

cream, sherbets, ices, sauces, gravies and other emulsions and colloids which may break or separate.

Fruit shortcakes, various ice cream toppings, many ice creams, sherbets and ices partially thaw at 15 F. Products of a high soluble solids content must not be allowed to warm to this temperature.

Other Problems to Consider

There are bacteriological and food spoilage problems to be considered (See Chapter 37). Precooked foods must be chilled immediately after cooking, frozen rapidly, then stored at well below freezing temperatures. Rapid reheating to prevent slow thawing is necessary for a safe, quality, product.

TYPES OF PRECOOKED FROZEN FOODS

For discussion here, precooked and prepared frozen foods may be divided into three groups: (1) foods to be served hot—soups, chowders, meat, poultry and fish dishes, vegetables, complete meals, gravies and some sauces; (2) foods that may be eaten at room temperatures—appetizers and sandwiches, breads and some rolls, cookies and cakes, most pies, fruit purées and sauces; and (3) foods to be eaten cold while frozen—such as frozen eclairs, ice cream and ice cream cakes, and sherbets.

Foods Served Hot

Soup and Chowders. Tomato and some other soups can be heat processed without marked change in flavor or consistency. Others while unfavorably changed by canning are not altered by freezing. Oyster stew, clam and fish chowders, onion soup, cream of shrimp, cream of corn or potato, green split pea, and snapper soup are but a few of the more than 28 kinds of frozen soups offered on the retail market.

Packaging was a big obstacle for those who considered freezing soup before 1950. The bag in an end-fill carton type of package, used for sliced strawberries and berries in sirup, was not suitable; when filled with hot soup, it was likely to leak. Paraffined cylindrical and tub-shaped cartons were satisfactory if the soup was cooled prior to filling. Few of these cartons could be used if the liquid was to be filled above 200 F. In 1953, a packer in Santa Barbara, California, offered frozen soup in tin cans, marked *perishable* on each end. The use of a can instead of a bag-in-carton package not only solved the problem of hot-filling and gave a product of lower bacterial content, but it greatly reduced the manpower required for packaging, through the use of automatic can filling and closing machines.

Another advantage in the hot-filling of tin cans is an airtight container. The partial vacuum obtained after cooling results in less oxidation, and loss of or change of flavor during cooling, freezing and storage. Methods vary from plant to plant. Two currently popular freezing methods are airblast and immersion freezing.

Meat Dishes. There is an endless array of ready-to-heat and serve, frozen cooked meat products being sold today. Beef, veal, lamb and pork are prepared in many forms. The popular demand is for pot pies, stews and roast meat packed with gravy, either alone or as part of a complete frozen meal. In addition there are many frozen products that contain meat, even though it is not considered a basic ingredient.

A summary of various studies made on precooked frozen meats concludes: The possibilities in the production of frozen cooked meats and meat dishes are great. Problems that remain to be solved are the need for more efficient packaging of roasted and broiled meats to be frozen without a sauce or gravy; the need for more work to determine how the warmed

over flavor can be avoided. Additional study is needed to determine whether or not meats cooked to a rare-done stage can be satisfactorily frozen and reheated; more effective methods for reheating the frozen product; and finally, the development of methods for preparing lower grade meats to give a highly acceptable product.

Meat stews (and other precooked frozen foods), if allowed to thaw and stand any length of time without refrigeration, serve as excellent substrates for the growth of microorganisms. Extreme care should be used in all of the manufacturing operations, and immediate freezing and continued storage at 0 F or below are recommended.

Studies on the effects of storage temperature, length of storage and the addition of certain antioxidants on precooked beef and pork stew have been made. It was found that the use of the antioxidants tested did not contribute to the keeping quality of the stews. Storage time and temperature were the most important factors in the retention of quality in Swiss steaks. Over the nine months' storage, there was a gradual decrease in the desirability of the product although samples at the lower storage temperature (-20 F) always gave a higher score.

For further information on frozen meat products, see Chapter 41, Frozen Meat Products.

Poultry Dishes. In recent years the Armed Forces and the public have shown a preference for frozen cooked poultry because of the desirability and ease of preparation of this product. Among the principal items are chicken meat for pot pies, french-fried chicken breast and thigh, sauté of chicken breast and thigh, and cooked turkey meat.

