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CHAPTER 36

THEORIES AND METHODS OF FREEZING

Sharp Freezing, Quick Freezing, Freezing by Immersion, Freezing by Indirect Contact, Air Blast Freezing, Freeze Drying, Fundamentals, Processing, Commercial Equipment

THE frozen food industry, as we know of it today, is comparatively recent in origin. About 1865, sharp (slow) freezing as a method of preservation came into use on a commercial scale with the artificial freezing of fish and poultry. The freezing preservation of meat started about 1800. The cold packing industry had its beginning about 1905 with the freezing of small fruits for remanufacture in jams, jellies, pies and ice cream. Commercial quick freezing of vegetables and the freezing of fruits for table use started about 1929, as did the freezing of consumer-size packaged fish, meat and poultry.

There have been many differences of opinion concerning the merits of quick freezing foods. When first introduced, quick freezing was acclaimed to be a panacea by causing less damage to the cell tissues and preventing bacteriological decomposition during freezing. Recent theories, however, indicate that the speed of freezing does not affect breakdown of the cellular tissues. Thus, the main reason for quick freezing is to increase product handling and to cool the product quickly to a point where bacterial, mold, and yeast growth are minimized. It is for these reasons that quick freezing is in predominant use in this country today.

The following is a discussion of the principal conventional methods of freezing used in the United States today. These methods are grouped according to the method of heat transfer, except for the sharp freezer which, because of its historical significance, is treated separately.

SHARP FREEZING

Sharp freezing (slow freezing) is now largely outdated and has been replaced by more efficient methods of freezing. The first sharp freezers consisted of insulated rooms maintained at temperatures varying from +5 to −20 F. The products placed in these rooms were usually cooled by natural convection with no provision for forced circulation. The sharp freezers were then modified to include banks of refrigerated shelves on which the product was placed for freezing. In recent years these freezers have been modified so that the shelves can be serviced by conveyors.

The sharp freezer is not satisfactory for freezing consumer-type packages because of its slow rate of cooling and the excessive bulging of the package that occurs. It is primarily used for whole or panned fish, boxed poultry, or meat.

The rate of freezing in commercial installations is quite slow and may vary from 12 to 72 hr, depending on the size of the product and the coil or room temperature. The space requirements per pound of product frozen and the labor needed to load and unload the food are both quite high. Equipment maintenance costs and the actual costs of refrigeration are quite low but do not offset these disadvantages.

QUICK FREEZING

Freezing by Immersion

As liquids are good conductors of heat, products may be frozen rapidly and efficiently by immersion in low temperature liquids. Fundamentally, the process involves pumping a continuous stream of the refrigerant solution past the products to be frozen and in contact with them, or in reverse, moving the product through the cooling solution.

The refrigerating media used for freezing unpackaged or lightly packaged products where contact with the refrigerant may result must meet Food and Drug requirements and should be nontoxic and edible. Sodium chloride brine, sugar-brine solutions, and propylene glycol have been used with satisfactory results. However, problems resulting from use of one or more of these solutions involve excessive salt penetration into the product; adherence of solution to the food, making it necessary to renew it periodically; and dilution of the solution with moisture or juices from the product. These problems are avoided when freezing canned or otherwise well-packaged products where there is a good protective barrier between product and solution.

Immersion freezing may be separated into two categories, that used for freezing canned products and that used for freezing unpackaged or lightly packaged products.

Freezers for Canned Foods. In 1933 W. J. Finnegan patented a fruit juice freezer known as the pipe or tube freezer. The product to be frozen is placed in a tin can and then forced through a tube by means of a spiral screw. The primary refrigerant (ammonia) passes through a closed annular space in the outer shelf of the tube. The secondary refrigerant, alcohol and water, is pumped around the product and is kept at −25 F by the liquid ammonia. A machine containing 6 tubular units can handle 2500 lb per hr of liquid or semi-liquid product.

Another freezer for canned products is the can freezer built by the Food Machinery Corporation. The freezing unit is essentially the same as a continuous cooker, except that materials were modified to withstand low temperatures and effects of the refrigerant, which has an ethyl alcohol base. The refrigerant flows through the freezer in a direction opposite to the movement of the cans. A can of orange juice can be cooled from 40 F to 0 F in 10 to 15 min.

One type of continuous liquid freezer consists of two concentric tubes with a solid rotary mutator equipped with spaces in the inner tube. The refrigerant passes through the