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A Review on Recent Techniques for Food Preservation

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Abstract - **Food preservation is most significant in the food industry to prevent food from the growth of bacteria and yeasts which causes spoilage of food. And also for the safety and reliability of food product, the freezing plays important role in the food industries. Modern industries has introduced many innovative food preservation freezing technologies which are explained in this review paper such freezing technologies are cryogenic freezing, air blast freezing, super-chilling, high pressure freezing and also alternate freezing processes such as ultrasound assisted freezing and electrically and magnetically assisted freezing. This freezing technique is most commonly used to preserve the food for long period in safe manner. In this food freezing process the food is cooled from ambient temperature to chilling temperature and then stored between temperature of -18^{o}C and -35^{o}C to slow down the microbiological, physical and chemical factors which are responsible for spoilage and deterioration in foods. This paper aims to accelerate the development and implementation of these freezing technologies by the food sector to achieve better quality and shelf life of food products.**

Keywords: **Food Challenges, Technologies, Refrigeration, Freezing, Cryogenics**

I. INTRODUCTION

Food preservation is the most common way of treating and taking care of food to stop or slow down food deterioration, loss of value, edibility, or dietary benefit and subsequently take into consideration longer food stockpiling. The term freezing denotes where the temperature of the food is decreased to a temperature beneath its edge of freezing point, while the term frozen is utilized to describe the ensuing state the food is kept in, i.e., the preservation of the food underneath that temperature during the rest of the cold chain [1]. Preservation usually involves preventing growth of bacteria and avoids food spoilage. The need to supply of fresh and healthy food is becoming progressively more necessary by the increasing world population with tons of demands in food sector to build the time span of usability and maintain the nutritional value, also texture and flavor of food [2]. Due present of the large amount of water in the food leads to the growth of bacteria, microorganisms and also chemical reactions, causing the spoilage of food. The purpose of this study was to provide a recent review on refrigeration techniques used in food industry and also discuss various food preservation techniques and there effects on nutritional value of food. In recent time the food industries usually uses freezing techniques like cryogenic freezing, air blast freezing, super-chilling, high pressure freezing, ultrasound assisted freezing, electrically and magnetically assisted freezing [3,4]. This review offers the researchers, technologies, and industry management inclusive understanding that could be highly useful to develop effective and integrative food preservative methods and to ensure food safety [5]. Different methods of food preservation are utilized which are mainly based on low temperature to decrease deterioration and biochemical degradation of food items. In which most commonly used methods includes ice storage between 0 ^{o}C and 4 ^{o}C, super chilled storage in the range of -1 to -4 ^{o}C, by means of slurry ice or in super chilled chambers without ice, and frozen storage at -18 to -40 ^{o}C [6]. At the time of freezing, the ice crystals get formed may significantly impact the cellular integrity, resulting in loss and degradation of food quality. It is generally archived that the size, morphology and conveyance of ice crystals are extremely associated with freezing conditions like freezing rate, which influences nucleation and then generation of ice crystals [7].

II. RECENT FOOD PRESERVATION TECHNIQUES

A. Cryogenic Food Processing Technology

The cryogenic food technology has marvelous scope for application of food processing and food preservation. Cryogenic refrigeration is a term in which the components and equipment are cooled below the temperature of 150 ^{o}K [8]. The gases like argon, oxygen, hydrogen, nitrogen, carbon dioxide and some of other gases that can get evaporates at very low temperature such expandable gases are used as a refrigerant in cryogenic refrigeration system. In the food industry, liquid nitrogen (N2) and solid carbon dioxide (CO2) are most commonly used in cryogenic system as a refrigerant [9]. Cryogenic systems reduces temperature of food item through the application of cryogen, while mechanical systems uses re-circulating refrigerant within an air cooler that exchanges heat from air circulating within the freezer to reduce food temperature [10]. Cryogenic processing can efficiently bring protein products like meat and seafood to the desired equilibration temperature. Also the cryogenic gas can be used in mixing process of dough or batter in baking or snack industries that it can protect shape, texture and quality of frozen dough items and prebaked breads. The cryogenic technology also helpful to extend shelf life and to maintain quality of fully baked products [9]. So it can be used in any food industries to maintain texture, quality of food item and to extend shelf-life of food item.

