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FREEZING OF FOOD PRODUCTS: A REVIEW

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ABSTRACT

Freezing is a technique in which the temperature of any food product is reduced below its freezing point and water content undergoes a change in state into ice. Implementing freezing technique for storing food product after harvest has been presented in this paper. Degree of cell wall rupture is related to freezing produced. Small sized ice crystals are responsible for less cell wall rupture than large ice crystals. If freezing is rapid a large number of small ice crystals are produced while slow freezing produces a few large ice crystals. Effect of freezing rate on quality and texture has also been presented. It was observed that freshness, texture, color, flavor and nutrient values of food product remain preserve during freezing. Important types of industrial freezers are also described in detail.

Keywords: Freezing, storing of food products, types of freezer.

I. INTRODUCTION TO FREEZING

Freezing of foods is one of the best available methods for preservation of the food products. It maintains the quality of the food products quite close to that of the fresh ones. Freezing is a phase transformation process, in which a liquid is converted into solid when its temperature is lowered below its freezing point. Hence, in order to achieve freezing, the food product should be exposed to low temperature. Micro-organisms (such as bacteria, yeast and moulds) cause spoilage of food products like meats, poultry, fish, dairy products etc. At normal room temperature, micro-organisms are active and cause spoilage of food products. If the temperature of food products is lowered significantly, the action of these micro-organisms is retarded to a greater extent, making it possible to store the food products for longer duration of time.

In early freezer designs, freeze food products were found to be laced with crystals of ice. However, in modern designs, the temperature is plunged quickly through the freezing zone. Generally, liquids freeze by crystallization which consists of- nucleation and crystal growth. Nucleation is the process in which the molecules start to gather into clusters (on the nanometer scale), arranging in a defined pattern that defines the structure of crystal. It takes place in a gas, liquid or solid phase. For example, ice formation from water.

The crystal growth is the subsequent growth of the nuclei that succeed in achieving the critical cluster size. Nucleation can take place at nucleation sites on surfaces contacting the liquid or vapor. Suspended particles or minute bubbles can also act as a site for nucleation. This is known as heterogeneous nucleation. Nucleation that

takes place without preferential nucleation sites is known as homogeneous nucleation. Homogeneous nucleation takes place spontaneously and in random manner, but it needs super-cooling of the medium.

II. RATE OF FREEZING

Freezing produced controls the degree of cell wall rupture of food products. In fast freezing, a large number of small ice crystals are produced. These small sized ice crystals leads to less cell wall rupture than slow freezing which produces only a few large ice crystals. Therefore, freezer manuals suggest that the temperature of the freezer be set at the coldest setting several hours before food products are placed inside it. Some manuals recommend the location of the coldest place inside the freezer and suggest placing unfrozen products at that site. The maximum number of cubic feet of unfrozen food product, which can be frozen at a given time, is also specified. Overloading the freezer with unfrozen food products can lead to long and slow freezing rate. Thus, overloading of freezer should be avoided.

III. FREEZING EQUIPMENTS

The industrial equipment for freezing can be categorized as follows:

1. Air-blast freezing equipments, where refrigerated air at certain velocity is blown over of food products.
2. Contact freezing equipments, where the food products are placed in contact with metal surfaces.
3. Immersion freezing equipments, where the food product is placed in a low-temperature brine.
4. Fluidized-bed freezing equipments, where the individual food products are moved along a conveyor belt and kept in suspension by an upward-directed stream of sufficiently cold air
5. Equipments utilizing a cryogenic substance (such as nitrogen or carbon dioxide).

IV. EFFECT OF FREEZING RATES ON QUALITY AND TEXTURE

In order to obtain frozen food products of high quality and maximum nutritional value, one should have sufficient knowledge of:

a) The chemical and physical reactions that take place during the freezing process.
b) Scientific knowledge of the effect of freezing on the tissues of food products.
c) Food microbiology.

The function of freezing process is to preserve food products at the same time its quality is maintained. This is achieved by lowering down the temperature of food product, hence slowing the quality deterioration processes, the oxidation of fat, the retarding action of microorganisms, enzymatic reactions and the loss of moisture from the surface of food products. Fresh fruits and vegetables, after being harvested, continue to undergo chemical changes, which deteriorate quality of the food product. Therefore such products should be stored in freezer soon after being harvest and at their peak degree of ripeness. Fresh food products contain chemical compounds known as enzymes, which cause the loss of texture, loss of nutrients, flavor changes in frozen products. These enzymes should therefore be inactivated to prevent such reactions. The blanching process is employed for inactivation of enzymes in vegetables. In blanching process, vegetable is the exposure to boiling water, steam or micro-oven for a short duration of time. This process is followed by rapid cooling of the vegetable in ice water.

