Cooperative Possibilities in FREEZING FRUITS *and* VEGETABLES

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COOPERATIVE POSSIBILITIES IN FREEZING FRUITS AND VEGETABLES

by

Anne L. Gessner

GROWTH OF THE FROZEN FRUIT AND VEGETABLE INDUSTRY

Production of frozen foods in the United States has increased rapidly during the war period. The frozen vegetable pack in 1943 was more than 223 million pounds, almost three times as large as the 1937-40 average. Preliminary figures for 1944 show an even larger pack, close to 236 million pounds. More than 214 million pounds of frozen fruit were packed in 1943, over half again as much as the average for 1937-40. Estimates for the 1944 pack of frozen fruits show a still greater increase, with a preliminary figure of over 330 million pounds commercial pack (tables 1 and 2 and figures 24 and 25, pp. 44, 46, & 45, 47.

Shortages of some canned foods during the war, together with a desire to purchase nonrationed foods, and a high rate of employment resulting in increased purchasing power all have stimulated consumer demand for frozen foods. It is anticipated by many that this demand will not only continue but will increase after the war. It is also expected that large numbers of effective display cabinets and new types of frozen products will contribute to this demand. Improved refrigerated transportation equipment will be another important factor in the distribution of these foods.

Fruit and vegetable cooperatives engaged in varying types of operations are interested in the future of frozen foods as a method of distributing their products.

Among the most interested are those cooperatives that have canned fruits and vegetables for some time and are now confronted with the problem of replacing old equipment and modernizing their plants. Such improvements must, in the main, wait until wartime stringencies are relaxed to permit further production of processing equipment and construction of new facilities. But it is none too soon for these processors to analyze their prospects and to study those products likely to be most profitable to their members.

Many associations now handling exclusively fresh fruits and vegetables are interested in freezing portions of their products later and have set up reserves to finance expansion to freezing operations as soon as equipment can be obtained.

Organizations that have been dehydrating foods for the war effort are now looking toward the future. Some cooperative dehydrators contemplate conversion to quick-freezing to secure another outlet for the fruits and vegetables grown by their members and to utilize their facilities and their experience in processing and merchandising.

Note. - The author desires to express appreciation to officials of the cooperatives who supplied information on their quick-freezing operations; to members of the Processed Commodities Division of the Western Regional Research Laboratory, U. S. Department of Agriculture, who gave generously of their time in supplying information on general requirements and methods of preparation; and to Harry C. Hensley of the Cooperative Research and Service Division staff for helpful suggestions and for supplying many of the photographs reproduced in the publication.

Before entering this field, each interested association needs to examine thoroughly the factors that may affect its chances for success.

OUTLOOK FOR THE FUTURE

The extent to which the demand for frozen foods built up during the war can be increased, or sustained, will be influenced by the extent to which purchasing power and high-quality products can be maintained. It is probable that for some time a large majority of the retail consumers of frozen foods will continue to be in the upper income groups.

HOME UNITS

It is probable, too, that urban purchasers of home units will be largely home owners in the upper income brackets. For the average family, there is less likelihood of investment in a low-temperature unit unless, perhaps, it represents part of a household refrigerator that requires replacement. Significant is the fact that distributors of certain types of home storage units are now locating in suburban areas and selling their units to home owners with relatively high incomes in those areas. These distributors sell all types of frozen foods and keep the home units supplied, in some cases by house-to-house truck routes. Such large distributors could well provide excellent outlets for nearby cooperative packers.

For the densely populated centers where the apartment house predominates, designs are now being developed for new types of refrigerators containing one or more frozen-food units. Servicing such units will present opportunities for large unit sales on house-to-house truck routes. Many rural families producing much of their own food and wishing to store it for use throughout the year may invest in home freezer units. An important factor, however, which will influence the rate at which these home units can be absorbed when they become generally available will be the extent to which the price can be held down while producing a good quality cabinet which will maintain a zero temperature.

Use of home units will probably result in distribution of nationally advertised brands to food retailers in large packages suitable for long home storage. There may also be possibilities for frozen specialties including frozen foods prepared by famous restaurants and chefs. Distributors of certain home units have found a ready market for frozen cooked foods and frozen bakery products.

LOCKER PLANTS

Estimates on the growth of frozen-food locker plants indicate that there are now about 6,000 locker plants in the United States[1] and that there will probably be about another 500 to 1,000 in operation by 1946. Of these, it is estimated that perhaps 70 to 80 percent may deal in commercial brands of frozen foods after the war and somewhere around 40 to 50 percent may sell home units. These, of course, are merely estimates and there seems to be no general agreement on the extent to which locker plants will engage in such operations.

Apparently, there is also some difference of opinion as to the advantages to be gained by locker plants,

[1]S. T. Warrington and Paul C. Wilkins, Frozen Food Locker Plants in the United States, January 1, 1943. Farm Credit Administration, U. S. Dept. of Agr., Misc. Rept. 81, March 1945.

through processing, packaging, and selling locally grown fruits and vegetables, particularly vegetables. Current surveys indicate that some locker plants will engage in these operations.

DISPLAY CABINETS

The designs under way for production of new types of retail display cabinets indicate a vast improvement over many of the cabinets now in use. New cabinets will provide visibility and accessibility. Some of the designs for new cabinets have compartments with doors for each product from which the packages will be delivered automatically to the purchaser. As a package is dispensed, another will replace it, so that the shelves will be kept stocked. Practical operation of such cabinets remains to be proven.

COMMERCIAL OPERATIONS

The trend in the production and distribution of frozen foods will probably continue more and more in the direction of regular commercialized methods, and the tendency to treat frozen foods as specialty items will continue to diminish. The larger chain stores may be expected to play a much more important role in the distribution of frozen foods after the war. Many super markets may find it advantageous to install walk-in freezers where they will be able to carry and display a large variety of frozen products.

Any great expansion in either production or distribution will require a comparable expansion and improvement in refrigerated transportation. Many refrigerator cars used for the shipment of frozen foods are wearing out. The postwar distribution program will, therefore, call for improved modern refrigerator cars and trucks.

Some distributors are of the opinion that the large distributors after the war will operate what are known as "peddler trucks." These trucks will be refrigerated, will carry a large stock of frozen foods, and will stop at retail stores and institutions to deliver any frozen merchandise that may be desired. This will represent the same type of operation that is being used today by the National Biscuit Company, soft drink distributors, and various other concerns.

PRICING METHODS

While the bulk of frozen-food sales may continue to be for some time largely limited to the upper income group, changes in pricing which may occur would materially alter this prospect. It is possible that with increased volumes of frozen foods, lower production costs would result, which, in turn, would mean lower retail prices. Larger unit sales with less frequent deliveries should also permit economies which would result in lower retail prices.

Some packers, while believing in maintaining strict quality, are of the opinion that eventually frozen-food packers will be justified in packing products under a second label for a class of trade which can economically use such products.

EDUCATION IN THE HANDLING OF FROZEN FOODS

Education of both the retailer and the consumer in the proper handling of frozen foods appears to be an important factor in the postwar acceptance of frozen foods. Retailers must be educated on the necessity of keeping the products properly frozen and not permitting them to thaw and refreeze. The consumer can be educated in the use of frozen foods by proper instructions for thawing and serving those products which must be defrosted and by adequate recipes for cooking those products which require cooking. Probably nothing is more irksome to the housewife unfamiliar with frozen foods than to find the package she has purchased entirely without or with only inadequate instructions for the preparation of its contents.

POSSIBILITIES FOR COOPERATIVES

Cooperatives engaged in the production of frozen foods after the war will find it necessary to use every improved method of processing and merchandising available to them. They will undoubtedly find large volumes of processed foods available at comparatively low prices. This will bring a return of keen competition and to be successful frozen-food packers will have to produce high-quality products.

Before reaching any conclusions regarding expansion or conversion to quick-freezing, interested cooperatives will be wise to study carefully the many aspects of an industry which shows every indication of being highly competitive in postwar years.

COOPERATIVE FREEZING OPERATIONS

Cooperatives in the Northwest were pioneers in fruit-freezing operations. A number of other cooperative associations have been freezing fruits and vegetables successfully and some have had extensive experience in developing methods and practices. Their freezing plants are located principally in Oregon, Washington, Michigan, Wisconsin, New York, Massachusetts, and Tennessee.

Some cooperatives have received wide recognition for the quality of their packs, among the more important of which are strawberries, cherries, peaches, peas, and string beans.

Other cooperative packs include red and black raspberries, boysenberries, loganberries, youngberries, blackberries, gooseberries, apples, grapes, prunes, rhubarb, lima beans, asparagus, corn, broccoli, and spinach.

Descriptions of efficient freezing operations for some of these commodities as observed in successful and experienced cooperative plants follow for the benefit of those associations now considering expansion or conversion of their own operations to fruit and vegetable freezing.

GRESHAM BERRY GROWERS

Vegetables

Important in this plant's vegetable freezing are the string beans operations. The beans are dumped from the field boxes onto an elevator belt feeding two pregraders. (See figure 1.) From the graders they are dropped into the bean snippers. After snipping and inspection, they are again elevated to two cutters. A second pregrading operation removes the large beans and the remainder go to a junior grader.

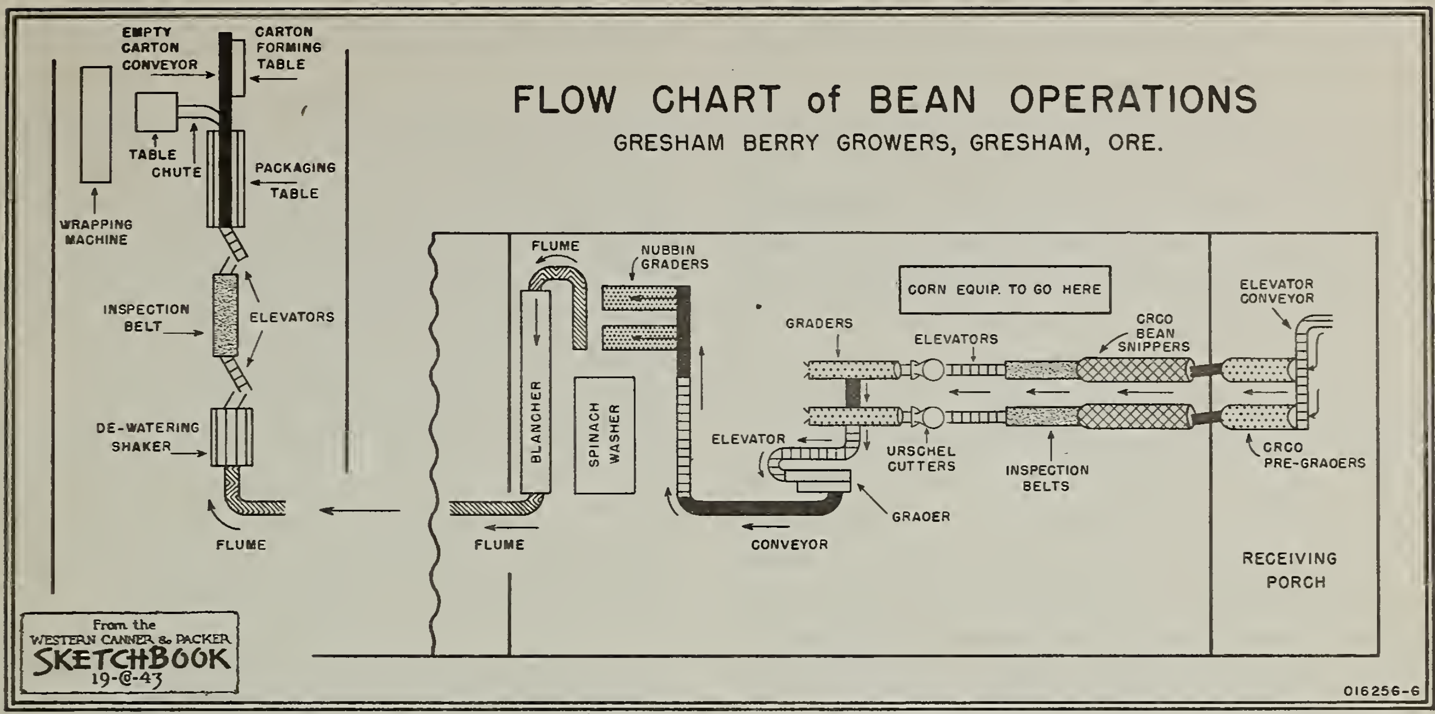


Figure 1. - This chart illustrates the string bean freezing operation in a large cooperative plant.

Some of the beans graded out in these operations are boxed for separate handling, but the bulk of the flow continues up another conveyor and an elevator leading to the nubbin graders. Nubbins (small or imperfect portions of beans) are removed by two such graders. The beans then fall into a short flume and are floated to the lower end of an inclined blancher. After emerging from the blancher they are floated in a long flume suspended just below the ceiling, which extends through the berry preparation department (described later) and makes a right turn to the packaging department.