The safety and stability of chicken à la king held under commercial and military storage was tested in 1951. When good sanitary practices are observed, a product of high acceptability and very low bacterial count can be produced. Both hot-packed and cold-packed samples were stored at 0 F for one year and standard plate counts were made at monthly intervals. Hot packing followed by a quick freezing, after two months storage gave a product that was almost sterile. The cold-packed product lost over 60 percent of its bacteria within 18 hr of freezing and storage at 0 F and, after 30 days, had only 14-15 percent of its initial load. Throughout the test period a panel rated both products very high but found the cold-packed sample more acceptable.

Chicken à la king contains all the necessary factors for the growth of *Clostridium botulinum*. In samples incubated at 86 F *botulinum* toxin was found even in several samples that were not inoculated with *botulinum* spores. A botulism hazard is a possibility whenever precooked frozen foods are mishandled.

Webster and Esselen confirmed the work of Castellani, Clarke, Gibson and Meisner who studied the possibility of food poisoning organisms surviving during the roasting of frozen stuffed poultry. They both showed that *salmonella*, *staphylococci* and *streptococci* will be killed during roasting if the temperature at the center of the stuffing reaches 165 F.

Sanitation as practiced by a large packer of frozen stuffed turkeys is stringent: each bird is washed and inspected to insure complete cleanliness; chilled to 35 F, washed and re-inspected.

The stuffing is mechanically mixed in a closed system which is sealed off from contamination. Birds and stuffing are kept at temperatures below 35 F at all times. The turkeys are mechanically stuffed in a matter of seconds and are packaged and placed in the freezer in a few minutes. They are frozen at an average temperature of -40 F. This results in low bacterial counts.

The turkeys are under constant laboratory control and

Government Inspected and Approved for Wholesomeness. The Poultry Inspection Service of the US Department of Agriculture supervises plant sanitation.

For further information on frozen poultry products, see Chapter 42, Frozen Poultry Products.

Fish and Shellfish. Fish sticks are the most important of the cooked fish products, but a large number of other products are offered. The list includes breaded codfish, codfish cakes, creamed cod, cod filets, breaded haddock filets, smoked filets, creamed finnan haddock, fish cakes, fish frankfurters, fish burgers, fish pudding, stuffed flounder, creamed haddock, halibut patties, cooked herring, kippered herring, smoked herring, creamed salmon, salmon creole, seafood à la queen, seafood creole, seafood loaf, tuna and other fish pies, smelts, swordfish tidbits and creamed tuna.

A variety of seafoods other than fish are frozen either in a prepared or precooked form. Breaded shrimp is now the leading frozen prepared shellfish product. Others of importance include shrimp à la king, à la newburg, baked with rice and bacon, with yellow rice, with beer, breaded; burger, croquettes, cocktail, cooked and peeled, crole, curried, deveined and peeled, eggplant, french fried, in sauce, 'n chips, paste, patties, pie, rolls, stew, stuffed, shrimpburgers, tidbits; abalone patties, sticks and breaded; clam chowder, breaded, cutlets, deviled, fried, minced; patties, sticks, stuffed, and with sauce; conch; crab à la king, breaded, cakes, cocktail, creole, deviled, loaf, meat, patties, rolls, sticks, stuffed and burgers; lobster à la king, boiled, boiled with butter, cakes, cocktail, croquettes, cutlets, deviled, dishes, fra diavolo, newburg, pie, rolls, stew, stuffed, tails, breaded, thermidor; oyster cocktail, newburg, pie, breaded, cutlets, fried, minced, pie, sticks, stew, and stuffed; scallops, breaded, cooked, and cream sauce; squid cooked and with sauce.

Most cooked or prepared fish and shellfish products are frozen at -10 F to -60 F in airblast, plate or other conventional type freezers. Rapid freezing and storage at below zero temperatures (-10 to -20 F) is essential to the quality of these products. They should be reheated for service without thawing.

For further information on frozen fish and shell fish, see Chapter 40, Frozen Fishery Products.

Vegetables. Some vegetables sold as regular frozen vegetables are really cooked products. Corn on the cob, winter squash, pumpkin all have been steamed enough in preparation for freezing to cook them.