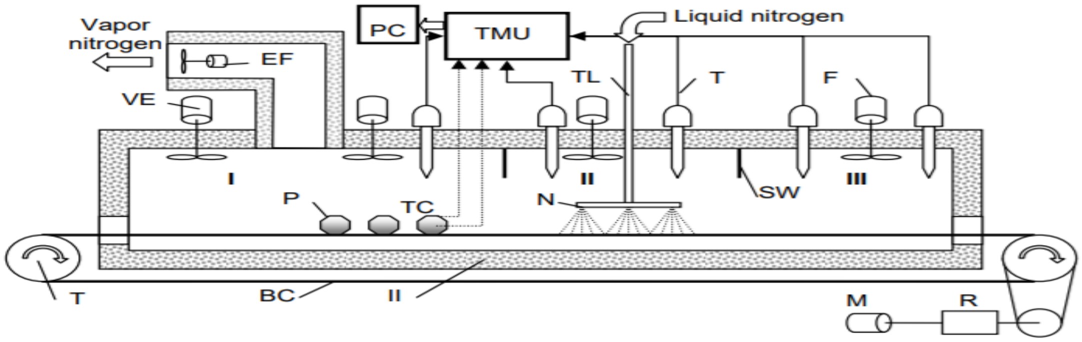

Fig. 1 Cryogenic Freezer [34]

B. Air Blast Freezing

Air Blast freezing technology is oldest and most commonly used technology in food industries. It is simple in construction and which is also cost-effective. It is economical, hygienic and relatively non-corrosive to equipment [11]. But as compared to the other conventional freezing techniques the rate of freezing is slow in air blast method. The main advantage is that it is suitable for irregularly shaped food items such as fruits and vegetables, on the other hand it has major limitations associated with temperature disequilibrium of foods [12]. At the temperature range of 4 ^{o}C to 10 ^{o}C, the rate of bacteria killing is largest due to cold-shock, even after stopping of this their metabolism is distributed. When freezing rate is slow, the microorganisms get enough time to adjust in the new conditions, henceforth food should be frozen rapidly [13].

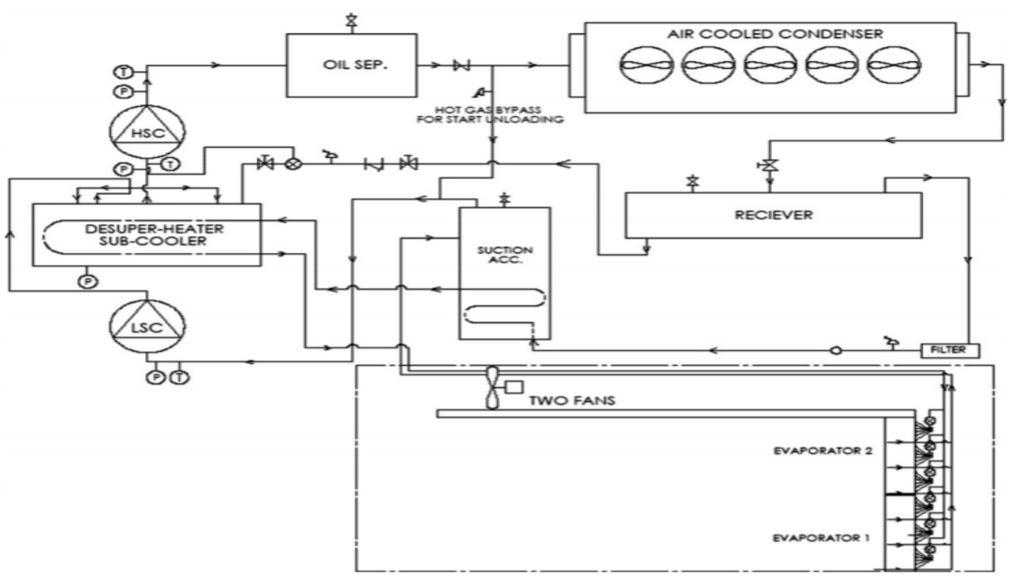

Fig. 2 Two stage carton blast freezer [36]