Water is removed in a dewatering shaker and the beans are carried to the inspection table by a short elevator. At the end of the table belt, the beans fall to another short elevator which carries them to the packaging table. The carton-forming table is at the end of the packaging table, which has a three-way belt system. Workers take empty cartons from the top belt and fill them at the side of the table, where gates divert the beans on the third belt into the containers.

The cartons are then weighed. Full packages are placed on the middle belt (returning portion of the empty-carton conveyor belt) and go toward the wrapping machine at the far end. Here cartons are wrapped, trayed, and taken to the freezer. Nubbins removed during the process are trayed separately and loose-frozen. Spinach and corn processing equipment can be put into this preparation line when needed.

At this plant spinach is packed mostly in 1-pound, 2½-pound, and 5-pound units. Corn and beans are packed in 1-pound, 2-pound, and 5-pound packages and also in bulk cartons ranging from 22 to 30 pounds.

Fruits

The major item in the frozen-fruit pack of this cooperative association is strawberries, of which almost 4½ million pounds were packed in 1943. The total annual fruit pack of the association is about 12 million pounds. The strawberry-freezing procedure at this plant is considered representative of the best practices of the frozen-food industry in the Northwest.

Strawberries are hauled to the freezing plant as soon as a truckload is ready and usually are frozen the same day when picked. Processing starts as early as sufficient berries are on hand to insure continuous operation and continues throughout the afternoon and night until all berries received during the day have been processed.

The berries are picked without caps and placed in 1-pound wood veneer baskets arranged 15 to the tray. Sixteen trays are weighed at a time, on a two-wheeled hand truck, as the berries are unloaded on the receiving platform. The 16 trays are trucked to the washer where a wire grid is placed over each tray as it is inverted, thus emptying the berries, but retaining the baskets in the tray. At top speed each worker empties about a truckload, or 16 trays, of baskets per minute.

Rapidly running water carries the berries to a bucket elevator which elevates them about 5 feet from where they are emptied into a flume and pass to a shaker grader. Water supply for this plant is furnished by two deep wells. The larger berries roll down over the slightly inclined slats and fall onto a belt moving at right angles to the grader. They are conveyed before a line of women who eliminate any foreign matter and any berries with hulls and pick out the overripe, damaged, and green berries. The good berries go either to the barrel or to the carton-packaging operation.

For the barrel pack, the berries are conveyed to a barrel which a worker rocks as the berries fall in from the conveyor belt. The flow of granulated sugar is adjusted from a bin above by means of a stop in a chute so that a weighed amount of sugar in the proportion of 2 + 1 (2 parts of berries to 1 of sugar), or 3 + 1 (3 parts of berries to 1 of sugar), or some other desired ratio, is uniformly mixed with the berries as they go into the barrel.

The smaller berries (those 1½ inches in diameter or under) roll through between the grading slats and fall into a flume of water which carries them on to the next shaker grader. On this grader, the berries 5/8 inches to 1½ inches in diameter are separated, and pass on to the inspection belts, where the defective berries and those with hulls are removed. The sound berries are then handled in the same manner as the larger berries.

The uncapped berries taken from the inspection belt are collected and taken to tables near the inspection belt, where women cut out the caps with spoons or small knives. These cut berries may then be mixed with those used in the preparation of sliced berries.

When the barrel has been filled with sugared berries, it is trucked to a scale where it is weighed and the weight adjusted to give the proper proportion of berries to sugar. The head is then put in place and the gross weight, the net weight, the tare, the kind and size of fruit, the proportion of berries to sugar, the code number, and the name and address of the packer are stenciled on one end.

The filled barrels are rolled into a sharp freezer in which forced air circulation is maintained. Here they are held at a temperature of approximately 10° F. below zero. The following day the barrels are rolled into an inner room held at approximately zero Fahrenheit. After a day or two in this room, the barrels are moved into a room held at a few degrees above zero. To hasten freezing and to help mix the sugar and the berries, the barrels are rolled every other day for a week or 10 days, after which they are stacked on end in a storage room.

In addition to its barrel pack of frozen fruit, this cooperative freezes carton packs in 1-pound, 2½-pound, 10-pound, and 30-pound sizes. Part of the carton pack is frozen as whole berries and part of it as sliced. At the time of our visit to the plant, the 1-pound and the 10-pound packs were sliced berries and the others were whole berries. The carton pack is placed on trucks and rolled into the freezing tunnel where it is left overnight. The temperature in the freezing tunnel is usually maintained at about 20° F. below zero, although it can be brought down much lower if desired. The trucks are taken out the next morning and the cartons are then stored in a room where the temperature is maintained at about zero Fahrenheit.

Equipment

The refrigeration machinery for this plant includes seven ammonia compressors. There are seven low temperature rooms and two freezing tunnels with air diffusers. Temperature in the tunnels can be reduced to as low as 40° F. below zero. The plant has handled as much as 210 tons of strawberries in 24 hours.

This association in the spring of 1944 completed an improvement program which provides for a 25-percent increase in its line of quick-frozen vegetables. The expansion included building a one-story 30- by 80-foot addition to the receiving room, redesigning the lay-out and raising the roof of the original receiving building, and installation of a second processing line. A part of the receiving room is being utilized to accommodate the added quick-freezing facilities.

WASHINGTON PACKERS, INC.

This cooperative, which freezes both fruits and vegetables, added extensive equipment for freezing peas in the 1944 season.

Pea-freezing operations

Some of the peas are cleaned at field stations; others are brought into the main plant where new cleaners have been installed. In these cleaners the peas are placed on wire mesh trays. Fans direct air through them and remove the dirt and chaff. Automatic brushes then clean the trays. On the receiving platform is a tenderometer by means of which the tenderness of each field box of peas can be automatically determined upon arrival.[2] After the peas are cleaned they are conveyed from the receiving platform through pipes of water under pressure. The water in these pipes is maintained at a temperature which provides a blanch at 212° F. for 90 seconds while the peas are en route.

[2]The tenderometer measures the force required to press a certain quality of peas through a standard grid. This force is directly proportional to the toughness of the peas which are being tested.

After the blanch, the peas are carried by gravity to a tank containing about 10 percent salt solution. Grading by brine flotation provides a product fairly uniform in maturity while retaining a garden-run appearance. The fancy peas float to the top and are carried to the sorting belt. The "sinkers" are carried away to be packed for a different grade. At this plant, which does canning along with its freezing operations, all peas are frozen. In the freezing process, the peas travel on a mesh belt through a tunnel in which a temperature of 20° F. below zero is maintained. Refrigeration for this tunnel is supplied by seven freezer units. Defrosting is staggered, one unit at a time being pulled out of operation each hour for defrosting.

The refrigeration system of this plant includes seven ammonia compressors, two receiving tanks, and a double-pipe condenser. The plant has seven storage rooms in which the temperature is maintained at approximately 5° F. below zero. The capacity load of the plant is about 200 tons of refrigeration.[3]

Other Packs

In addition to its large pack of frozen peas, this association freezes strawberries, boysenberries, rhubarb, gooseberries, black caps (black raspberries), corn, peas, spinach, and asparagus. Canned pack of the association includes peaches, pears, apricots, gooseberries, beans, carrots, diced beets, and whole beets.

The equipment used by this association in freezing its rhubarb pack was designed by plant personnel. A major part of the spinach preparation line is used for rhubarb. A wide conveyer, consisting of wooden sections operating as a continuous belt, carries the whole stalk, crosswise, to the cutter. On the sections about 1 foot apart, are single rows of metal pins resembling nail ends put in from underneath. A rhubarb stalk placed against this row is held firmly enough to be evenly sliced by a gangsaw cutter. Spacing of the circular blades gives a 1½-inch cut. The metal pins of the conveyor pass between the blades.

After cutting, the rhubarb moves to a rotary washer and then to the sorting table. From the sorting table, it goes to the blancher, then falls into a flume and is chilled by cold water as it is carried by gravity flow for about 30 feet before it is again elevated for packing. From a dewatering platform, the rhubarb is carried a few feet by a belt and discharged into the containers (1-pound and 30-pound size) placed under it. The association found that blanching to preserve the color of the rhubarb is not required as it retains its bright color without any scalding at all, but the primary reason for the blanch is to eliminate the difficulty of filling containers with entirely raw pieces.

Packaging

The frozen products of this association are packed in 1-pound, 2½-pound, 5-pound, 10-pound, and 30-pound cartons and also in barrels. All packages or cartons have moisture-vapor-proof liners. The 1-pound boxes are packed 24 to a fiberboard carton; the 2½-pound, 12 to a carton; and the 6-pound, 5 to a carton.

[3] The standard ton of refrigeration is the quantity of heat in B.t.u. required to melt one ton of pure ice at 32° F. into water at 32° F. in 24 hours.

At the time of our study the association was using plain unprinted cartons. Those to be distributed under its own brand name had a wax overwrap with the brand name multilithed thereon. Those packed under other distributors' brands were covered with a plain wax wrap and had a printed brand insert under the transparent wax wrap.

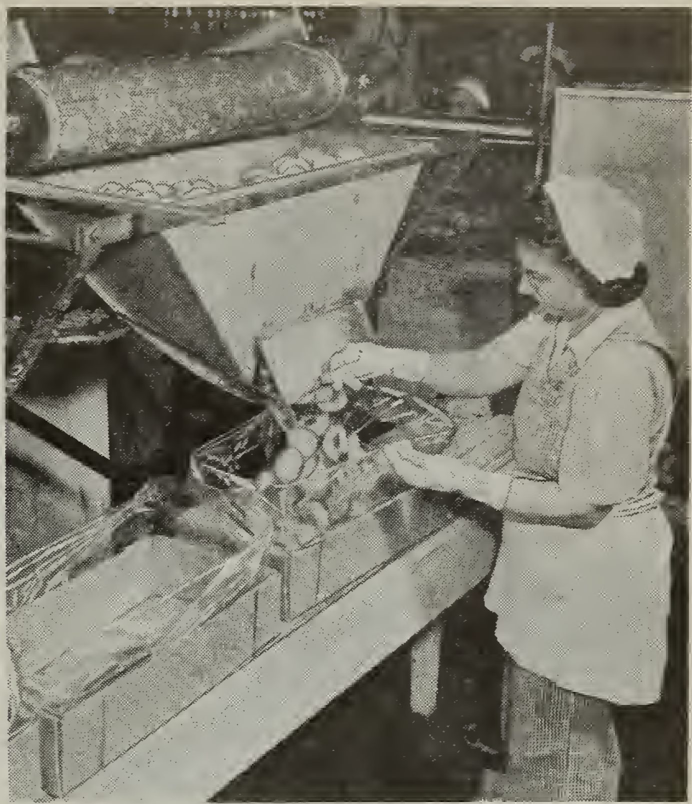


Figure 2. - Peaches are treated in sirup, then released from the hopper into cellophane-lined cartons which protect them from loss of moisture, freshness, and flavor.

WASHINGTON CANNERS COOPERATIVE

An important product of this canning and freezing cooperative is its frozen-peach pack, particularly halved peaches in 30-pound units. The peaches are transferred from the field boxes to a conveyor belt where workers on either side rapidly halve and pit them. From this operation the peaches continue on the belt to a steam chamber, thence to a cold-water treatment, after which they are peeled and the bad spots removed. The belt then carries the peaches to a hot sirup blanch and after that to a cold sirup chamber. From the cold-sirup treatment, the peaches are dropped into a hopper and an operator puts the processed fruit in cellophane-lined cartons.[4] On leaving the hopper, the cartons are weighed and sugar added in the proportions of 4 + 1. The edges of the liner are heat sealed, the lid of the carton closed, and the product conveyed on a hand truck to the freezing tunnel. Freezing in the tunnel, which is maintained at 18 degrees below zero, requires a period of 4 hours. After freezing, the packages are stored at 5 degrees above zero (figure 2).

In addition to the 30-pound units of halved peaches, the cooperative packs sliced peaches in 1-pound packages. The process is similar to that for the 30-pound size, except that the peaches are sliced before going into the hot sirup blancher. The sliced peaches are transferred from the main hopper by pan to a platform hopper feeding into a paddle mixer where sugar is added in the ratio of 4 + 1. The mixed product then goes through a filler and into 1-pound fiberboard containers lined with moisture-vapor-proof bags. The product is checked for weight, the liner heat sealed, and the packages, which are packed 24 to a carton, are sent to the freezing room (figure 3).

A portion of this association's peach pack is also frozen in barrels. General processing methods for the barrel pack are similar to

[4]This 30-pound carton is described in detail on page 18 of the section dealing with packaging.