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The formation of small ice crystals during freezing is required. Rapid freezing is the practical way to form large number of small ice crystals. Large ice crystals produced as a result of on slow freezing leads to damage of cell, causing unnecessary change in. Most of fruits and vegetables contain about 90% of water by weight held within the cell walls and provides structural support and texture to them. Freezing fruits and vegetables mainly results in freezing of this water. When the water freezes, it expands and the ice crystals cause damage to the cell walls. Consequently, the texture of the defrosted food product will be much softer than it was when raw. This textural change is discernable in products, which are consumed raw. For example, a frozen tomato when defrosted becomes mushy and watery. Therefore, tomatoes are not generally frozen. Textural changes due to freezing are not noticeable in products which are cooked before eating because cooking also softens cell walls. Also, these changes are not observed in vegetables having high starch content such as peas, corn etc.

V. TYPES OF FREEZERS

Important types of freezer are described below:

5.1 Blast Freezer

The simplest technique of freezing is to place the food product in insulated cold storage room maintained at sub-freezing condition. In such case, heat transfer is by natural convection will occur. This result to slow freezing rat and produces large ice crystals in the food products and gives sufficient time for missing of flavors of different food products. Thus, deteriorate the quality of the food products. In air-blast freezers, refrigerated air at certain velocity is blown over the food product and convective heat transfer takes place.

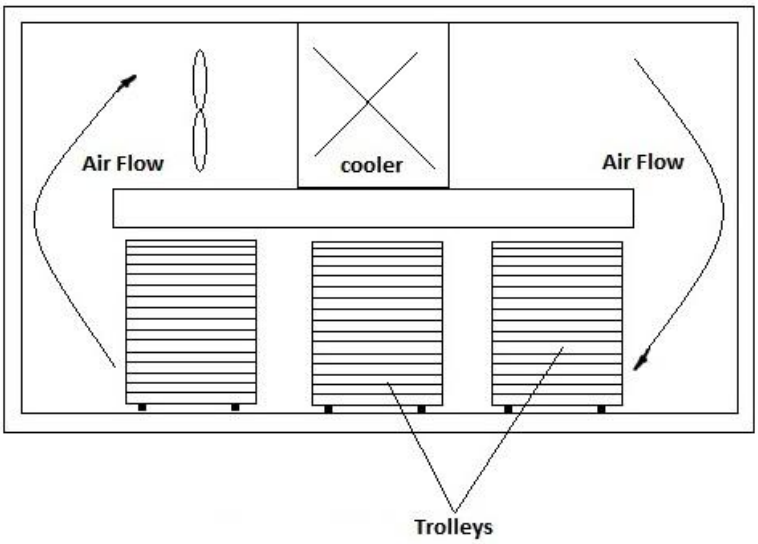

Fig 1: Blast Freezer

Fig. 1 shows working of a simple blast freezer. It can be seen from that figure that blast freezers is provided with blowers to pass on refrigerated air over the surface of the food products in order to freeze them at a rapid rate. Modern blast freezers are equipped with movable trays for customizing location of food products for freezing. A blast freezer quickly lowers the temperature of foods product. In such freezers, an extremely cold temperature promotes very quick freezing, which produces small ice crystals. At normal temperature, bacterial growth in

food products takes place at a rapid rate. Thus, food product becomes unsafe for consumption. The micro-organism can't survive in the extremely cold condition of blast freezer. These freezers are used in food industry to preserve meat, fish, dairy products etc. Blast freezer preserves texture, color, flavor and nutritional value of the food products.

5.2 Contact Plate Freezer

In contact plate freezer, food products are frozen by placing them in contact with metal surfaces cooled by refrigerants (such as refrigerant-12, 22 or ammonia). The food products can rest on, slide against or be pressed between metal plates. In all cases, cooling is achieved by heat conduction. Fig. 2 shows contact plate freezer. Contact plate freezers consist of a series of flat hollow refrigerated metallic plates. The plates are arranged parallel to each other and may be either horizontal or vertical. The spaces between the plates can be varied, the plates can be opened out for loading and closed so that the surface of the metallic plates is in direct contact with the food products. A slight pressure is applied between the plates and the food product during freezing process in order to achieve good face to face contact. Contact plate freezers are quick and efficient, however, their use is limited to flat foods with thickness not more than 8 cm. For example meat, fish, ice creams, chopped leafy vegetables etc.

