### **Food Freezing**





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- -It is the process of **solidification or crystallization**.
- -it is an exothermic process.
- -In **freezing**, the physical state of water changes from liquid to solid phase.



The freezing process occurs in two successive steps,
i.e, "NUCLEATION" and "CRYSTAL GROWTH".
1. NUCLEATION

**2. CRYSTAL FORMATION** 

### NUCLEATION



- Before ice can form ,a nucleus or seed is required upon which crystal can grow. The process of producing this seed is termed as nucleation.
- A nucleus is a site from which ice crystal starts to grow and hence cover all over the surface to freeze it.
- It is the critical step that results in complete phase change.
- Nucleation can be of 2 types-
- a) Homogeneous nucleation
- b) Heterogeneous nucleation
- a) Homogeneous nucleation:
- -It occurs when water is free from all the impurities viz., pure water or distilled water.
- -In this the nucleation occurs inside the liquid and unaided by any sort of surface and defects, that's why, it is called as Homogeneous nucleation.





NUCLEATION HOMOGENEOUS unaided by any surface or defects.

HETEROGENEOUS NUCLEATION aided by some surface (container wall, grain boundaries) or defects (dislocations or vacancies etc).

### Process of Homogenous Nucleation



- 1. Initially, when water is at normal room temperature, the water molecules move in random fashion and collide with each other.
- 2. When we start to reduce the temperature, the water molecules start to cease.
- 3. By further reducing the temperature till 0 °C, the few water molecules start to aggregate. These aggregates are very unstable and may not rise to a stable crystal.
- 4. At below 0 °C temp (-10 C to -20 C), the stable aggregates of water molecules starts and these aggregates or embryos or clusters are called as "Nuclei" and process called as nucleation.
- 5. As the temperature decreases, the critical radius of nuclei increases.
- 6. The homogenous nucleation occurs at very low temperature.
- 7. The probability of homogenous nucleation is 1 at -41 °C.

#### **Homogeneous Nucleation**

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# Heterogeneous nucleation or Catalytic Nucleation



- It occurs when water molecules aggregate in crystalline arrangement on nucleating agents such as active surfaces like container surface.
- Heterogeneous nucleation occurs at the surface of impurities.
- The impurities present in the system, act as catalyst to aid the heterogeneous nucleation. That's why, it is also called as Catalytic nucleation.
- Any interface with another material has potential importance for nucleation., for examples include:
  - i) a free surface
  - ii) the wall of a container
  - iii) embedded particle
  - iv) an interphase boundary in a liquid or solid and
  - v) a grain or domain boundary in a solid.
- This type of nucleation predominates in food systems.
- Unlike the homogeneous nucleation, the heterogeneous nucleation occurs at lower temperature due to presence of impurities.







### Types of freezing processes

There are various freezing processes that are being employed as per the requirement.

- 1. Slow freezing:
- 2. Quick/fast freezing:
  - i) Individual quick freezing (IQF):



### Slow freezing

- **Slow freezing** occurs when food is directly placed in **freezing** rooms called sharp freezers. It is also known as sharp **freezing**.
- It occurs at temperature -24 °C or above.
- In slow freezing, less number of nuclei are formed and as a result of slow freezing more concentrated solution is left in inter-cellular spaces which causes osmotic effect and liquid comes out from cells.
- The size of ice crystals is big and hence, damage the food cells causing loss of texture, nutrients, colour & flavour on thawing.
- This affects turgidity of cell and they collapse and on thawing cannot regain their original shape. Also, crystals forms are larger in size and pierce the cell membrane, puncture it and damage the cells.
- This method involves **freezing** by circulation of air by convection i.e. through a specially insulated tunnel, either naturally or with the help of fans
- In slow freezing, the thermal arrest time is more than 30 min.
- Thermal arrest time is the time required to decrease the product temperature from 0 ° C to – 5 ° C.





- Quick freezing of food by exposure to a blast of air at a very low temperature.
- It occurs at temperature -25 °C or less. It did not damage the food cells.
- In quick freezing large numbers of nuclei are formed, hence having large numbers of crystals of smaller size evenly distributed within the cell and in the intercellular space.
- Since process is very quick, hence no concentration effect occur and commodities retain their original shape.
- Unlike slow freezing, very small crystals of ice are formed in quick freezing which do not rupture the cells of the food and so the structure is relatively undamaged.
- A quick-frozen food is commonly defined as one that has been cooled from a temperature of 0 °C to -5 °C or lower, in a period of not more than 2 hours, and then cooled to -18 °C.
- The important feature of this process is ultra-rapid freezing to very low temperatures (-30°C to - 40°C)

### Food quality in quick and Slow freezing





#### **Slow freezing vs Fast/Quick Freezing**

ZERO LEARNING ACADEMY



#### **Difference b/w Slow freezing and Fast/Quick Freezing**



S. No	PARAMETER	FAST FREEZING	SLOW FREEZING
1.	Definition	The food products are exposed to such a low temperature which is well enough to inhibit oxidative and microbial changes which are responsible to change colour and flavour.	It refers to freezing in air with natural circulation or with electric fans
2.	Microbial growth	There is more prompt prevention of microbial growth	Prevention of microbial growth is not as prompt as in fast freezing
з.	Size of ice crystals	Small ice crystals are formed which does not lead to cell disruption.	Allow the formation of large disruptive ice crystals which damages the cell
4.	Vapor Pressure	Water vapor gradients are not formed hence minimum dehydration	Ice crystals have lower water vapor pressure than regions adjacent to cells hence water moves from cells to growing crystals hence cell becomes dehydrated and permanently damaged
5.	Time	Reduces processing time hence microbial contamination will be less.	Processing time is comparatively high than fast freezing
6.	Applications	Wide applications in industries. Freezing of fruits and vegetables meat and poultry products	Successfully employed for cryopreservation of meristems of peas, potato, cassava, strawberry etc

#### Difference Between Crystal Size And Shape After Freezing







## Individual quick freezing (IQF)

- IQF is the latest technology available in freezing and with the advent of the same.
- IQF is achieved by using very low temperature cryogenic refrigerants as a freezing medium viz., liquid nitrogen.
- it is now possible to preserve and store raw fruit and vegetables in the same farm-fresh condition for more than a year, with the color, flavor and texture of produce remaining as good as fresh from the farm.
- In IQF, each piece is frozen individually using technique of fluidization resulting in freezing of fruit and vegetables only in 10 to 12 minutes which otherwise takes at least 3 to 4 hours or even more in the blast freezer.
- This results into better texture and there is no lump/ block formation and the product is free flowing.
- One does not have to thaw or defrost the whole packet to take out only a portion, and the rest will remain frozen till required again

### INDIVIDUALLY QUICK FROZEN OF IQF BANANA SLICES





# **Global Individual Quick Freezing (IQF) Market**

Market by Product Analysis (USD Mn)







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## Conclusive remark



- Slow freezing kills only few microbes and forms large ice crystals thus causing mechanical damage to the cells
- but in case of quick freezing, it kills all the pathogens and maintain uniformity in extra or intracellular water and form small ice crystals which leads to less damage to the cells.
- But there is one major disadvantage of fast freezing and that is large investments for deep freezer, and moreover it is energy intensive process which is not in slow freezing.
- Ultimately in respect of food quality the "fast freezing is better than slow freezing".