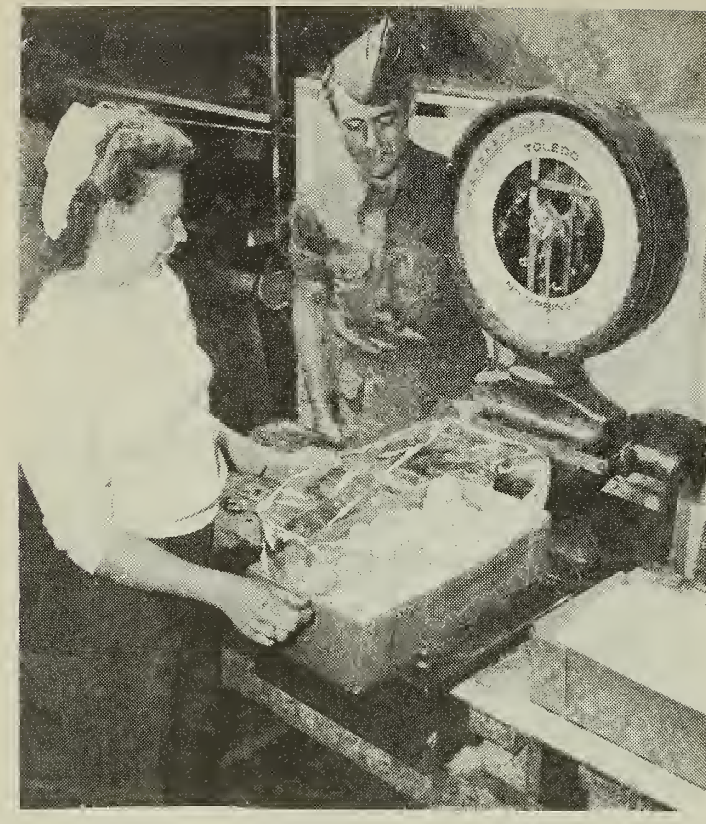


Figure 3. - Peach-filled cartons are weighed with care and sugar is then added. This one contains 30 pounds of fruit and sugar.

those described above. The barrel pack is held at zero temperature for 6 days, during which time it is periodically rolled to speed the operation. The barrels are then stored at 5° F. above zero (figure 4).

INITIAL REQUIREMENTS FOR PROCESSING FROZEN FRUITS AND VEGETABLES

First consideration by cooperatives interested in expanding or converting to freezing operations should be directed to the raw product. To state the question briefly: Is there a sufficient volume of suitable types and varieties of the raw product available within practical distance of the proposed freezing plant, or is the region by virtue of soil and climate a potential source of fruits and vegetables suitable for freezing? The fact that a cooperative may have had marked success with the types or varieties of fruits and vegetables it has marketed either fresh or canned does not necessarily imply that such fruits and vegetables lend themselves to freezing operations.

Certain types and varieties of fruits and vegetables are well adapted for quick-freezing, while others are not. In the main, fruits selected for freezing should have a pronounced characteristic flavor and should be slow to discolor. For example, berries, as a group, and cherries freeze well. They are highly colored, highly flavored, quite acid, and quite sweet. Other characteristics which influence freezing qualities of fruits are stability of color and flavor when exposed to air. Some fruits such as apples, apricots, and peaches tend to discolor from oxidation. Certain treatments may be used in the prefreezing preparation to retard such oxidation.

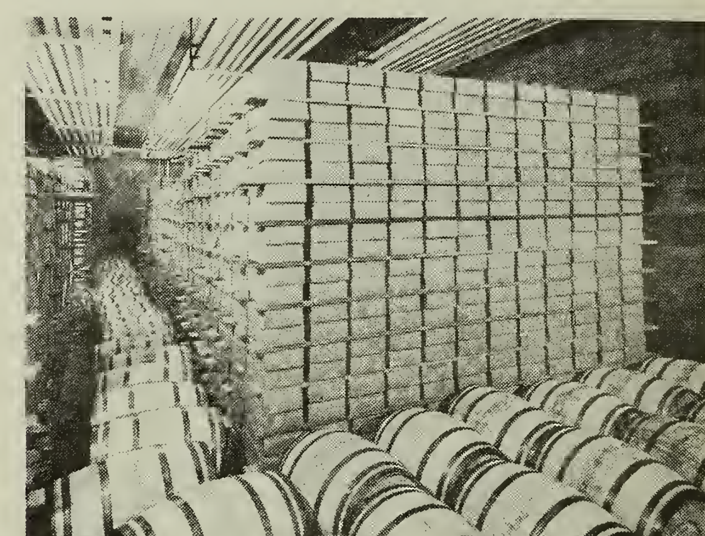


Figure 4. - Storage temperatures of approximately 0° F. are recommended. For certain products they should be even lower. Cartons must be stacked away from walls and ceilings and laid upon strips of wood so the air flow will not be impeded. For those not completely frozen, vertical spacing also is needed, as well as dunnage between every other layer. Barrels are laid down and rolled periodically to insure complete mixture of contents until frozen, after which they are stacked on end.

For the most part, fruits for freezing should be fully ripe when harvested. The importance of other requirements in the raw product varies according to the type of frozen pack. If the fruit is to be frozen whole or in halves for consumer packages, size and shape are extremely important. On the other hand, these requirements are less important in sliced fruit, and need not be considered if the fruit is to be crushed or made into puree. Information on the varieties of various types of fruit currently considered satisfactory for freezing appears in table 4, page 52, of this report.

Vegetables characterized by relatively low moisture content and correspondingly high solids content, which are usually cooked before serving, are generally considered best adapted for quick-freezing. These include garden peas, lima beans, sweet corn, asparagus, brussels sprouts, sprouting broccoli, carrots, cauliflower, spinach and other greens, and winter squash. Vegetables of high moisture content and correspondingly low solids content which are usually served raw, as lettuce, radishes, and celery, do not produce as satisfactory quick-frozen packs. The list of vegetables unsuitable for freezing grows shorter, however, with improved methods of preparation for freezing, increased knowledge of behavior under frozen conditions, and improved methods of preparing and serving. Some vegetables, such as Irish Potatoes, which have other methods of preservation peculiarly suited to them, have not been recommended for freezing.

Some varieties possess characteristics which make them particularly desirable for freezing. For example, certain varieties of carrots are selected for high color, low fiber, good sugar content, and flavor; peas for color, tenderness, and sweetness; beans for low fiber and stringlessness; and corn for color, tenderness, and sweetness. Varieties of the types of vegetables currently suggested for quick-freezing appear in table 5, page 54, of this report.

It will be necessary for the interested cooperative not only to determine that the right types and varieties of the raw product are available, but that they are available in sufficient quantities to permit the most efficient and economical operation. Volume should be sufficient to maintain the proper ratio between the raw material supply and plant capacity. It is just as necessary to avoid overproduction as underproduction. Selection of types and varieties to permit staggering the harvesting dates will tend to level out the volume peaks and allow maximum use of manpower and equipment.

Other factors to be carefully considered are the availability of sufficient suitable labor for preparation and freezing operations, the supply of adequate electric power and water, and proper sewage disposal. Should they decide to undertake freezing operations, cooperatives not previously engaged in processing will probably find it necessary to secure technical assistance from food chemists and experienced refrigeration engineers.

When a cooperative interested in freezing operations has surveyed its area and determined that sufficient quantities of the right types and varieties of the raw produce can be made available within practical distance of the proposed plant, and if no other serious problems appear, consideration may be given to such items as handling, processing, packaging, and distributing the frozen product.

THE PRODUCT

Two of the most important factors affecting the quality of frozen fruits and vegetables are maturity and method of handling. Stage of maturity requires careful attention as it is so largely dependent upon weather conditions, which frequently vary from season to season. The harvesting of fruits or vegetables for freezing at just the right stage of maturity is all-important in the flavor and quality of the finished product. Much more attention must be paid to the stage of maturity in freezing than in canning, since this method of processing does not level out the unfavorable features of overmaturity or immaturity as does the cooking of canned products. If overmature, the product may be tough and have a strong flavor, and if immature, it may lack flavor and body.

The second factor, handling from time of harvest until the products are frozen, is extremely important from the standpoint of quality retention. Proximity of the source of raw material to the preparation and freezing plant is an important factor in the quality of the frozen product. While fruits and vegetables can be transported some distance, if necessary, they require extreme care in handling to prevent bruising and other injuries. Between harvesting in the field and processing at the plant, bruising and injuries are aggravated by the growth of microorganisms and by respiration. These processes can be checked by artificial cooling during long hauls. Care in handling, of course, is important in canning, but deserves even greater consideration when the products are to be frozen.

Vegetables should be processed the day they are harvested, although fruits properly precooled may be held over. Tests indicate that shelled peas, for example, depreciate in quality at a rate proportional to the length of the holding period and to the temperature. This loss of quality is evident in apparent increase in the starch content, toughening of the skins, undesirable color changes, and development of off-flavors. Loss of quality varies with different products and with different temperatures.

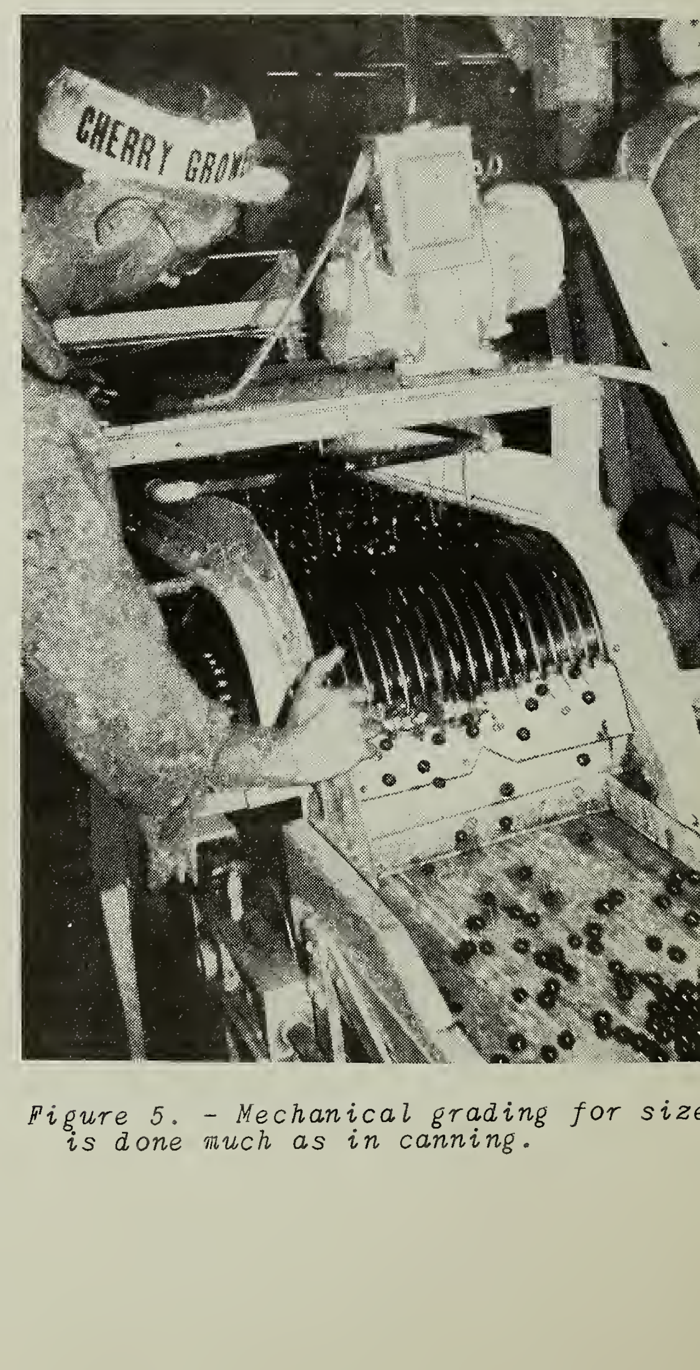


Figure 5. - Mechanical grading for size is done much as in canning.

PREPARATION

Fruits

The preparation of fruits for freezing is much the same as for canning. They are washed, graded, trimmed, peeled, halved, pitted or cored, as may be required, just as in canning. Size grading of fruits may be either manual or mechanical. Manual grading may be confined to removal of culls and other undesirable products, or it may mean use of special grading tables which permit each inspector to grade the product into several sizes. By a system of belts and dividing fences, inspectors segregate the product into lots according to size. Most of the mechanical graders operate by rolling the product over a support fitted with openings that are small at the entrance end and larger farther along, so that pieces of different sizes drop through at different places (figure 5).

Fruits may be packed whole without sugar (dry pack) or whole with sugar, sliced and packed with sirup, or sliced or crushed and packed with sugar depending upon whether they are to be used by the retail trade, by pie makers, preservers, or other subsequent processors (figure 6).

The treatments given fruits in preparation for freezing are usually to prevent oxidation or enzyme actions, or both. They are largely confined to peaches, apricots, and apples, and include heat treatment (steam or sirup scald), dipping in sulfurous acid or other solution, or use of certain chemicals such as 1-ascorbic acid. Blueberries, according to tests conducted by the Georgia Agricultural Experiment Station, are also improved by blanching prior to freezing. The chief benefit in the

Figure 6. - Culls and undesirable pieces must be removed by hand.

case of blueberries is not to prevent oxidation but to inactivate enzymes which produce objectionable structure.

