

Frozen food

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Freezing food preserves it from the time it is prepared to the time it is eaten. Since early times, farmers, fishermen, and trappers have preserved their grains and produce in unheated buildings during the winter season.^[1] Freezing food slows down decomposition by turning residual moisture into ice, inhibiting the growth of most bacterial species. In the food commodity industry, there are two processes: mechanical and cryogenic (or flash freezing). The freezing kinetics is important to preserve the food quality and texture. Quicker freezing generates smaller ice crystals and maintains cellular structure. Cryogenic freezing is the quickest freezing technology available due to the ultra low liquid nitrogen temperature -196 °C (-320 °F).^[2]

Preserving food in domestic kitchens during the 20th and 21st centuries is achieved using household freezers. Accepted advice to householders was to freeze food on the day of purchase. An initiative by a supermarket group in 2012 (backed by the UK's Waste & Resources Action Programme) promotes advising the freezing of food "as soon as possible up to the product's 'use by' date". The Food Standards Agency was reported as supporting the change, providing the food had been stored correctly up to that time.^[3]

Contents

- 1 Preservatives
- 2 History
- 3 Technology
- 4 Packaging
- 5 Effects on nutrients
 - 5.1 Vitamin content of frozen foods
- 6 Effectiveness
- 7 Quality
- 8 Reaction
- 9 See also
- 10 Notes
- 11 References
- 12 External links



A frozen processed foods aisle at a supermarket in Canada



Cutting frozen tuna using a bandsaw in the Tsukiji fish market in Tokyo, Japan (2002)

Preservatives

Frozen products do not require any added preservatives because microorganisms do not grow when the temperature of the food is below $-9.5\text{ }^{\circ}\text{C}$ ($15\text{ }^{\circ}\text{F}$), which is sufficient on its own in preventing food spoilage. Long-term preservation of food may call for food storage at even lower temperatures. Carboxymethylcellulose (CMC), a tasteless and odorless stabilizer, is typically added to frozen food because it does not adulterate the quality of the product.^[4]

History

Natural food freezing (using winter frosts) had been in use by tribes in cold climates for centuries. By 1885 a small number of chicken and geese were being shipped from Russia to London in insulated cases using this technique. By March 1899, the "British Refrigeration and Allied Interests" reported that a food importing business, "Baerselman Bros", was shipping some 200,000 frozen geese and chickens per week from three Russian depots to New Star Wharf, Lower Shadwell, London over three or four winter months. This trade in frozen food was enabled by the introduction of Linde cold air freezing plants in three Russian depots and the London warehouse. The Shadwell warehouse stored the frozen goods until they were shipped to markets in London, Birmingham, Liverpool and Manchester. The techniques were later expanded into the meat packing industry.

From 1929, Clarence Birdseye introduced "flash freezing" to the American public. Birdseye first became interested in food freezing during fur-trapping expeditions to Labrador in 1912 and 1916, where he saw the natives use natural freezing to preserve foods.^[5] More advanced attempts include food frozen for Eleanor Roosevelt on her trip to Russia. Other experiments, involving orange juice, ice cream and vegetables were conducted by the military near the end of World War II.

Technology

The freezing technique itself, just like the frozen food market, is developing to become faster, more efficient and more cost-effective.

Mechanical freezers were the first to be used in the food industry and are used in the vast majority of freezing / refrigerating lines. They function by circulating a refrigerant, normally ammonia, around the system, which withdraws heat from the food product. This heat is then transferred to a condenser and dissipated into air or water. The refrigerant itself, now a high pressure, hot liquid, is directed into an evaporator. As it passes through an expansion valve, it is cooled and then vaporises into a gaseous state. Now a low pressure, low temperature gas again, it can be reintroduced into the system.

Cryogenic or (flash freezing) of food is a more recent development, but is used by many leading food manufacturers all over the world. Cryogenic equipment uses very low temperature gases – usually liquid nitrogen or solid carbon dioxide – which are applied directly to the food product.^[6]

Packaging

Frozen food packaging must maintain its integrity throughout machine filling, sealing, freezing, storage, transportation, thawing, and often cooking.^[7] As many frozen foods are cooked in a microwave oven, manufacturers have developed packaging that can go straight from freezer to the microwave.

In 1974, the first differential heating container (DHC) was sold to the public. A DHC is a sleeve of metal designed to allow frozen foods to receive the correct amount of heat. Various sized apertures were positioned around the sleeve. The consumer would put the frozen dinner into the sleeve according to what needed the most heat. This ensured proper cooking.^[8]

Today there are multiple options for packaging frozen foods. Boxes, cartons, bags, pouches, Boil-in-Bags, lidded trays and pans, crystallized PET trays, and composite and plastic cans.^[9]

Scientists are continually researching new aspects of frozen food packaging. Active packaging offers a host of new technologies that can actively sense and then neutralize the presence of bacteria or other harmful species. Active packaging can extend shelf-life, maintain product safety, and help preserve the food over a longer period of time. Several functions of active packaging are being researched:

- Oxygen scavengers
- Time Temperature Indicators and digital temperature data loggers
- Antimicrobials
- Carbon Dioxide controllers
- Microwave susceptors
- Moisture control: Water activity, Moisture vapor transmission rate, etc.
- Flavor enhancers
- Odor generators
- Oxygen-permeable films
- Oxygen generators^[10]
- Validation of cold chain

