Frozen Foods

Until frozen foods came along, there had been no major innovation in preserving food since the early 19th century, when Nicolas Appert, a French candymaker, invented canning. More than a century later, in 1925, Clarence Birdseye, an American inventor, quick-froze fish on a refrigerated moving belt and started a new industry. Large-scale commercial food freezing began a few years later, when a major processor bought Birdseye's patents and began marketing frozen fruits and vegetables.

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Despite uneven product quality, the use of frozen foods grew slowly but steadily during the 1930's. After World War II ended in 1945, and refrigerators and home freezers came back on the market, consumption increased more quickly. In 1948, U.S. production of frozen foods passed the billion-pound mark. But the new industry had serious problems. Consumers of frozen foods complained of changes in color and texture and loss of flavor. The industry also worried because frozen foods sometimes lost important nutrients and suffered occasional bacterial contamination during processing and storage. In the late 1940's, the industry began working with the Western lab to find answers to its problems.

What followed at WRRC was known as the Time-Temperature Tolerance (TTT) Project. Its aim, simply stated, was to improve the quality of frozen food. The project began with tests of 50,000 samples of frozen fruit and orange juice, but its scope was soon expanded to include vegetables, poultry, prepared foods, and bakery items. Building their own freezing facilities inside their lab, Western lab scientists experimented with every step in food freezing, from selection of the variety grown to harvesting, handling between field and plant, blanching and freezing, packaging and storage, and transport of the products to the market. What they learned during the next 8 years helped immeasurably to ensure the survival and growth of the U.S. frozen food industry.

Post-World War II research at the Western lab, known as the Time-Temperature Tolerance Project, helped solve one problem after another for the fledgling frozen food industry. The result today in the typical market is an amazing variety of convenience foods with acceptable flavor and texture.

A key discovery was that blanching, or scalding, is the single most critical operation in freezing vegetables commercially. Without adequate blanching to inactivate naturally occurring enzymes, storage life of frozen foods was limited to 3 months or less. Too much blanching, on the other hand, altered the color or flavor of vegetables or damaged texture. WRRC scientists developed a simple but sensitive biochemical test to detect enzyme activity after blanching. It was soon adopted by industry.

Also discovered was the cause of off-flavors and loss of vitamin C and sugar in frozen peas, which often deteriorated rapidly after removal from their pods. Scientists found that so-called delay off-flavor occurred when bruised peas were held too long before processing. As a result of the research, plant managers took steps to reduce the transit time for peas between field and plant. Sometimes, on hot days, peas are cooled with ice water immediately after picking. Today, plant operators communicate with the field by car radios to coordinate harvesting and processing and to minimize processing delays.

Keeping storage temperatures of frozen food cold enough was also critical. All frozen foods, researchers learned, have one characteristic in common: a limited tolerance to temperature fluctuations. It is essential to keep these products at 0° F or below. Frozen peaches, for example, will not turn brown for a year if they are packaged tightly and kept at 0° F. At 10° F, they will begin to turn brown after 45 days; at 28° F, in only a day. Frozen strawberries, if stored at 0° F, will retain all of their vitamin C. At storage temperatures warmer than that, they start losing it. Near the freezing point, at 30° F, scientists found that only a fraction of the vitamin remains.

Raspberries posed a special problem. In the Pacific Northwest in the 1950's, 10 percent of the raspberry crop had to be destroyed because of contamination by thrips, which are very small and destructive winged insects. The industry risked having whole shipments of frozen berries condemned. The simple answer to the problem, said WRRC researchers, is to wash out the raspberry thrips with detergents before freezing. The procedure reduced loss due to thrips to about 2 percent and kept the raspberry freezers in business.

Curdling of gravies and sauces in precooked frozen meats and vegetables was an annoying problem that threatened the growth of such convenience foods as TV dinners. Many household cooks had become discouraged with such preparations because so much stirring was required to smooth the gravy that the solid foods became mushy and unappetizing. The Western lab tried a technique used in preparing Oriental ceremonial foods—a flour made from waxy, or glutinous, rice instead of wheat flour to thicken gravies. Sure enough, they stayed smooth after freezing.

USDA scientists solved one frozen food problem after another, keeping the fledgling industry alive.

Later, waxy-rice flours were used to thicken frozen puddings, replacing the traditional cornstarch.