Vegetables

Vegetables also are prepared as for canning; they are washed, graded, and trimmed as may be required. Quality grading is used for certain vegetables such as peas and lima beans, employing a salt brine solution of about 10 percent salt by means of which the higher quality is floated to the top and the "sinkers" go to the bottom. (See figure 7.) In preparing vegetables for freezing, scalding or blanching is necessary to prevent enzyme action. This blanching process prevents deterioration in color, flavor, odor, and nutritional value during storage. The time needed for blanching is usually shorter for freezing than for canning.

The first vegetables frozen were unsuccessful because the products were not blanched. Experiments showed that freezing and thawing caused abnormal enzymic activity and

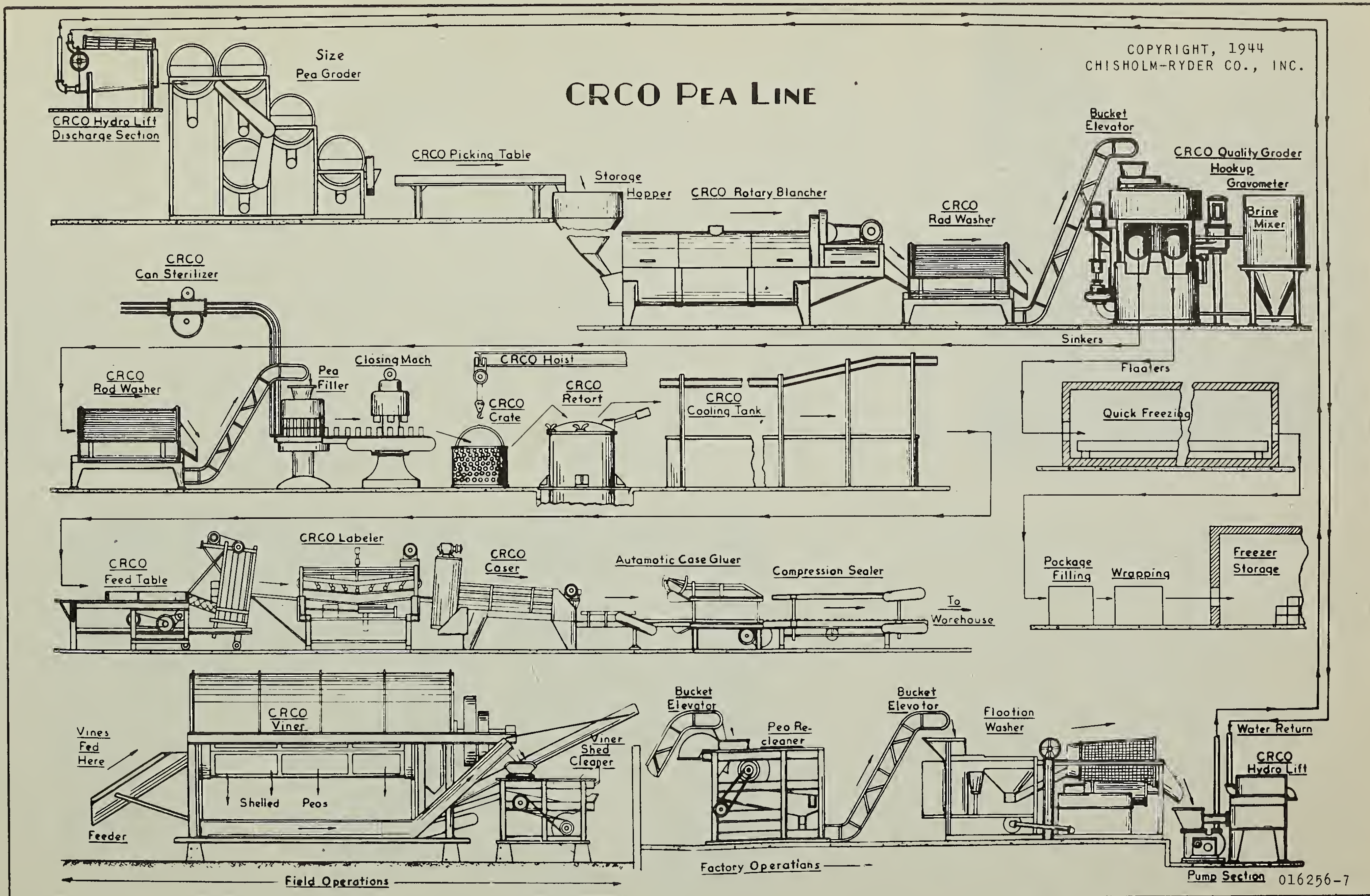


Figure 7. - Flow chart for peas showing movement of "floaters" to freezer and of "sinkers" to canning line. Field operations are shown at bottom of chart.

this resulted in the development of off-flavors. It was found that this effect was so pronounced with raw vegetables as to make their freezing impractical. Further experiments showed that if the enzymes were inactivated by a short precooking treatment, vegetables could be frozen, and if properly stored, the flavor would be retained for a considerable period. It was found that the scalding of vegetables inhibited the development of off-flavors during cold storage and thawing, and improved the general keeping qualities of the frozen product.

Blanching may be done by heating the vegetable in either steam or hot water. Some processors prefer one blanching method and some the other. Steam blanching is preferred by some for asparagus and leafy greens and boiling water for all other vegetables. An information sheet developed by the U.S.D.A. Western Regional Research Laboratory on a test for adequacy of blanching in frozen vegetables appears on page 57 of this report. Both the cabinet and the continuous-belt types of blanchers are in widespread use among food processors.

After scalding some method of cooling is employed to stop cooking of the product, to avoid too much blanching, and to speed up the rate of freezing. The cooling process may be done by cold water sprayed on the product or by immersion in water. As prolonged contact with the cold water results in leaching of valuable vitamins and minerals, an effort is usually made to reduce the length of the cooling period to a minimum. Where the cooling process may be accomplished by blowing air across or through the blanched product on trays or belts, this leaching of soluble solids may be avoided.

TYPES OF PACK

There are three types of pack for frozen fruits and vegetables. These are commonly referred to as "cold pack," package freezing, and loose pack.

Cold pack is probably the oldest form and is used largely for fruits. The fruits (chiefly berries, cherries, and plums) are placed in paraffin-lined 50-gallon barrels, 30-pound tins, or large fiberboard containers, and mixed with the desired amount of sugar, which may be a 3 + 1, 4 + 1, or other ratio; that is, three or four parts fruit to one part sugar. The ratios of sugar to fruit are weight and not volume ratios. Sugar is added to the fruit in the barrel while it is continually rocked or shaken to get an even distribution of sugar throughout the mixture. The shaking or rocking process is usually a manual operation, although some

Figure 8. - Sugar is added to the fruit in the barrel while it is continually rocked or shaken to get an even distribution throughout.

plants are equipped with a mechanical device for the purpose (figure 8).

The barrels are then placed in the freezer room on their sides and held at temperatures ranging in different plants from 10° F. below zero to slightly above zero. They are rolled over by half a turn four times a day for about a week or 10 days to insure complete mixture of the contents. After freezing, the barrels are placed on end in a low-temperature room, the temperature of which, it is now widely recommended, should be held at approximately zero degrees. Under present commercial operations, however, there is considerable difference in the methods employed in different freezing plants.

Some fruits are packed in barrels without sugar and frozen at 0° F. or below. Such products should be stored at approximately zero.

"Quick-freezing," which is the term generally applied because of the short time required to complete freezing, is done in both packaged and loose forms. By the first method, used for sugar-packed fruits or solid-packed vegetables, the product is placed in varying sizes of packages, as 12-oz., 1-lb., 2½-lb., 5-lb., or 10-lb., in which usually a moisture-vapor-proof liner has been inserted. The packages are then placed on trays and transferred on trucks to the freezing room, or the container may be placed in a heavily waxed carton with other packages of the same size, and then frozen. After freezing, the packages are wrapped in a heat-sealing, water impervious wrapper and placed in storage at a temperature of 0° F. or below.

"Loose pack" is frozen before it goes into the package or container.

Figure 9. - The cellophane pouch is shaped over this specially designed mandrel, which may be collapsed for storage when not in use, and the carton is then fitted over the liner.

This method is used for loose or dry packed fruits and vegetables. They may be frozen either on trays or on a conveyor belt, the frozen product then is packaged and transferred to the storage room.

PACKAGING

The packaging materials and the equipment used for frozen foods will be different from those used for canned products and also, to some extent, from those used for dehydrated foods. Certain food processors, however, are of the opinion that some of the self-sealing, moisture-vapor-proof, laminated bags which have been used for dehydrated foods should find permanent use in packaging frozen foods. Preliminary tests show that "some of them may revolutionize the packaging of frozen foods in efficiency, cheapness, and simplicity of filling."

The general requirements for a satisfactory frozen-food package are that it be made of moisture-vapor-proof, grease-proof, odorless, tasteless, noncorrosive material that can be completely sealed. An important requirement is that the package hold its contents against leakage and loss of moisture. Another requirement is that it hold against loss of volatile flavors, odors, and change of color (figure 9).

Over a period of time certain types of packages have become more or less standardized in their use. The 10-, 12-, and 16-ounce sizes are ordinarily packed for home use; over 1 but less than 10-pound sizes for small institutions; and the 10-pound and larger packs for large institutions and industrial users.

Large Containers

Barrels made from fir, paraffin-coated on the inside, are widely used for cold-pack fruits. The 50-gallon size is most extensively used. Smaller quantities are also packed in kegs. For certain products, particularly frozen poultry, wooden boxes lined with parchment or waxed paper are used to a large extent. Tin cans, some made with a special enamel lining, have been widely used for frozen products. During the war, however, the supply of tin available for the manufacture of food containers has been greatly reduced so that use of tin for frozen foods has been restricted to certain products.

Because of this severe restriction on the use of tin, several types of fiberboard containers, particularly the 25- and 30-pound sizes, have come into rather general use. These larger sizes are used for some frozen vegetables, but in the greatest numbers for frozen fruits.

The 1944 frozen-food pack statistics of the National Association of Frozen Food Packers indicate that a greatly expanded usage of 30-pound containers accompanied the increase in frozen-fruit pack in 1944. The volume of frozen fruits and berries packed in 30-pound containers (fiber and tin) increased from 53 million pounds in 1943 to 123 million pounds in 1944. Despite this tremendous increase, however, both retail cartons and small institutional sizes maintained the same relative position occupied in 1943. In both 1943 and 1944, about 7 percent of the frozen fruit and berry pack went into retail cartons and less than 1 percent was put up in small institutional sizes (over 1 but less than 10 pounds). The expanded usage of 30-pound containers resulted primarily from a decreased percentage of the pack going into barrels - in 1943 about 44 percent

Figure 10. - This cylindrical container, used extensively as a wartime substitute for tin, is also fitted with a cellophane liner.

of the total was packed in barrels but in 1944 only 32 percent was packed in such containers (figure 10).

The most significant development in container usage for frozen vegetables was the increased importance of the pack in retail cartons during 1944. In 1942, the pack in cartons of 1 pound net weight or less amounted to 38 percent of the total, and in 1943 this percentage dropped to 32 percent. In 1944, however, about 44 percent of the total pack was in retail cartons. At the same time there was a decline in the percentage of the pack going into small institutional sizes (over 1 but less than 10 pounds), and also a reduction in the proportion of the pack put up in large institutional and industrial sizes (10 pounds and over) (figure 11).

As an example of the larger-unit packaging operations, the cooperative whose frozen-peach pack is discussed on pages 9 and 10 of this publication used a two-piece telescope-type corrugated fiber-board container for its 30-pound peach pack during the 1944 season. This container is 20 inches long, 10 inches wide, and has an inside depth of 4½ inches. The cellophane liner used with it may be removed intact from the carton and the product,

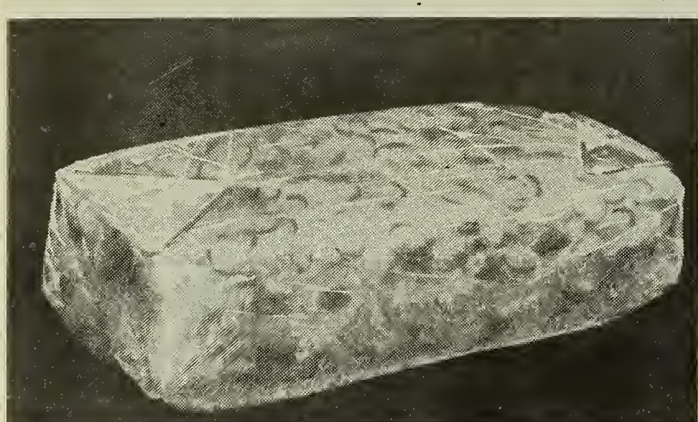


Figure 11. - The sealed cellophane liner permits removal of the frozen product for inspection.