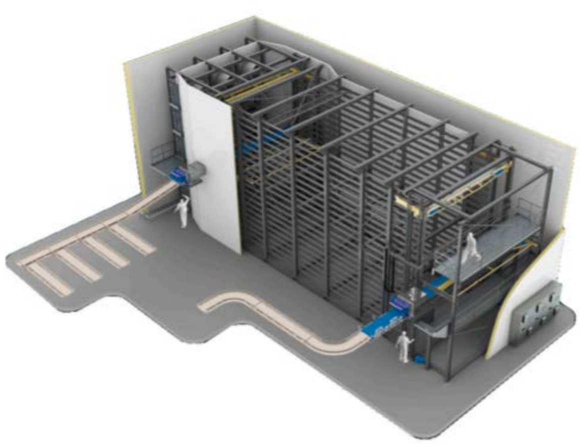

Fig. 3 Multilevel Air Blast Box Freezer [35]

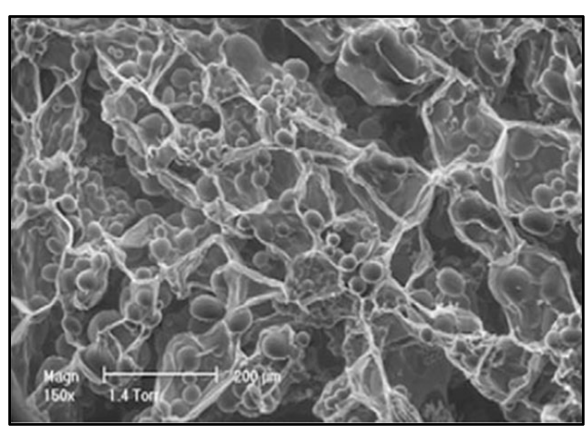

Fig. 4 Potato tissues, which were air-blast frozen and then thawed [14]

C. Super Chilling

To reduce the temperature of food products below the initial freezing point and also to increase shelf life of the food product the method used for this is superchilling. Superchilling implies temperatures in the borderline between chilling and freezing. It is the method in which the temperature of food items is reduced and maintained at 1-2 °C. The initial freezing points of most foods are between -0.5 °C and -2.8 °C [15]. Superchilling is most commonly used to preservation of fish and meat food products. The point is to restrict the level of ice formation to somewhere in the range of 10% and half of the food item's water fraction. In superchilling temperature is considered as most critical factor for controlling growth of bacteria in food products, mostly in fish and meat food items [21, 22, 23]. There are three most common freezers used for superchilling process which are mechanical freezers, cryogenic freezers and impingement freezers. For the superchilling process all freezers have different advantages, limitations and drawbacks, as they are selected based on suitable factors as maximize product quality, operating flexibility and return on investment (ROI) while minimizing waste, costs and downtime [2].

As compared to conventional chilling studies are shown that the superchilling can extend better shelf life of food product. As per results super chilling brings better quality and extended shelf life of stored food about 1.5-4 times as compared to conventional chilling [16].

D. High Pressure Freezing

High Pressure Freezing is the process in which cooling is done by the application of pressure on samples up to its phase change temperature. In this process the freezing happens under a constant pressure [17]. For high pressure freezing process, the highly pressurized carbon dioxide gas is introduced as a pressure agent in a pressurized chamber. With a decent knowledge of the water phase change, the application of high pressure can incredibly help freezing process and further develop item quality. The primary benefit of high-pressure freezing is that the underlying development of ice is immediate and homogeneous all through the entire volume of the item in light of the high super cooling came to on pressure discharge [18, 19, and 20]. In this studies, few carrot slices has been frozen to below -18 °C under pressure of 6MPa (which is considerably low pressure used than most of studies uses high pressure) within 5 min of timeframe. As a result the samples of carrot slices are compared with samples frozen by immersion in LN or in a -80 °C freezer and result is that the sample of carrot slices which are frozen by high pressure freezing had less tissue damage, low drip loss and also better nutrient preservation than another samples [1].