Effects on nutrients

Vitamin content of frozen foods

- Vitamin C: Usually lost in a higher concentration than any other vitamin.^[11] A study was performed on peas to determine the cause of vitamin C loss. A vitamin loss of ten percent occurred during the blanching phase with the rest of the loss occurring during the cooling and washing stages.^[12] The vitamin loss was not actually accredited to the freezing process. Another experiment was performed involving peas and lima beans. Frozen and canned vegetables were both used in the experiment. The frozen vegetables were stored at $-23\text{ }^{\circ}\text{C}$ ($-10\text{ }^{\circ}\text{F}$) and the canned vegetables were stored at room temperature $24\text{ }^{\circ}\text{C}$ ($75\text{ }^{\circ}\text{F}$). After 0, 3, 6, and 12 months of storage, the vegetables were analyzed with and without cooking. O'Hara, the scientist performing the experiment said, "From the view point of the vitamin content of the two vegetables when they were ready for the plate of the consumer, there did not appear to be any marked advantages attributable to method of preservation, frozen storage, processed in a tin, or processed in glass."^[13]
- Vitamin B₁ (Thiamin): A vitamin loss of 25 percent is normal. Thiamin is easily soluble in water and is destroyed by heat.^[14]

- Vitamin B₂ (Riboflavin): Not much research has been done to see how much freezing affects Riboflavin levels. Studies that have been performed are inconclusive; one study found an 18 percent vitamin loss in green vegetables, while another determined a 4 percent loss.^[15] It is commonly accepted that the loss of Riboflavin has to do with the preparation for freezing rather than the actual freezing process itself.
- Vitamin A (Carotene): There is little loss of carotene during preparation for freezing and freezing of most vegetables. Much of the vitamin loss is incurred during the extended storage period.^[16]

Effectiveness

Freezing is an effective form of food preservation because the pathogens that cause food spoilage are killed or do not grow very rapidly at reduced temperatures. The process is less effective in food preservation than are thermal techniques, such as boiling, because pathogens are more likely to be able to survive cold temperatures rather than hot temperatures.^[17] One of the problems surrounding the use of freezing as a method of food preservation is the danger that pathogens deactivated (but not killed) by the process will once again become active when the frozen food thaws.

Foods may be preserved for several months by freezing. Long-term frozen storage requires a constant temperature of $-18\text{ }^{\circ}\text{C}$ ($0\text{ }^{\circ}\text{F}$) or less.^[18]

Quality

The speed of the freezing has a direct impact on the size and the number of ice crystals formed within a food product's cells and extracellular space. Slow freezing leads to fewer but larger ice crystals while fast freezing leads to smaller but more numerous ice crystals. Large ice crystals can puncture the walls of the cells of the food product which will cause a degradation of the texture of the product as well as the loss of its natural juices during thawing.^[19] That is why there will be a qualitative difference observed between food products frozen by ventilated mechanical freezing, non-ventilated mechanical freezing or cryogenic freezing with liquid nitrogen.

Reaction

According to a study, an American consumes on average 71 frozen foods a year, most of which are pre-cooked frozen meals.^[20] Many food critics host shows are dedicated to the tasting and reviewing of frozen foods, the web show *Freezerburns* being one of the more notable ones.^[21]

See also



A frozen food warehouse at McMurdo Station, Antarctica

- List of frozen food brands
 - List of frozen dessert brands
 - List of ice cream brands
- Refrigerator

Notes


1. Tressler, Evers. *The Freezing Preservation of Foods* pp. 213-217
2. Sun, Da-Wen (2001). *Advances in food refrigeration* (<http://www.worldcat.org/title/advances-in-food-refrigeration/oclc/48154735>). Leatherhead Food Research Association Publishing. p.318. (Cryogenic refrigeration)
3. Smithers, Rebecca (February 10, 2012). "Sainsbury's changes food freezing advice in bid to cut food waste". *The Guardian*. Retrieved February 10, 2012. "Long-standing advice to consumers to freeze food on the day of purchase is to be changed by a leading supermarket chain, as part of a national initiative to further reduce food waste. [...] instead advise customers to freeze food as soon as possible up to the product's 'use by' date. The initiative is backed by the government's waste advisory body, the Waste and Resources Action Programme (Wrap) [...] Bob Martin, food safety expert at the Food Standards Agency, said: "Freezing after the day of purchase shouldn't pose a food safety risk as long as food has been stored in accordance with any instructions provided. [...]"
4. Arsdel, Michael, Robert. *Quality and Stability of Frozen Foods: Time-Temperature Tolerance and its Significance*. pp. 67-69
5. "Frozen Foods". Massachusetts Institute of Technology.
6. W.B.Bald, Food Freezing: Today and Tomorrow, J.P.Miller, The Use of Liquid Nitrogen in Food Freezing, p.157-170, Institute for Applied Biology, Springer-Verlag
7. Decareau, Robert. *Microwave Foods: New Product Development*. pp. 45-48
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9. Russell, Gould. *Food Preservatives*. pp. 314
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19. W.F.Stoecker, Industrial Refrigeration Handbook, 2000, Chapter 17 Refrigeration and freezing of foods, 17.10 The freezing process
20. Harris, J. Michael and Rimma Shipstova, *Consumer Demand for Convenience Foods: Demographics and Expenditures* (PDF), AgEcon, p. 26, retrieved 16 July 2011
21. Stock, Sue (18 April 2010). "Web viewers warm up to frozen food show". *News & Observer*. Retrieved 10 July 2011.

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Categories: 1863 introductions | 1923 introductions | Convenience foods | Food preservation | Food storage

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