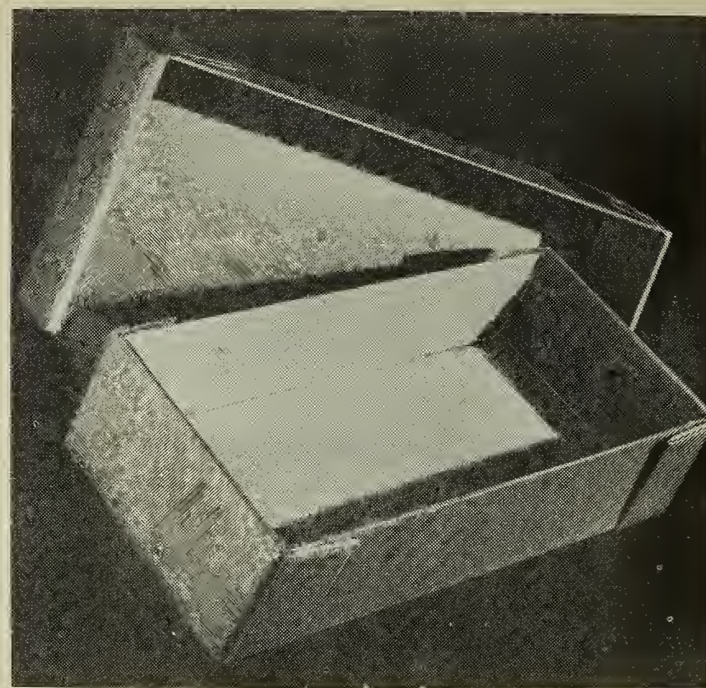


Figure 12. - The two-piece telescope-type corrugated fiberboard container is used over cellophane liners for 30-pound packs. The top and the bottom are reinforced with a patented end fold which gives unusual stacking strength during freezing and storage.

visible through the liner, may be carefully inspected by prospective buyers. The size and shape of the container make it easy to handle on trucks and it may be stacked conveniently in tiers of 20 in the warehouse. Also the wide mouth of the carton permits easy and rapid filling. Each part of the carton (top and bottom) is made from a single strip of 200-pound kraft board with a special patented fold. The ends of both folded interlocked pieces require no stitching, tape, glue, or seals in assembling. The carton has the advantage of unusual stacking strength (figure 12).

The cellophane liner is shipped flat, 18 by 30½ inches in size, in units of two sheets, with the bottom and side edges laminated. Shipping in this manner insures retention of tensile strength of the liner and protection against wear and tear in shipment. The sheets are shaped into liners over a specially designed

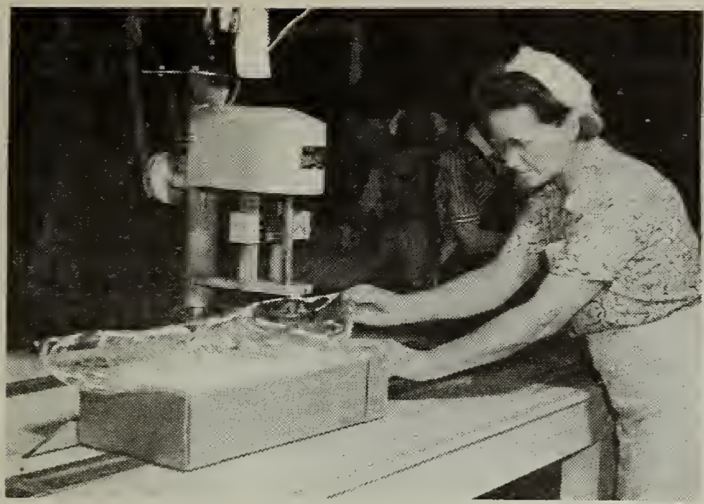


Figure 13. - Edges of the liner, which extend about 8 inches above the container after filling, are heat-sealed before the top of the carton is applied.

mandrel and the outer container is then fitted over the liner. The mandrel is collapsible, and in position has a height of 24 inches, length of 19½ inches, and width of 9½ inches. When not in use, the mandrel is collapsed and requires a minimum of storage space. The double sheet is opened on the nonlaminated edge and telescoped onto the mandrel. The laminated bottom fits into the inside bottom of the container and this is particularly important as the greater the pressure against the laminated part, the less is the possibility of its bursting. The edges of the liner, which extend about 8 inches above the container after filling, are heat sealed (figure 13).

Small Containers

The smaller paperboard containers in the 12-ounce, 16-ounce, 2½-pound, 4-pound, and 5-pound sizes are used for both frozen fruits and frozen vegetables. Moisture-vapor-proof liners are generally used in these cartons and they may be top- or end-filled.

For the most part, these paperboard containers fall into three classifications: (1) The printed carton, covered by a transparent overwrap; (2) the plain, unprinted carton covered by a printed opaque overwrap; and (3) a plain carton on which a printed insert is laid and the package wrapped in a transparent overwrap which permits reading of the printed label. The processor using his own brand and controlling his own distribution throughout, finds a printed carton with a plain transparent overwrap desirable, while the processor selling through other distributing organizations having their own brand names is likely to use the second or third type of package. In some plants the overwrap is omitted. When the printed carton is used in such plants, the product is frozen before packaging and is then placed in moisture-vapor-proof bags which are heat sealed and inserted in paperboard cartons. The heat seal on the bag is then considered adequate to prevent loss of moisture from the product.

Most of the smaller cartons with overwraps, and a good share of the larger ones, are wrapped by automatic machines.

Since postwar designs of frozen-food cabinets for retail stores emphasize the display or self-service types, it is probable that various brands of frozen-food packages will compete with each other in attracting the buyer's eye. This means that frozen-food packers will be warranted in paying special attention to their packages and in developing "eye-appeal" in their labels. Some of the cooperatives visited during the course of this study were in the process of changing their overwraps and their cartons. One large cooperative had under way arrangements for a multilith carton carrying the same attractive brand label as its canned products. Since this is an unusually colorful label, the new package will represent a fairly expensive investment. Another association was revising its multilithed overwrap to provide a more colorful package. The brand name of this association's frozen products, which conveys the idea of garden freshness, is a particularly effective one.

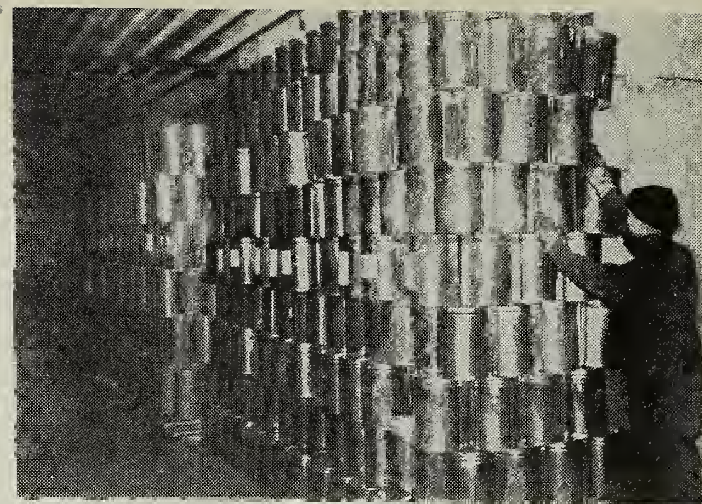


Figure 14. - Products frozen hard enough for storage are transferred to rooms kept at 0°F. Tin containers such as those in front were restricted during wartime so cylindrical fiber containers, seen in the rear, were substituted. For storage these are stacked solid on strips of wood or dunnage.

STORAGE

A storage temperature following freezing of not higher than 0° F. is recommended and temperatures above 5° F. are considered unsatisfactory for best results. For some vegetables and fruits, such as asparagus, corn on the cob, mushrooms, snap beans, apples, and peaches, a slightly lower temperature of 5° F. below zero has been recommended. Although high humidity is objectionable in cool storage (above 32° F.) because it causes products to mold, in cold storage (below 32° F.) high humidity is desirable. Air of a much higher temperature than the cooling coils gives up moisture when it strikes the coils, which freezes on the cooling surfaces as frost. If the air in a low-temperature room is low in humidity it will draw moisture from the stored products, causing excessive desiccation unless the products are properly packaged in impervious materials. The products should be stacked away from walls and ceiling, and floor dunnage (strips of wood) should be used so that the air flow beneath the load is not impeded. If the products are completely frozen they should be stacked solid. However, if there is any doubt that they are completely frozen they should be stacked with vertical spaces of a few inches between every second tier and with horizontal spaces provided by dunnage between every other layer (figure 14).

LABOR REQUIREMENTS

Direct labor required to handle the product from the time it arrives at the plant until it is transferred to storage ordinarily includes the following:

Receiving and Storage Labor

Handles unloading of material, transfer of product to preparation line, washing and fumigating of empty crates and boxes, and cleaning up.

Preparation Line

Preliminary sorting and grading, trimming, coring, peeling, cutting, blanching, cleaning up, waste disposal, and the operation and servicing of preparation equipment.

Packaging Line

Filling, sealing, wrapping, and boxing; operation and servicing of equipment used; keeping of packaging supplies on hand; stacking of packaged products on trays; and transferring of trays to freezer. (This labor will vary depending on whether the product is packaged before or after freezing, whether it is frozen on a conveyor belt or on trays, whether an overwrap is used, and similar details.)

Freezing Labor

Operation and servicing of freezing tunnels, still rooms, and refrigeration machinery and equipment.

Storage Labor

Handling transfer of product into and out of storage.

TRANSPORTATION

Several types of refrigerated cars have been in use for the transportation of food products. While some standard refrigerator cars are of steel, most of them are of wooden construction with steel underframes. Insulating materials are usually hair felt, ground cork, Dry-Zero, or Celotex, and are 2 to 3 inches thick. These standard refrigerator cars, even with careful icing and salting, have been found unsatisfactory for transporting quick-frozen foods in hot weather.

More recently, heavily insulated refrigerated cars have been used for the transportation of frozen foods. These cars have from 7 to 7½ inches of insulation in the roof and from 6 to 7 inches in the floor and in the side and end walls. Their average capacity is 2,400 cubic feet. Before being loaded with frozen foods, the cars are iced with coarse ice and 25 to 30 percent salt. In 24 to 48 hours, depending on outside temperatures, the temperature in the car can be brought down to 15° F. or lower. The car is carefully loaded with packages stacked tightly together and is again iced with ice and 30 percent salt. During shipment re-icing is done at all regular icing stations.

A few cars have been built which employ mechanical refrigeration, with the compressor placed underneath the car and the condenser on the roof. Evaporators are located at each end of the car, and each is partly submerged in a brine tank. The brine tanks provide refrigeration when the car is stationary or moving too slowly to operate the compressor properly. An electric motor permits operation of the compressor if the car is stationary for some time. Use of these cars for transportation of frozen foods is limited mainly to short runs.

Some shippers of frozen foods prefer truck movement to rail movement on medium hauls because of the speed and the convenience. In modern trucks, fiberglass is extensively used for insulation. Because of the damage caused by dripping brine, ice-salt mixtures are usually not employed for refrigerating trucks. Instead, cartridges containing frozen brine are sealed and placed in the truck.

Solid carbon dioxide has been widely used as a truck refrigerant. The refrigerant is usually in a container or bunker attached to the ceiling and is loaded by means of a roof hatch. The use of solid carbon dioxide in trucks is more economical than in refrigerated cars as the trucks are more easily and better insulated, and the usual haul is shorter by truck than by rail.

More recently, mechanical refrigeration in truck bodies has been so much improved that it is replacing some of the other methods of cooling. In one system the refrigerating unit is driven by an electric motor which may be supplied with electricity from the generator or from any source of current while the trailer is being loaded. The unit consists of a two-cylinder compressor with an air-cooled condenser and receiver. Finned cooling coils are suspended from the ceiling of the trailer. A number of other mechanical refrigeration systems have been successfully used. Small refrigerated trucks are in use for deliveries from local warehouses to retailers and institutional users and, to some extent, for house-to-house deliveries.

The shortage of refrigerated transportation has been one of the bottlenecks in the distribution of quick-frozen foods. It is expected that there will be considerable expansion and improvement in refrigerated transportation after the war when materials will be available for the construction of modern refrigerated cars and trucks.

SANITATION

Plant sanitation must receive careful consideration since quick-frozen fruits and vegetables are not sterilized at any time during preparation or processing. Ready growth of bacteria occurs in vegetables when they are kept at ordinary temperatures. While bacteria do not thrive on acid fruits, yeasts and molds grow rapidly, particularly in warm, humid temperatures. A temperature of 32° F. will retard the growth of many micro-organisms, but does not prevent their ultimate increase. Blanching of vegetables results in only partial destruction of micro-organisms.

Extreme care is required in keeping conveyors, inspection belts, and other equipment clean. A good water supply is necessary for proper sanitation. Bacterial counts taken periodically during a production day will indicate whether sanitation is receiving sufficient attention. If tests made later in the day show increasing numbers of bacteria, somewhere along the production line sanitation is not receiving adequate attention and the situation should be promptly checked into to determine where the contamination is occurring. Contamination might occur during preparation, while the product is cooling after blanching, during any delay between blanching and freezing, in a period of slow freezing, or, if thawing takes place, after freezing.