In time, WRRC scientists developed nine principles for freezing vegetables, still subscribed to by industry today. (1) The product must be freezable: peas freeze; cucumbers do not. (2) The variety must be suitable: garden peas, for example, freeze better than peas grown specifically for canning. (3) The raw product must be first class: freezing preserves defects as well as superior quality. (4) Handling between field and plant must be as prompt as possible. (5) Natural enzymes must be inactivated by blanching. (6) Freezing must be fast enough to ensure quality, yet economical enough to be competitive. (7) The plant must be kept sanitary and the line clean to prevent contamination by molds, yeasts, and bacteria. (8) Packaging must ensure that no moisture is lost during a year's storage. (9) Storage temperatures must be uniform and never, never exceed 0° F. The importance of this final item led to an industrywide Mark of Zero campaign to educate processors, shippers, marketers, and consumers.

Discoveries in connection with the TTT Project resulted in publication of some 100 scientific papers. Today, more than 30 years later, the Western lab still receives inquiries about freezing and storage techniques.

Several years after TTT was completed, engineers at the Western lab developed an experimental blanching method that retained 90 percent of the nutrients in frozen vegetables. Loss of nutrients posed a dual problem for the industry: The product was not only less nutritious but the organic materials left behind in the blanching water were a serious water pollutant. The new method was called individual quick blanching (IQB, for short). It ensures that each vegetable piece is uniformly heated to kill enzymes. The pieces are spread in a single layer on a moving belt that conveys them quickly through a steam chamber. They are held in the steam only long enough for the heat to partially penetrate each piece. Then the vegetables are piled up on a slow-moving belt that conveys them through an insulated chamber, where the heat already applied is redistributed and penetrates to the interior of each piece. Exposure time of each piece to halt enzyme activity is only one-fourth to one-half that required in conventional blanching. Quick-blanched frozen vegetables have a firmer texture and taste more like the fresh product.

Another WRRC lab innovation was dehydrofreezing. In this process, fruits and vegetables are partially dehydrated before freezing, cutting their weight in half. While the process has proved effective with a variety of products, its chief commercial use today is in freezing pieces of potatoes and apples for institutional use. Many researchers are willing to bet that the use of dehydrofreezing will soon be expanded.

Not every fruit and vegetable responds to conventional freezing—strawberries and green beans, for example. After thawing, juices leak from strawberry cells and green beans lose texture. WRRC researchers in the 1960's found that rapid freezing of berries and beans with liquid nitrogen resulted in much more satisfactory products. They also found that consumers were willing to pay a few cents more to take advantage of the improvements.

Loaves of frozen dough for bread also posed difficulties. While sales were brisk when these were first marketed, consumers were disappointed that the bread lacked the aroma, flavor, and texture they had expected. WRRC microbiologists found that freezing diminishes yeast activity, particularly when the bread has been stored for more than 2 months. In 1970, the product was improved in several ways, all aimed at increasing yeast activity. The result was a product that proved popular—and has stayed popular.

In 1978, a chemical engineer at the Western lab found that vegetables frozen in a liquid freezant require 25 percent less energy to process them than vegetables frozen in conventional air-blast freezers. Freezing times were reduced from 25 minutes to as little as 2. The freezant used in tests consisted of 15 percent table salt, 15 percent alcohol, and 70 percent water at a temperature of -6.7° F. Taste panelists said they liked mixed vegetables frozen in this manner as well as those frozen conventionally.

Surplus Oranges

Some 50 years ago, Florida oranges were a surplus crop. The only orange juice available was either squeezed from fresh oranges (a lot of trouble at 7 a.m.), mixed from a relatively flavorless concentrate (which remained unsold on grocery shelves), or poured from a can (which had a flavor all its own).

In 1946, Louis G. MacDowell, director of research for the Florida Citrus Commission, suggested that adding a little single-strength fresh juice, or "cut-back," to slightly over-concentrated orange juice might restore the flavor and aroma lost during vacuum evaporation. He and two colleagues took the idea to a field station of the Southern lab at Winter Haven, Florida, where USDA researchers had the equipment and expertise to help MacDowell develop his idea. They found that it not only worked but that the vastly improved concentrate could be easily frozen. USDA, as had been agreed in advance, took out a patent on the process. And so the frozen concentrated orange juice industry was born—an industry today worth $400 million a year in sales.