Quality changes in foods during frozen storage

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Food quality during frozen storage

- For a very large number of food products, freezing represents the best preservation method with respect to food quality.
- On the other hand, unless appropriate measures are taken, the deleterious effect of long-term frozen storage on all the sensory attributes of product may be significant.

- Frozen storage, even at fairly low temperature, does not mean the absence of deteriorative processes.
- On the contrary, frozen foods may undergo profound quality changes during frozen storage.
- While the rate of reactions is generally (but not always) slower in frozen foods.
- The expected shelf life, and therefore the time available for the reactions to take place, is long.

Effect of frozen storage on food quality

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- The frozen storage may affect the food quality in several ways:

A. Effect on physical quality of food
B. Effect on nutritional quality of food
C. Effect on sensory quality of food
D. Effect on microbial quality of food

Effect on the physical quality of food

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- The main physical changes of foods verified during freezing processes are related to the risk of freeze cracking, moisture migration, recrystallization of ice crystals and drip loss during thawing.

1) Freeze Cracking

- The small ice crystals formed with high freezing rates obtained with cryogenic freezers, allow preservation of food structure.
- However, products may crack under those conditions.
- This may happen when the internal stress of unfrozen food is higher than the frozen material strength at food surface.
- **To avoid cracking, a previous cooling step should be applied prior to freezing**.
- The reduction of the temperature gradients between the product and the freezing medium by providing a **pre-cooling step** decrease significantly the risk of freeze cracking.

2) Moisture Migration

- During freezing processes, when **cell contents are super cooled**, moisture movements may occur by an **osmotic mechanism**.
- The occurrence of temperature fluctuations results in vapor pressure differences, which are responsible for moisture migration.
- If frozen products are stored without an adequate moisture barrier, the ice on the food surface sublimes, since ice water pressure is higher than the environment vapor pressure.
- An opaque dehydrated surface is formed (microscopic cavities previously occupied by ice crystals) with an unsightly white color. This leads to **freezer burn**.

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3) Recrystallization

- Modifications in the size, shape or orientation of the ice crystals are known as "recrystallization" and usually lead to quality losses in some products.
- Recrystallization reduces the advantages of fast freezing leading to physico-chemical changes of food products.
- This process may happen in three different ways:

(i) **Isomass recrystallization** : changes in surface shape or internal structure.

(ii) **Accretive recrystallization**: linkage of two adjacent ice crystals to form a large crystal (), and

(iii) **Migratory recrystallization**:

- increase of the average size of the crystal.
- It is the most important and it is mainly related to temperature fluctuations during storage.
- If temperature increases, the product's surface warms slightly, the ice crystals melt, moisture moves to regions of lower vapor pressure and some areas will be dehydrated.
- When temperature decreases, water vapor does not form new nuclei points and links to the existing ice crystals.
- This originates a reduction of the number of small crystals and an increase of large crystals, disrupting the cellular structure.
- The recrystallization during storage and transportation may **lead to freeze-dried packaged product** or to **toughening of animal tissue**.

4) Drip Loss

- During ice formation, water is removed from the original location.
- However, during thawing, water may not be reabsorbed in the same regions, and usually drip loss is observed.
- **Size and location of ice crystals, rate of thawing, the extent of water reabsorption, the status of the tissue before freezing**, and the water-holding capacity of the tissue have a great influence on drip losses.
- The time required for thawing should be longer than the one used for freezing (for comparable temperature driving forces).
- In frozen meats, a slow thawing process at low temperatures will permit a better water diffusion in the thawed tissue and its relocation in the fibers.
- In vegetable tissues, the water is not reabsorbed.

Effect on the nutritional quality of food

- Some of the frequent types of nutritional deterioration in frozen foods are:

  i. Protein denaturation resulting in toughening of muscle foods, protein–lipid interaction.

  ii. lipid oxidation and oxidative changes in general (e.g. loss of some vitamins and pigments).

Effect on the sensory quality of food

- The sensory attributes affected by freezing viz., the flavor and color of foods are affected very slightly, if at all, by the process of freezing itself.
- The main quality factor that may be adversely affected by freezing is the texture.

Effect on microbial quality of food

- The freezing stage causes the apparent death of **10%-60%** of the viable microorganisms.
- Freezing inactivates the microbes by reducing their enzymatic activity.
- These values increase during frozen storage. Factors such as low temperature, extracellular ice formation, intracellular ice formation, concentration of solutes and internal pressure may be involved in the microbial inactivation.
- The sensitivity of microorganisms to the freezing process differs considerably.