A temperature of 15° F. is the highest permissible for storing frozen fruits and vegetables based strictly on the prevention of the growth of micro-organisms. However, temperatures usually recommended are much below this and most of the cooperative freezers visited in this study were maintaining cold-storage temperatures at somewhere between 5° below and 5° above zero Farenheit.

FEDERAL INSPECTION

The inspection service of the Office of Marketing Services, War Food Administration (United States Department of Agriculture) furnishes a means by which cooperative freezers may voluntarily arrange for certification of the quality of their packs by competent Federal inspectors. Inspection may be continuous at the plant or it may be based on samples selected from the commodities packed by the association.

Continuous Factory Inspection

Under continuous factory inspection qualified Federal inspectors of the United States Department of

Agriculture are present in the plant at all times when it is in operation, observing the preparation and freezing of the foods processed in the plant. Foods frozen under continuous factory inspection are often identified by a shield on the container and may bear the legend "Packed Under the Continuous Inspection of the U. S. Department of Agriculture." Grade labels in terms of U. S. grades may be used on fruits and vegetables packed under continuous inspection, as U. S. Grade A, U. S. Grade B, and U. S. Grade C; or the synonymous terms of U. S. Fancy, U. S. Choice or U. S. Extra Standard, and U. S. Standard.

Only processed fruits and vegetables (including frozen foods) packed under the continuous inspection service of the U. S. Department of Agriculture may carry the prefix "U. S." in connection with the grade designation. If the prefix is used, it means that the product has been prepared in a plant operating under the continuous inspection service and that the inspector has certified the grade of the finished product. If the prefix is not shown, the grade statement means that the packer or distributor assumes responsibility for the accuracy of the grade designation.

Processing plants participating in continuous factory inspection must meet certain strict requirements. The plants are thoroughly inspected to make sure that these requirements - which have to do with sanitation in the plant, adequate provisions for personal cleanliness of employees handling food, and proper observance of superior housekeeping standards - are met.

Owners of the plants participating in the continuous factory inspection program pay to the Treasurer of the United States, the cost of the service as stated in the contract, which cost is based upon the inspectors' salaries and incidental expenses. Gross cost per case varies inversely with the size of the pack.

Inspection of Selected Samples

Inspection of selected samples may be accomplished in one of three ways:

1. Samples may be sent by the association direct to the inspection office serving the territory in which the samples originate.

2. Samples may be drawn by an officially licensed sampler and forwarded by him to the nearest inspection office.

3. Samples may be drawn in many of the large markets of the country by a representative of the Federal Inspection Service, who will forward them to the proper inspection office for inspection and certification. Samples also may be drawn at any point which can be conveniently reached from any of these markets. A list of these inspection markets of processed fruits and vegetables may be obtained from the War Food Administration, Office of Marketing Services, Washington 25, D. C.

Inspection under these three methods will be in accordance with U. S. Standards for Grades approved or promulgated by the U. S. Department of Agriculture, on the basis of Federal specifications, or in accordance with any specification suitable for the purpose. The fee for inspecting samples is levied on a unit basis.

United States Standards

United States standards have now been developed for grades of the following frozen fruits and vegetables: Cherries (red sour pitted), raspberries, strawberries, asparagus, beans (lima and snap), broccoli, cauliflower, corn (whole-grain), peas, and spinach. Standards for other frozen products are being developed.

RESEARCH

Much experimental work has been done and is continually under way at the Western Regional Research Laboratory of the U. S. Department of Agriculture, at various agricultural experiment station laboratories, and in the laboratories of food-processing organizations to improve methods of preparation, freezing, packaging, and storing of frozen foods. The Refrigeration Research Foundation, organized in 1943, was created solely for the purpose of carrying out a long-range program of research dealing with refrigeration of food and other commodities.

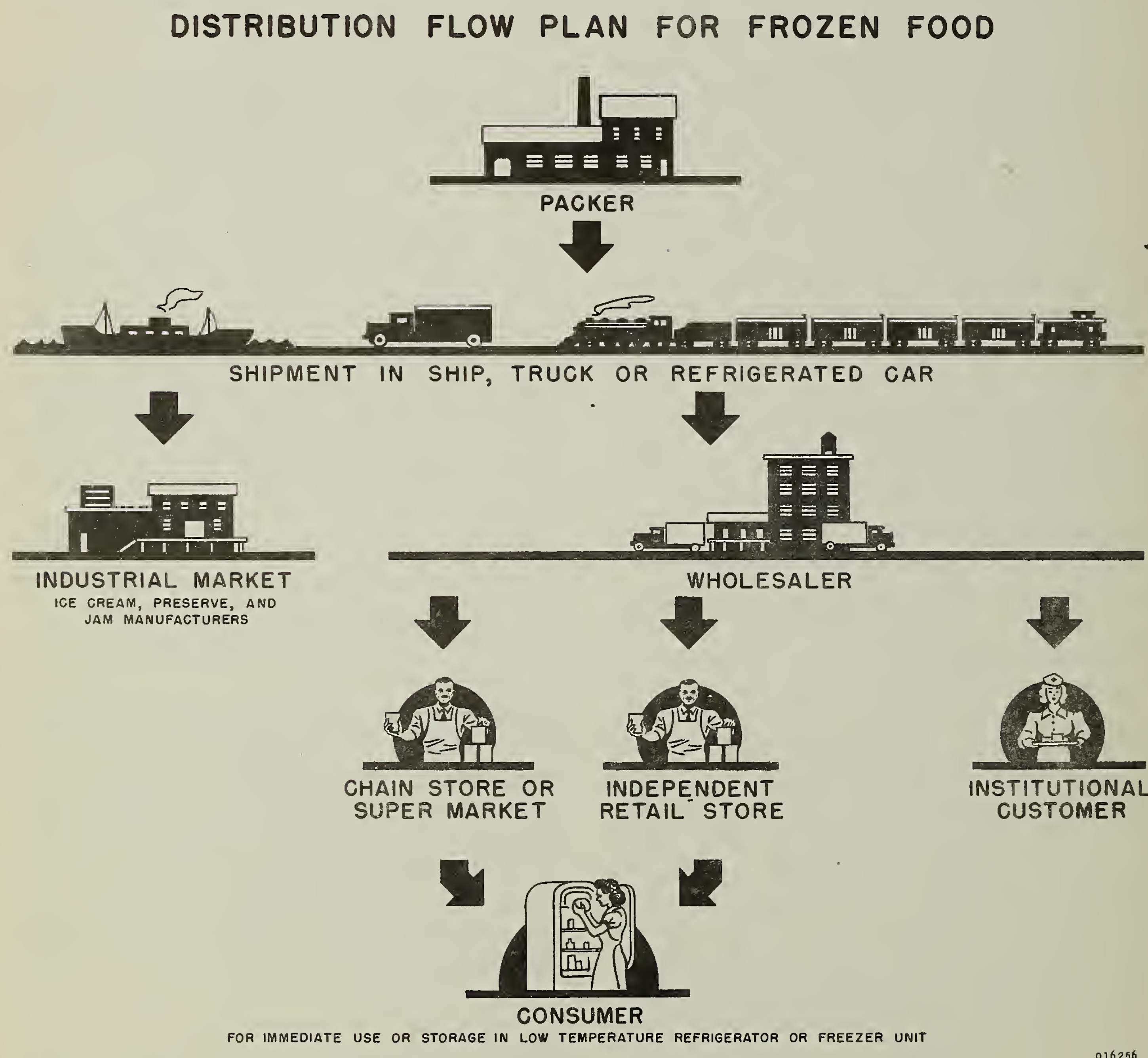


Figure 15. - Both large and small packers may use variations of this plan. Large packers may distribute either through selected distributors or through their own direct branches; small packers may sell direct to local retail outlets and employ brokers for more distant sales.

DISTRIBUTION OF THE PRODUCT

Consumers of frozen foods fall into three general categories. These are: (1) industrial consumers, such as ice cream and jam and jelly manufacturers; (2) institutional, including restaurants, hotels, clubs, hospitals, and similar institutions; and (3) retail, composed of customers of independent and chain stores. The usual distribution flow plan for packers of frozen foods is illustrated in figure 15.

CHANNELS

Frozen-food packers, for the most part, have connections with leading food brokers in the important centers of frozen-food consumption. These brokers operate on a commission basis, usually 4 to 5 percent on all sales. Large processors and wholesalers may buy their frozen products through these brokers and then sell to the smaller processors and institutions.

One channel of distribution which has been used for frozen products is dairy, ice cream, and ice companies, which distribute a variety of frozen foods along with their own products. In this method of distribution, maximum use is made of well-established channels and of existing storage facilities.

The small package usually goes through the channels of broker, wholesaler, and retailer. In some cases, however, the processor may assume the functions of the broker and the wholesaler. One cooperative packer, for example, sold directly to retail stores in the local area and employed brokers elsewhere. Sometimes a company performs primarily the wholesaler's function, contracting with individual packers for a supply of certain frozen products and using its own brand name. In this case, the company may arrange for the sale of cabinets to the retailer, but does not have control over the retailer's use of them.

Some of the larger packers of frozen foods today are distributing either through selected distributors in each territory or through their own direct branches. The direct branches are established only in the larger cities, but it is probable that if large packers of canned foods go into the frozen-food business, a considerable percentage of the distribution may be through direct branches all over the country.

Several of the large cooperative frozen-food packers in the Northwest are represented by a regional sales agency. This agency keeps in close touch with its members and is responsible for all selling details. In addition, the agency supplies information to members and recommendations on methods of processing.

This agency has contacts with food brokers in the larger cities. Its policy is to use the same broker frequently for the canned as well as the frozen packs. Choice of broker depends merely on ability to dispose of the products to the best advantage. Some cooperative frozen-food packers, on the other hand, prefer to use different brokers for the canned and for the frozen packs. They believe that, if the same broker is used for both, one product is likely to receive more attention and the other one less.

RETAIL TRADE

Cooperatives are showing much interest in the retail trade. Here, the type of display cabinet generally in use, with its lack of display and frequent inaccessibility of the product desired by the shopper, has been an important limiting factor in the distribution of packaged frozen foods. The lack of special low-temperature transportation equipment has also retarded expansion.

It has been pointed out by some research workers that the elimination of waste in frozen foods ranges from 30 to as much as 60 percent for frozen vegetables. Moveover, research has shown that when the foods are properly handled prior to freezing and are carefully stored thereafter, they retain their vitamin content to a very satisfactory degree. Care and sanitary handling by the packer, proper storage by the distributor, and the right method of preparation or serving by the consumer following removal from refrigeration are all required to maintain this degree of satisfaction.

In addition to elimination of waste and the retention of nutritional value, frozen vegetables have another advantage in that they cook more quickly than fresh vegetables. All these advantages contribute to the acceptability of the product.

RECENT DEVELOPMENTS

Distributors and retailers of frozen foods, even though they may feature one brand, now frequently sell several brands. The primary reason for this change was shortage of supplies. Distributors found it necessary to seek new sources of frozen foods to supply growing demands. Their distribution is now similar to that of canned foods where many brands are bought and sold.

The fact that distributors will buy from more than one packer, and that factors of cost, maximum production, and quality of packs are controlled in large measure by the abundance and the quality of produce grown in a particular area, indicate that a packer can profitably process and sell large volumes of a small number of products rather than a complete line. Some who are familiar with the industry maintain that packers with only limited production would do well to discontinue spreading their product thinly over a large territory and to concentrate in a more restricted area. However, processors located in an area which produces large quantities of a product not generally available elsewhere may have considerable national demand for their products. In this case, the cost of transportation is a factor secondary to demand.

Another development in the marketing of frozen foods has been changes in the original products. Formerly, the frozen foods appearing on the retail market were usually in a form unchanged, except for freezing, from the form in which they were harvested. Newer frozen products include cooked foods, fruit purees, and bakery products. These purees make use of good fruit, although not of the highest quality, which will result in lower production costs because of a higher percentage of recovery of finished product from the raw material.

PLANT FACILITIES AND EQUIPMENT

Those cooperative associations that contemplete quick-freezing operations without the benefit of previous processing experience may find helpful some discussion of the plant facilities and equipment necessary for a modern freezing plant. In the case of either expansion or conversion to freezing by cooperatives already engaged in canning or dehydration, the major building construction and installation of preparation equipment will have been made. Such associations will be familiar with preparation and processing procedures up to the point of freezing. Some of these associations, however, in addition to acquiring facilities for quick-freezing, may be interested in modernizing their plants and replacing old equipment during the process of conversion, after wartime restrictions and priorities are removed.

CONSTRUCTION

Most of the modern freezing plants are of fireproof construction. Suggested building material is reinforced concrete which may be faced on the exterior with brick. Less expensive material would be brick outer walls with heavy wooden construction within. Some operators suggest that storage and freezing rooms should be as nearly cubical as possible, avoiding excessive ceiling height, since cubical construction furnishes the least wall surface for any given storage space and the smaller wall surface means less heat loss. The building should have concrete floors with proper drainage and every provision should be made to keep the plant in sanitary condition.

