the refrigerant (Cryogen) as heat is absorbed from the freezing food. The food is exposed to an atmosphere below -60°C through direct contact with liquefied gases such as nitrogen or carbon dioxide. The heat from the food provides the latent heat of vaporization or sublimation of the cryogen. The cryogen is in intimate contact with the food and rapidly removes heat from all surfaces co-efficient and rapid freezing. Liquid nitrogen and solid on liquid carbon dioxide are the commonly used refrigerants. Low initial investment and rather

high operating costs are typical for cryogenic freezers. The limitation cryogenic freezer is the rate of excess cryogen residue in foods.

1. Liquid nitrogen freezers: Liquid nitrogen refrigerants are colourless and odourless. In these freezers, the packaged or unpackaged food travels on a perforated belt through a tunnel where product is cooled by gaseous nitrogen and frozen by liquid nitrogen spray. Liquid nitrogen, with a boiling temperature of -196°C at atmospheric pressure, is a by-product of oxygen manufacture. The refrigerant is sprayed into the freezer and evaporates both on leaving the spray nozzles and on contact with the products. Typical food products used in this system are fish fillets, seafood and fruits like berries. The temperature is either allowed to equilibrate at the required storage temperature (18-30°C) before the food is removed from the freezers or alternatively food is passed to a mechanical freezer to complete the freezing process. The use of gaseous nitrogen reduces the thermal shock to the food and recirculation fans increases the rate of heat transfer.

2. Liquid carbon dioxide freezers: Liquid carbon dioxide exists either as a solid or gas when stored at an atmospheric pressure. When the gas is released to the atmosphere at -70°C, half of the gas becomes dry-ice snow and the other half stays in the form of vapour. This unusual property of liquid carbon dioxide is used in a variety of freezing systems, one of which is a pre-freezing treatment before the product is exposed to nitrogen spray.

Disadvantages: High capital costs and suitability only for flat and thin foods are the major disadvantages.
A typical plate freezer is shown in Figure 13.9. Plate freezers may be batch, semi-continuous or continuous in operation.