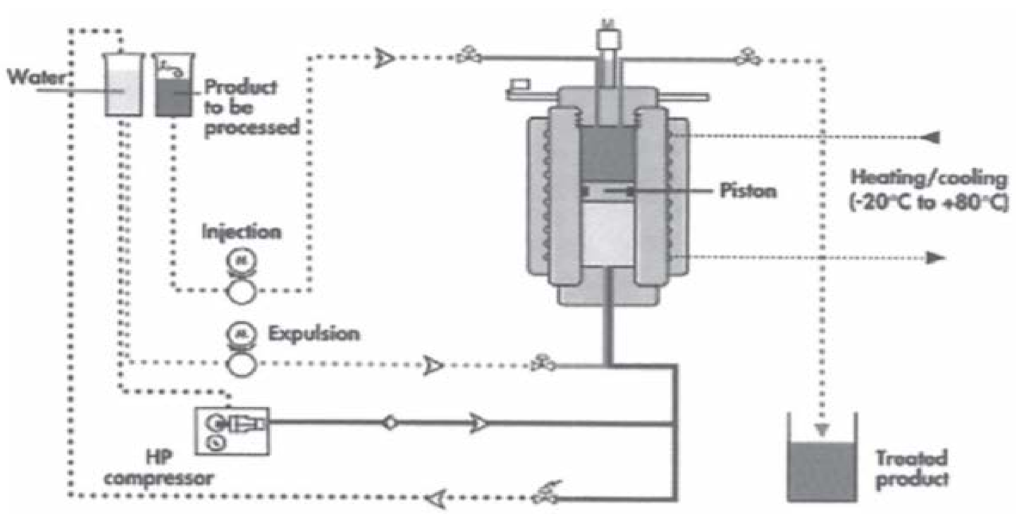

Fig. 5 High pressure freezing system (Courtesy of ALSTOM) [37]

E. Ultrasound Assisted Freezing

For rapid freezing of food items using tissue pre-degassing, method used for this is ultrasound assisted freezing. In ultrasound assisted freezing ultrasound generates micro-streaming and cavitation effect for freezing of food items. By using this process we get advantage of raising the heat transfer, promoting ice crystal formation and also fracturing large crystals of ice [3]. Ultrasound waves have different propagation velocities in varying physical state of media. Crystal of ice, air bubbles, and liquid concentration affects ultrasonic reduction in frozen solution system.

The ultrasound velocity is significantly quicker in ice (3900ms−1) than in water (1400ms−1), which can be used to gauge the ice content in liquid food systems [24]. Despite the fact that reviews show that, as an expected device, ultrasound can be utilized to make ice crystals in model food smaller [25].

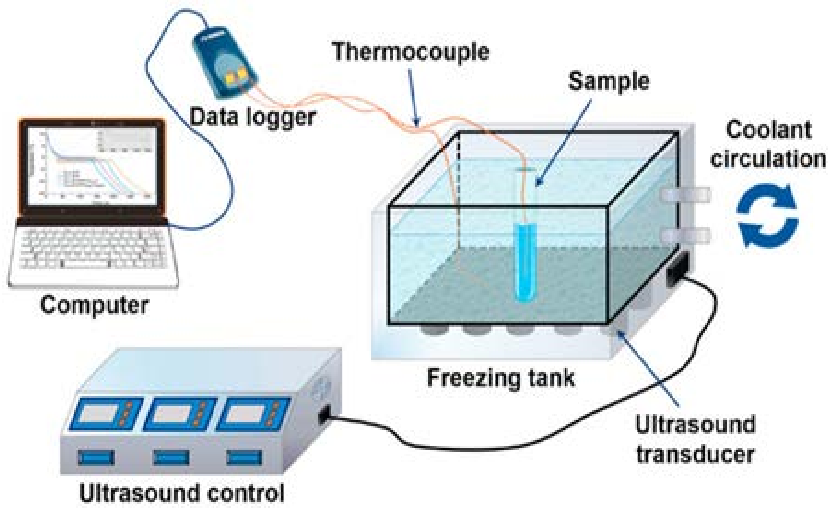

Fig. 6 Ultrasound-assisted freezing system [38]

F. Electrically and Magnetically Assisted Freezing

There are three electromagnetic technologies has been emerged for food freezing which are high-voltage electric field, magnetic fields, and radiofrequency [26, 27, 28, 29].

1. Electrically Assisted Freezing (EF)

Electrically assisted freezing is the technique which works on the principle that in the food products there are polar molecules of water present, when after passing an electric field current they get oriented inside food product and helps in regulating of ice crystallization process as well as a super-cooling process [39]. The principle of applying an electric field in the freezing system is for the most part dependent on the polar particles for positioning or rotating movements which become stronger under the effect of the electric field. Thusly, the impacts of water molecules under electric field can influence the free energy, which can control super cooling and ice crystallization [3, 30].