A large number of precooked vegetables are frozen commercially, either as part of a frozen meal or of a prepared dish, such as chicken pies, yet the quantities precooked and frozen are small with the exception of potatoes. Cooked artichokes, asparagus, baked beans, green or snap beans, kidney, lima, pinto beans and soy beans, soy bean sprouts, cabbage, carrots, celery, water chestnuts, sweet corn, eggplant, okra, onions, blackeyed peas, green peas, peppers, potatoes, pumpkin, rhubarb, rice, spinach, squash, sweet potatoes, tomatoes, turnips, yams and zucchini are commercially frozen.

Usually the vegetables should be slightly undercooked so that during cooling, freezing and reheating they will not become mushy or lose color and flavor. This is important in tender, immature vegetables.

Then the product should be rapidly cooled with a minimum of agitation so the hot product will not continue to cook. Rapid cooling under sanitary conditions prevents multiplication of microorganisms.

Package the vegetable in air-tight, moisture-vapor-proof, hermetically-sealed cartons or other containers, impermeable to oxygen. If small metal packages are used, hot filling, followed by immediate rapid cooling, is desirable.

The packaged product should be rapidly frozen in an airblast freezer or a plate or some other type of quick freezer. A low storage temperature is essential in the case of loose-frozen products or those not protected with a cream sauce or gravy and not solid packed. Temperatures of 0 F or lower are required.

For further information on frozen vegetables, see Chapter 38, Frozen Fruits and Vegetables.

Complete Meals. The most difficult problem in producing meals on a platter is to work out a system of preparing, cooling, freezing, packaging and reheating the products so that meals will taste freshly cooked and not warmed-over. This requires coordination to a high degree. Each operation must be so timed and coordinated with every other operation that each of the products progresses steadily through the plant with a minimum of delay anywhere along the line.

Each aluminum foil tray holding a meal is covered with lightweight aluminum foil. The tray is often slipped into a shallow carton. The packages are then automatically overwrapped and placed on shelves on a wheeled rack for easy movement into an airblast freezer. Or the foil covered trays are first frozen on shelves on a wheeled rack in a -20 F airblast. When frozen, the metal trays are put into the cartons and overwrapped. Sufficient space should be left between the trays or cartons on the rack to permit air circulation around each carton during freezing. The storage life of meals on trays depends upon the component parts and their individual storage.

Prepared Foods Served at Room Temperature

Appetizers and Sandwiches. Properly packaged bread frozen rapidly and stored for a year at 0 F is as fresh as bread held at 70 F for a single day. When exposed to a dry atmosphere, slices of many kinds of bread quickly become dry and unpalatable. This reinforces the importance of rapid preparation and sealing of sandwiches, appetizers and similar products in moisture-vapor-proof sheetings or packages.

Sandwiches and canapes should be frozen rapidly, otherwise the bread will stale before it is solidly frozen. When the temperature reaches 0 F, bread staling almost ceases. To freeze these products rapidly, they must be in relatively small packages (not shipping containers) in a freezer maintained at 0 F or lower. The freezer should be designed for rapid heat transfer. The packages of sandwiches, canapes, or hors d'oeuvres should be put into fiberboard shipping containers after freezing. Many of these products have a limited storage life.

Breads and Rolls. Research indicates that bread stales slowly when it is warm; moderately rapidly at ordinary room temperatures; rapidly when it is chilled to 50 to 30 F; but slowly at 0 F or below. Frozen bread of high quality can be obtained only if the loaves are chilled and frozen in a very short time and, when the bread is to be used, it is rapidly thawed. If the bread is to be held for more than a few weeks, a storage temperature considerably below 0 F should be used.

One packer indicates the following conditions must be met if quality breads and rolls are to be obtained. Freeze only fresh baked products; products should be securely wrapped. Air at -20 F is extremely dry and wrapping materials should have good protective qualities against the transfer of moisture vapor. The products should be subjected to the freezing process within four hours if possible, and certainly within eight hours after baking. The quicker the product is frozen the better the quality and fresh flavor.

Warehouse freezing temperatures should be no higher than -10 F, and -20 F is better. Products should be exposed to cold in individually wrapped units, placed on racks if this is practi-