A primary consideration for all floor construction not over excavated spaces, where inside temperatures are below freezing, is drainage. Floors for freezers should never be laid over wet soil. Drain tile and sand or cinder fill of sufficient depth will be required so that even flood waters cannot accumulate under the floor, where freezing will take place, and result in heaving and destruction of the floor.

LAY-OUT

Some cooperative associations contemplating entrance into the freezing field will, no doubt, have certain definite ideas of their own concerning the most desirable features of any proposed lay-out. Before any definite plan can be drawn up, it will be necessary to determine the probable maximum volume per day to be put through the plant during peak operations. The number and length of the trimming and inspection belts, for example, will be governed by the number of workers needed for these operations, which in turn depends upon the volume being handled in the plant.

The number of workers required for the various operations will also affect plans for the spacing of equipment. Considerable labor saving can be accomplished by giving attention to the details of lay-out. Some cooperative associations visited during this study were changing their plant lay-outs so as to take advantage of gravity flow in handling the product, thus decreasing the number of employees required and eliminating elevators and conveyors at certain points.

In addition to the preparation, freezing, and storage rooms, the usual plant lay-out provides for receiving, shipping, and packaging rooms or space, locker and wash rooms, a laboratory, and a machine room housing the refrigeration machinery. The laboratory should be located preferably in a position convenient to the preparation and packaging rooms. Locker and wash rooms should be within easy access of the preparation line, so as to avoid unnecessary loss of time by workers.

In some plants, the office is located in a position overlooking the receiving and shipping platform for convenience in checking movement of products in and out of the plant. In most of the cooperative plants visited, all of which were operated in conjunction with a cannery, the office was located in a separate building overlooking the plant.

Cooperative associations considering the construction of new facilities may find it worth while to give serious thought to the possibilities of future expansion in both volume and number of commodities to be processed, keeping in mind that if ample space is provided and proper arrangements are made in the new layout, additional freezing machinery and other equipment can be added.

INSULATION

Type and thickness of insulation to be used in the construction and operation of a freezing plant, as well as adequate vapor proofing, should have very careful consideration. Unless attention is given these items, maintenance and operating costs may be high. The greater the efficiency of the insulating material, the less will be power or fuel cost, maintenance cost of insulation and mechanical equipment, and initial cost of machinery. The cost of such insulation, with interest allowance on the investment, would have to be measured against these savings. The savings indicated become relatively greater in the case of smaller buildings, because the heat load to be removed by insulation is relatively greater.[5]

The insulating materials in general use are cork, corkboard, wood, sawdust, shavings, charcoal, paper, mineral wool, glass wool, Celotex, Palco Wool, Dry-Zero Insulation, straw, and hair felt. The requirements for effective insulation, in addition to resistance against heat and vapor, are that the materials be odorless, light in weight, and not inclined to pack or settle. Insulation should also be proof against rot, vermin, and other destructive agencies.

The problem of keeping moisture out of insulation is an important one. Moisture is driven into insulation by the vapor-pressure differential that exists between the high and low temperature side of the insulation. Insulating materials to be used for low-temperature storage which are not resistant to moisture penetration must be protected with vapor proofing.

Whatever type of insulation is used, special care must be taken in its application. Edges of the insulation should be placed close together and uneven surfaces made smooth. The economy and the satisfaction resulting from the insulation selected will depend in a large measure on the care and skill in its application.

EQUIPMENT

The amount of equipment required will depend upon the volume and the types of commodities to be frozen in the plant.

Preparation

Those associations which have been canning or dehydrating will find the preparation equipment already in use suitable for preparation of the frozen pack unless greatly increased volumes and additional types of commodities are to be

[5] In a plant containing 1 million cubic feet of volume, cube shaped, there would be .06 square feet of heat absorbing surface to be insulated per cubic foot, compared with 0.6 square feet in a commercial refrigerator, cube shaped, containing 1,000 cubic feet.

frozen. By adding certain pieces of equipment and removing others, the same preparation line may be altered to handle different commodities. Estimates of the preparation equipment required to run one line of corn, peas, and a number of other commodities shown in appendix D, page 57, may be helpful, particularly to associations which have previously handled only fresh fruits and vegetables.

Refrigeration

The freezing equipment used in various types of freezing operations and the types of refrigeration machinery in general commercial use are discussed in later sections of this publication, pages 31 - 39.

STORAGE SPACE

Adequate storage space is of major importance in any freezing operation. Peak deliveries of products during seasonal operations may require extensive storage space prior to freezing. Likewise, the low temperature space for storage to follow freezing should be sufficient to permit the most efficient use of manpower, equipment, and facilities in handling shipments. Some estimates show that upwards of 60 percent of all time devoted to manufacture is chargeable to materials-handling, and while that for food-processing is less, the percentage is still sizable. Any means of cutting handling costs, therefore, should increase productive capacity and financial returns. The use of powered trucks and pallets has greatly increased in recent years in the canning and packing business, and new processors will probably want to take this into consideration in their warehousing plans.

COMMERCIAL FREEZING AND STORAGE

Some cooperative associations are not in position to do their own freezing or warehousing and it is necessary for them to transfer their products to commercial freezers. A number of cooperative associations which started freezing operations on a commercial freezing and warehousing basis have since found it advantageous to install their own freezers and warehouses. Other cooperatives have been restricted by wartime priorities, but plan to construct their own facilities as soon as these restrictions are removed.

INSTALLATION AND OPERATING COSTS

Costs of installation will, of course, depend upon the type of building construction, the amount and capacity of equipment installed, and a number of other factors which will vary somewhat for each installation. Likewise, costs of operation will vary according to volume and efficiency of the plant; labor costs; and costs of power, water, supplies, and similar items. The wide variations possible in the type and size of each item of equipment are factors which make an overall estimate valueless, as the requirements for individual plants will be different.

CONVERSION OF DEHYDRATION FACILITIES

As yet no very accurate forecast can be made regarding the future of the dehydration industry. A survey conducted in the spring of 1944 by the Bureau of Agricultural Economics, U. S. Department of Agriculture, indicates that there are possibilities of considerable postwar demand for certain dehydrated foods.

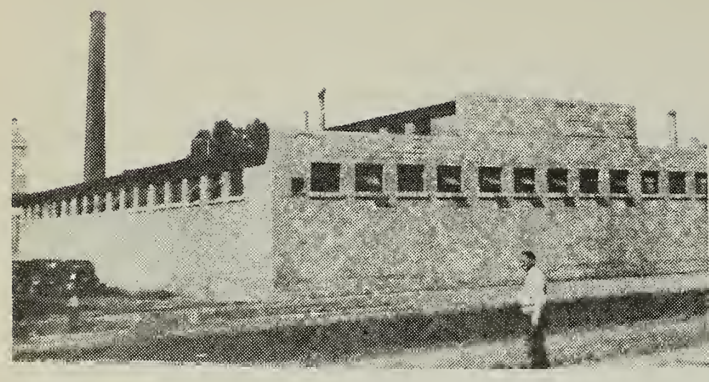


Figure 16. - This modern building houses dehydration equipment. When converted it will be a fireproof, well-ventilated, and well-lighted plant for processing frozen foods.

Dehydration plants located in the areas producing the dehydrated products most desired by the consuming market will probably continue to produce dehydrated products. Other plants, with products for which consumers show less preference, may curtail production or convert their facilities to other types of processing. Some food processors who have been producing large quantities of dehydrated foods are already planning for at least partial conversion of their dehydration facilities to freezing operations (figure 16).

PRESENT EQUIPMENT

An outstanding potato dehydration plant, for example, was originally constructed with a view to conversion later on to freezing operations. The management is of the opinion that conversion of five of the present twin-unit dehydration tunnels to air-blast freezing will be comparatively simple. Conversion contemplates removal of heating units, replacement of present doors with refrigerator doors, and installation of cooling coils in front of the fans. These fans are 30 h.p. airplane type and produce 70,000 cubic feet of air per minute. Additional insulation will be required for the tunnels, which are constructed of cinder blocks. Plans of the organization include acquisition of processing equipment for vegetables which are not now processed and construction of additional storage facilities.

For dehydrated vegetables, the preparation equipment is the same as would be required in the preparation of vegetables for freezing. Conversion of the dehydration plant to freezing would, therefore, be concerned with the adaptability of the dehydration tunnels, the installation of refrigeration machinery, and the acquisition or availability of cold-storage space.

The length of dehydration tunnels varies depending on volume and type of tunnel, and most tunnels are insulated against loss of heat through the outside walls. The air flow may be parallel to or counter to the flow of the product, or it may operate on the center-exhaust principle, entering at both ends of the tunnel and discharging at the center. Large volumes of air are circulated to satisfactorily dry the product, which process may require about 6 hours, depending on the product being dehydrated.

In quick-freezing every effort is made to prevent removal of moisture, whereas successful dehydration requires maximum removal of moisture without scorching the product. Usually quick-freezing requires less than 10 percent of the time required for dehydration. In converting to freezing, first consideration would be given to conversion of the tunnel to conform to the volume of product it is expected will be put through the plant and to suitable insulation. The requirements for efficient insulation were discussed in the preceding section of this publication.

If the dehydration tunnel is one that was originally converted to dehydration from drying operations and has been operating as a somewhat inefficient emergency set-up, it is unlikely that the expense of additional insulation and of refrigeration machinery required for conversion would be warranted. It is probable that under these conditions the converted equipment would still represent inefficient and uneconomical operation. Transmission of heat into refrigeration tunnels would generally be a more serious and expensive disadvantage than loss of heat from an inefficient steam-heated dehydration tunnel. This means that greater consideration should be given to the insulation of a freezing tunnel than to that of a dehydration tunnel.

NEW EQUIPMENT

It is probable that the heating coils used in dehydration should be replaced with steel coils for freezing. One suggested conversion plan calls for placing the new cooling coils on top of the dehydrator with ducts arranged to blow the air in at the side of the tunnel and to exhaust the air through the coils located on the roof, returning it back to the blower. Another suggested method is to purchase unit fan coolers, to locate these units on the side of the tunnel, so arranged as to blow the air from the discharge of these units into the side of the tunnel and return it to the unit. Such unit freezers are discussed under the heading Air Blast on this page.

In addition to the conversion of the dehydration tunnel, it would be necessary to convert part of the plant storage space for low-temperature storage, which should be maintained at about 0^{o} F. This would require additional investment in insulation. The refrigeration machinery and appurtenances necessary for a tunnel of the desired capacity and for a storage room represent another sizable investment. Power cost in supplying refrigeration and in operating the tunnel fans will be an operating item to be considered in conversion to freezing.

METHODS OF FREEZING

Quick-freezing may be done by several types of freezing equipment. These include freezing by cold-air blast; freezing on a flat metal plate underneath which the brine flows; freezing the material between two movable (or stationary) cold plates; spraying cold brine on the packaged or unpackaged products, or submerging the product in brine or in a sugar solution.

AIR BLAST

This method is widely used for commercial freezing of fruits and vegetables. To achieve rapid freezing, a blast of air is directed through refrigerating coils, and, if even quicker freezing is desired, the cold-air blast is confined in an insulated tunnel. In some cases, as in figure 17, cold air in the freezing room is circulated by small individual fans.

The coils used in air-blast freezing are of many varieties. Pipe coils give satisfactory results, but have the disadvantage of taking up a lot of space and requiring large quantities of refrigerant.

The unit freezer, installed by some cooperatives using air-blast equipment, consists of a bank of finned coils, the fins spaced widely enough so as not to frost together and require too frequent defrosting.

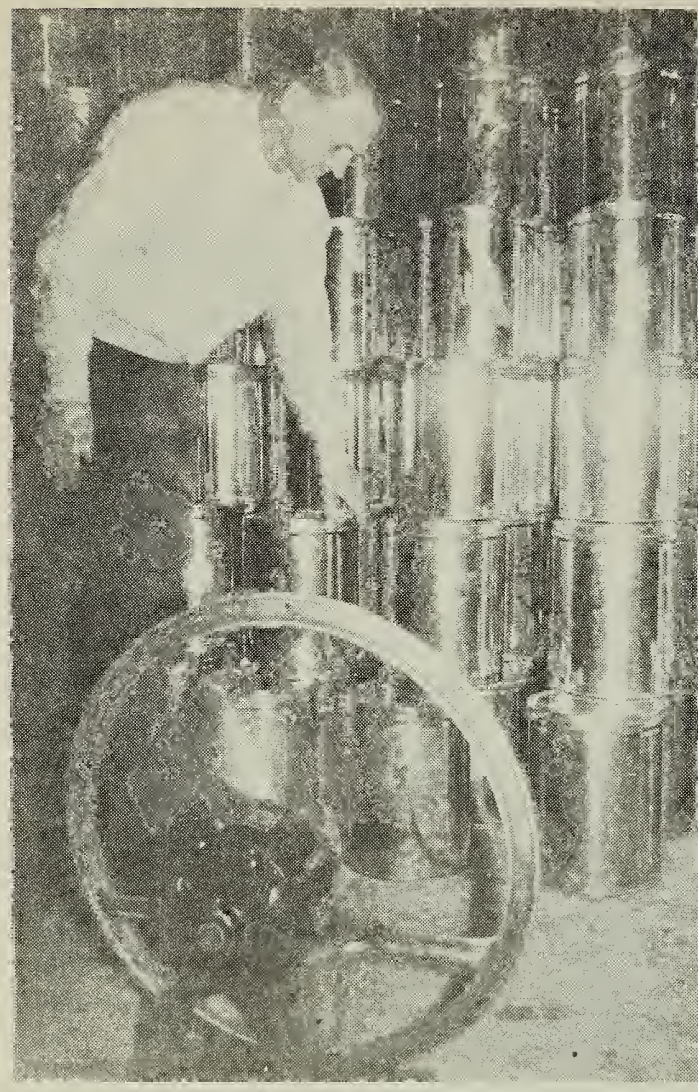


Figure 17. - At 10° F. below zero, with small individual fans to circulate air through the spaces between stacks, these cans holding 30 pounds net weight will freeze solidly in 36 hours.