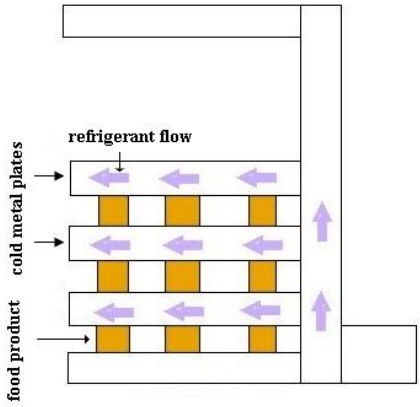

Fig 2: Contact Plate Freezer

5.3 Individual Quick Freezing

Individual Quick Freezing (IQF) is the modern freezing technique and it enables preservation and storage of raw fruit and vegetables in the farm-fresh condition for more than a year. This technique is very effective in preserving color, flavor and texture of food product. IQF is the only process in which all the properties of most of the parent food products are preserved. The important characteristic of this type of freezing is ultra-quick freezing to very low temperatures (-30°C to -40°C) designed to inactive the activities of the micro-organisms that cause deterioration of food products. In this type of freezing process, each piece is frozen individually using fluidization technique (i.e. product is suspended on high velocity air) which leads to freezing of food products in 10 to 12 minutes which otherwise takes at least 3 to 4 hours or even more in the blast freezer. Air directed up through perforated belt. Product flows in one end and overflows out other end. It gives high heat transfer rates. IQF is applicable to food products such as fruits, vegetables, meat, pasta, rice etc.

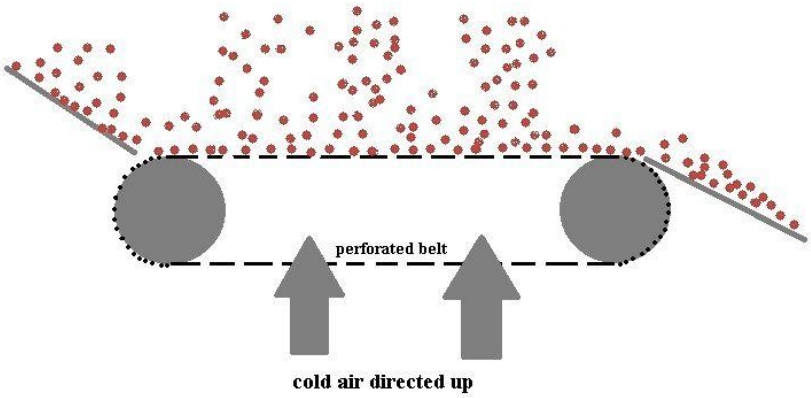

Fig 3: Individual Quick Freezing

5.4 Cryogenic Freezer

In cryogenic freezer, the food product is brought into direct contact with the refrigerant. The food products placed on the conveyor belt come into contact with the counter current flow of nitrogen gas (at a temperature of about -50°C). Fig 4 shows working of a cryogenic freezer.

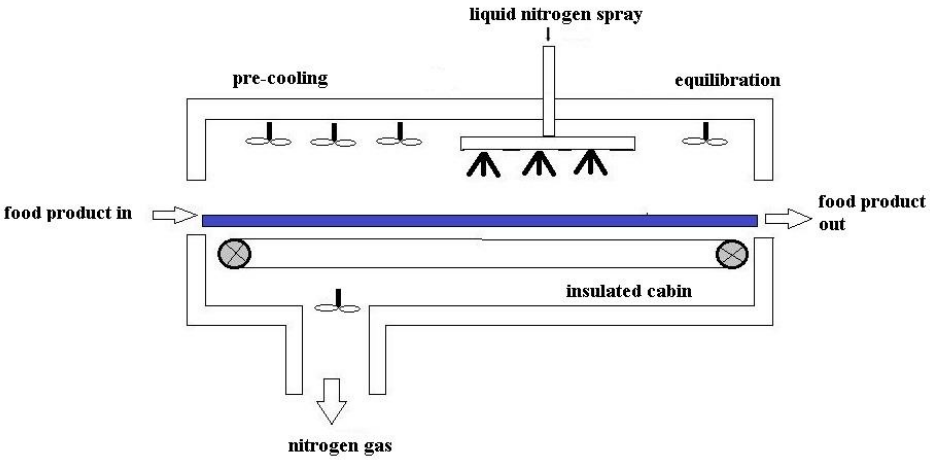

Fig. 4 Cryogenic Freezer

As the product passes to the pre-cooling stage of the freezer, the gaseous nitrogen partially freezes it and up to 50% of the product heat is extracted. The food product then passes below the spray of liquid nitrogen where freezing process is completed. The end stage in the freezer provides some time for the product temperature to reach equilibrium. The main advantage of this system is that freezing is very rapid and size of the freezer is comparatively small. Also, compressor and condenser are not the integral part of this freezer. Liquid nitrogen must be retained in a vacuum insulated pressure vessel with continuous venting to keep the contents cool and the internal pressure down. The limitation of cryogenic freezer is cost of nitrogen and regular supply of nitrogen gas.

VI. CONCLUSIONS

In this paper, freezing as technique for preserving food products have been studied. The point can be summarized as follows:

1. Freezing maintains the quality of food products very close to that of the fresh ones.
2. At low temperature, action of micro-organism becomes retarded, making it possible to storage food product for longer time without spoilage.
3. Cell wall rupture is related to freezing rate. In case of fast freezing, numbers of small ice crystals are produced while slow freezing creates few large ice crystals. The small single ice crystals produce less cell wall rupture as compared to large one. Therefore, freezer should produce quick and rapid freezing rates.
4. Important freezing equipments are discussed in detailed with possible applications.

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