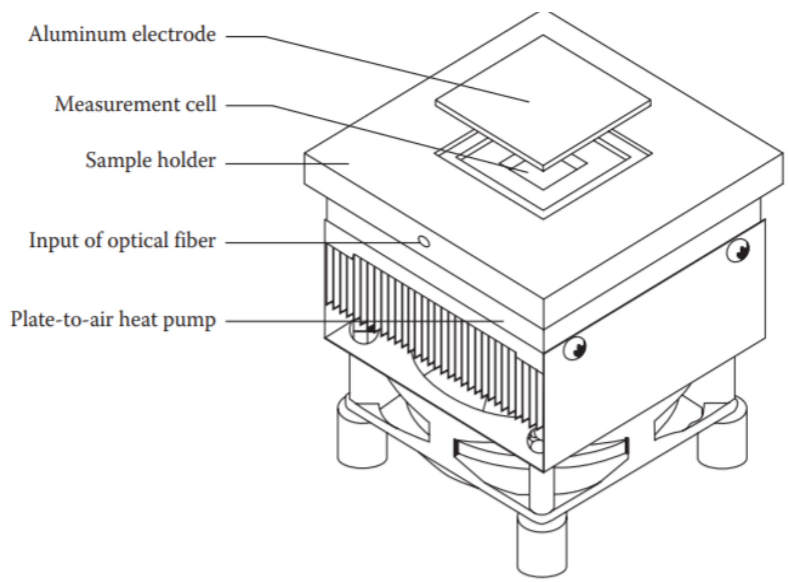

Fig. 7 Experimental setup of Electrically Assisted Freezing [39]

2. Magnetically Assisted Freezing (MF)

The magnetically assisted freezing is not an actually a refrigeration system rather it is a technique which help the existing freezing process and methods to further develop the product quality and freezing rates [40]. This method is depends on the magneto caloric effect (MCE), when a magnetic field is applied adiabatically, rise in reversible temperature characterizes the basic property of magnetic solids. The magneto caloric impact peaks around the magnetic ordering (or Curie) temperature [31].The freezing characteristics of water molecules can be changed by a magnetic field, as diamagnetic material and water molecules are at risk of the improvement of magnetic dipole moments under a magnetic field [32, 33].

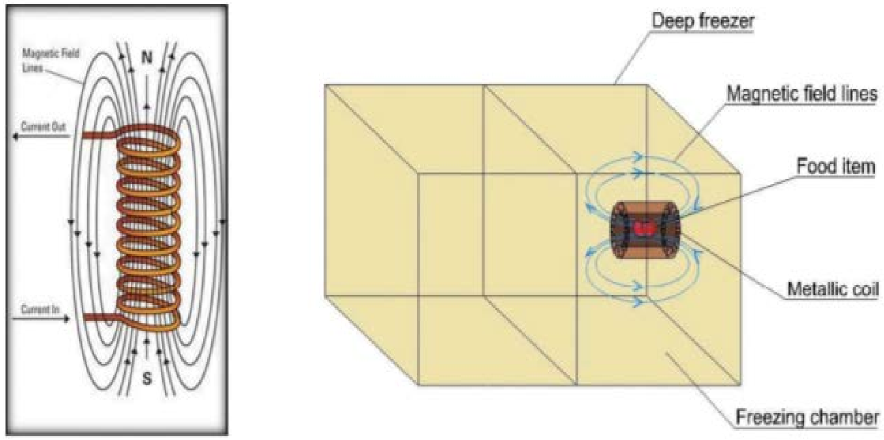

Fig. 8 Schematic diagram of magnetically assisted freezing

III. CONCLUSION

In this review paper different types of freezing technologies are discussed. Many of the freezing technologies have certain advantages and disadvantages which are suitable for various types (color, size, shape, chemical properties, and physical properties) of foods. Freezing processes are related with different physical and chemical properties, such as heat thermal storage, ice crystal formation. The alternate processes which are Ultrasonic assisted freezing process and electrically and magnetically assisted freezing have different techniques to maintain and improve overall aspects of freezing process. It is observed that these alternate freezing methods are more suitable for freezing than the other freezing methods which are discussed in this review paper. By implementing of this alternate freezing processes quick freezing, lower movement of water, smaller amount cells damage, and less texture deterioration can be achieved.

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