The coils are encased in a metal housing placed in a pan to catch the moisture dripping from them when defrosting takes place. Above the coil is mounted a group of spray nozzles for defrosting and above them are the fans. The units can be arranged so that the air is sucked or blown through the coils. For the refrigeration produced, the units are comparatively small in size. In freezing loose products, there is usually considerable water on the outside of the product, and some of this moisture is carried with the air and deposited on the coils. These coils can be readily defrosted with a brine or water spray.

Where air-blast freezing is done, with the product either loose or packaged on trays, screen racks are used, which are approximately 3 feet by 4 feet in size. These racks or trays are stacked about 20 high on suitable trucks and rolled into the freezing room or unit. The air is usually maintained at temperatures of 20° F. to 30° F. below zero. Passage of air between the trays is permitted by having 2-inch blocks nailed to the four corners of the trays, thus providing space between them.

The tray-type freezer is more adaptable to the smaller plant, which must use one freezer to take care of most of its needs. A primary disadvantage of tray freezing is the large amount of labor involved in filling the trays, loading the trays in trucks, placing them in the freezer, and again unloading and dumping the trays after freezing.

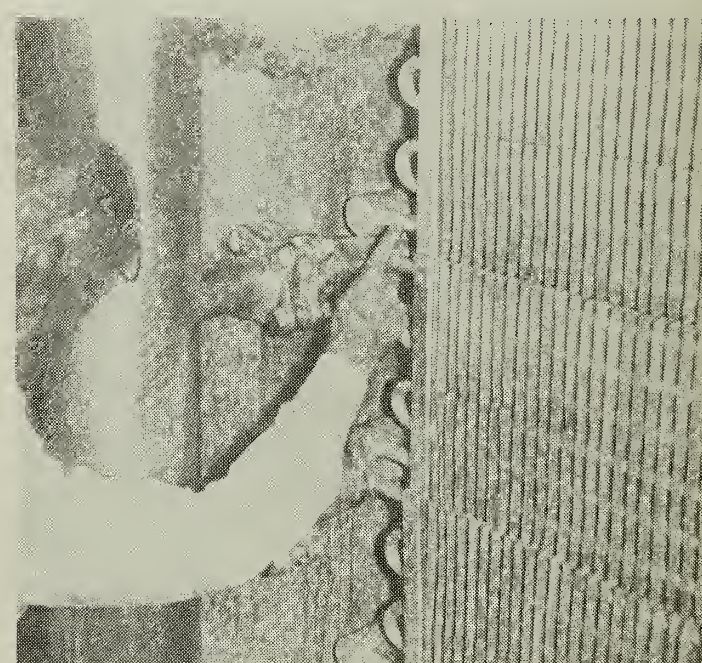


Figure 18. - In these small coils, arranged in series, cold liquid ammonia enters at the bottom and vaporizes as it absorbs heat passing upward through the coil. The vapor is returned by suction to the compressor. Operated as a flooded system, each coil receives its ammonia supply from its own header as pointed out by the operator.

Some cooperative associations with large volumes do both tray freezing and conveyor belt freezing. Conveyor belts are now widely used in freezers, especially in the larger plants where facilities for processing and blanching the products are installed. This type of equipment is particularly well adapted to a cannery line and requires less labor cost than the tray method.

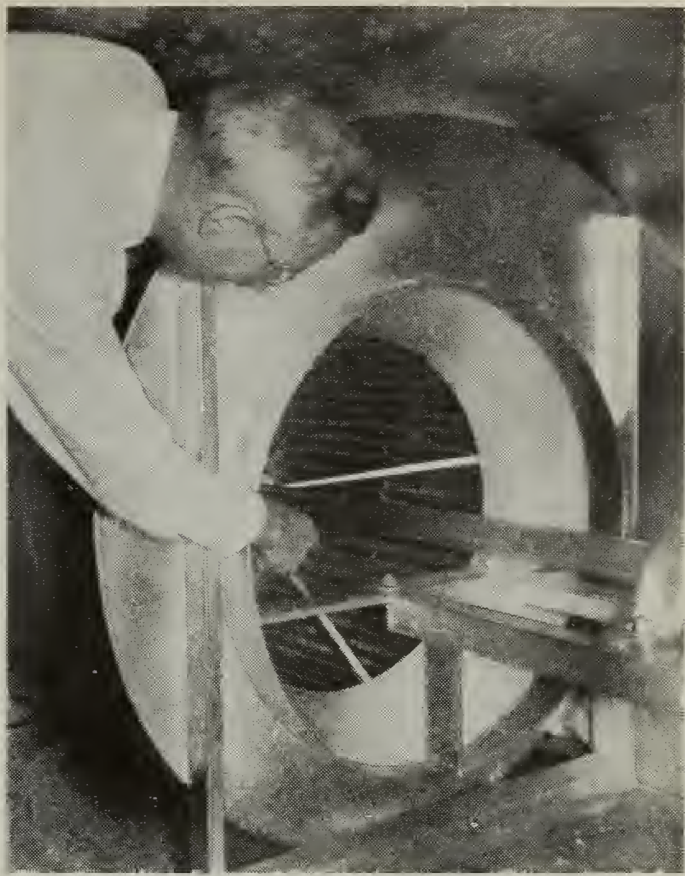


Figure 19. - One of four "squirrel cage" fans which supply 100,000 cubic feet of air per minute. The air circulates over the product to be frozen and then passes through a large coil in which is ammonia at 60° F. below zero. The result is a temperature of 40° F. below zero for freezing purposes.

In this freezer, a long slow-moving belt made of woven wire passes through a tunnel or enclosure containing very cold air in motion. The belt speed is varied according to the time required to freeze a particular product. The tunnel is usually 80 to 100 feet long and may contain one or more of the conveyor belts. The produce is placed on one end of the belt and removed frozen at the other end. Difficulty is frequently experienced with loose frozen products freezing to the belt. Some plants employ mechanical devices to agitate the product and thus eliminate this difficulty.

Usually the cold air enters the tunnel at the opposite end from the one where the product enters, so that the air travels counterflow to the direction in which the product is moving. The temperature may be between 0° F. and 20° F. below zero, and frequently much lower temperatures are used. A belt 5-feet wide and 80-feet long with the proper temperature and amount of air will freeze 1 ton of peas per hour.

The air is usually cooled by blowing it over bunker coils before it enters the tunnel, although some tunnels are equipped with coils throughout their length. The air velocity varies according to the requirements of the plant. It is necessary to recirculate a rather large volume of air in order to obtain a relatively small rise in the temperature of the air as it leaves the product. Some tunnels are equipped so that cold air is blown on both the top and the bottom of the entire length of the freezing belt (figure 19).

A variation in the single-stage method of tunnel freezing consists of delivering the air from fans at either end to the center of the tunnel, mixing the two air streams within the tunnel, and causing the air to flow toward both entrances of the tunnel, where it again passes over two sets of bunker coils for cooling. Another variation consists of a series of fans delivering air crosswise the length of the tunnel.

One problem present in air-blast tunnel freezing is dehydration of the product. In the opinion of some operators, however, it is possible to maintain a range of temperature within which the drying effect will be almost negligible while the increase in cost due to increased volume of circulating air will be offset by the absence of shrinkage and by improved quality of the product. In multistage freezing, the rise in temperature of the air during its passage over the product is reduced to a practical minimum by removing only fractional parts of the total heat in progressive stages. Because of the relatively small mean temperature difference between the coil surface and the recirculated air and the small rise in the temperature of the air, greater humidity is maintained in the separate freezing stages, thus reducing moisture evaporation from the product.

Vertical Arrangement

An innovation in the conveyor arrangement designed by Rensselaer H. Green,[6] is one which consists of a vertical-type conveyor arranged so that the food trays move upward. The trays of the product to be frozen are fed automatically to the conveyor on the first floor and the product is automatically discharged at the second floor level after it has been frozen on the way up. The frozen product, dumped into a hopper, travels by gravity to automatic filling machines. The empty tray is returned on a conveyor to the automatic tray feeder on the first floor, and is again filled for another trip upward through the freezer. The freezing unit on the first floor is a modern spray-type air-circulating unit in which the air passes over cooling coils while a nonfreezing solution is sprayed over the coils to prevent frost accumulations. On the second floor a standard air-blast freezing unit is used. As the product is frozen during its passage through the lower space, frosting is no problem in the second unit and spray defrosting becomes unnecessary. The air travels counterflow to the product, the temperature of which is progressively reduced as it travels through colder and colder air.

This freezer has a capacity of 2,000 pounds per hour, and contains 50 trays each holding 20 pounds of product. Passage through the freezer requires 30 minutes.

Several advantages are credited to this type of freezer. Absence of frost on the coils permits continuous use with no decrease in efficiency. Labor requirements are kept at a minimum as the freezing tunnel operation can be carried on with one person weighing the product into the trays at the feeding end and another person dumping the frozen product from the trays at the discharge end. The temperature of the air leaving the trays is successively lower, tray by tray, and the average temperature difference between food and air is kept at a minimum consistent with the freezing load required. This, together with circulation of large volumes of air, results in a minimum of dehydration. The floor space occupied by this type of freezer is 168 square feet, as compared with 750 square feet for the continuous belt type conveyor or 280 square feet

[6] The names of various freezing systems are mentioned here to help cooperatives identify the types. Reference to any commercial type of freezing system is in no way to be construed as a recommendation therefor. Any omissions of commercially successful systems are unintentional.

for the truck-and-tray type, all of 2,000 pounds per hour capacity.

Another vertical type freezer, the York Continuous Fast Freezer, is suitable for both loose products and packages and is entirely automatic when handling loose products. The product is conveyed to the freezer on a belt or flume. As the entrance conveyor moves the freezing tray into the freezing column, the product is levelled off to a depth of about 1½ inches by means of a levelling plow. The tray containing the loose product is moved vertically upward through the freezing column by a hydraulic jack controlled by a time clock. When the tray has reached the top of the freezing column, the product is completely frozen. A discharge conveyor moves the tray out of the column on to an automatic dump where the frozen product is removed. The empty tray is automatically returned to the starting position and the frozen product from the discharge hopper flows by gravity to the packaging machinery. The entire operation is controlled from a time clock set on a time cycle sufficiently long for the product being handled.

A single unit has a capacity from 3,500 to 4,000 pounds of loose product per hour. The freezer operates on a true counter current principle, the coldest air striking the coldest product. The evaporator for cooling the air consists of finned coils with hot gas defrosting.

Truck and Tray Arrangement

Another freezer designed by this corporation, the York Fast Freezer, is of the truck-and-tray type and is suitable for both packages and loose frozen products (see figure 20). This freezer is manufactured in 6 and 10 truck units with capacities up to 6,000 pounds of product per hour. The evaporator coils and fans are located over the product trucks and the air flow is lengthwise of the tunnel. The cold air passes over the product trays at air velocities of about 2,000 feet per minute. The product trays are manually loaded and placed in position on the trucks, and the truck pushed into the first cooling position in the freezer. A conveyor operated from a time clock moves the truck through the freezing tunnel. The 6-truck tunnel is 10 feet wide by 11 feet high by 29 feet long. The 10-truck unit has the same cross section but is approximately 36 feet long.

On both types of these freezers the evaporator coils are continually flooded with refrigerant from a refrigerant circulating pump. When the refrigerant pump is stopped the coils are immediately drained of refrigerant making defrosting by hot gas a simple and rapid operation. Defrosting may be accomplished without removing the product from the freezing tunnels.

The Finnegan freezer, which is being commercially used in a number of plants, is an air-blast freezer. Described as a multistage tubular freezer, it is made up of two vertical banks of liquid-ammonia flooded recirculating tubes that have extended fin surfaces. These tubes are enclosed in an insulated cabinet to form a freezing tunnel. The tubes run along each side of the tunnel, with space left between them to permit passage of trucks with trays on which the products are frozen. The tunnel is divided into six sections or stages, one for precooling, four in which the freezing is done, and the last for tempering. Air at a velocity of

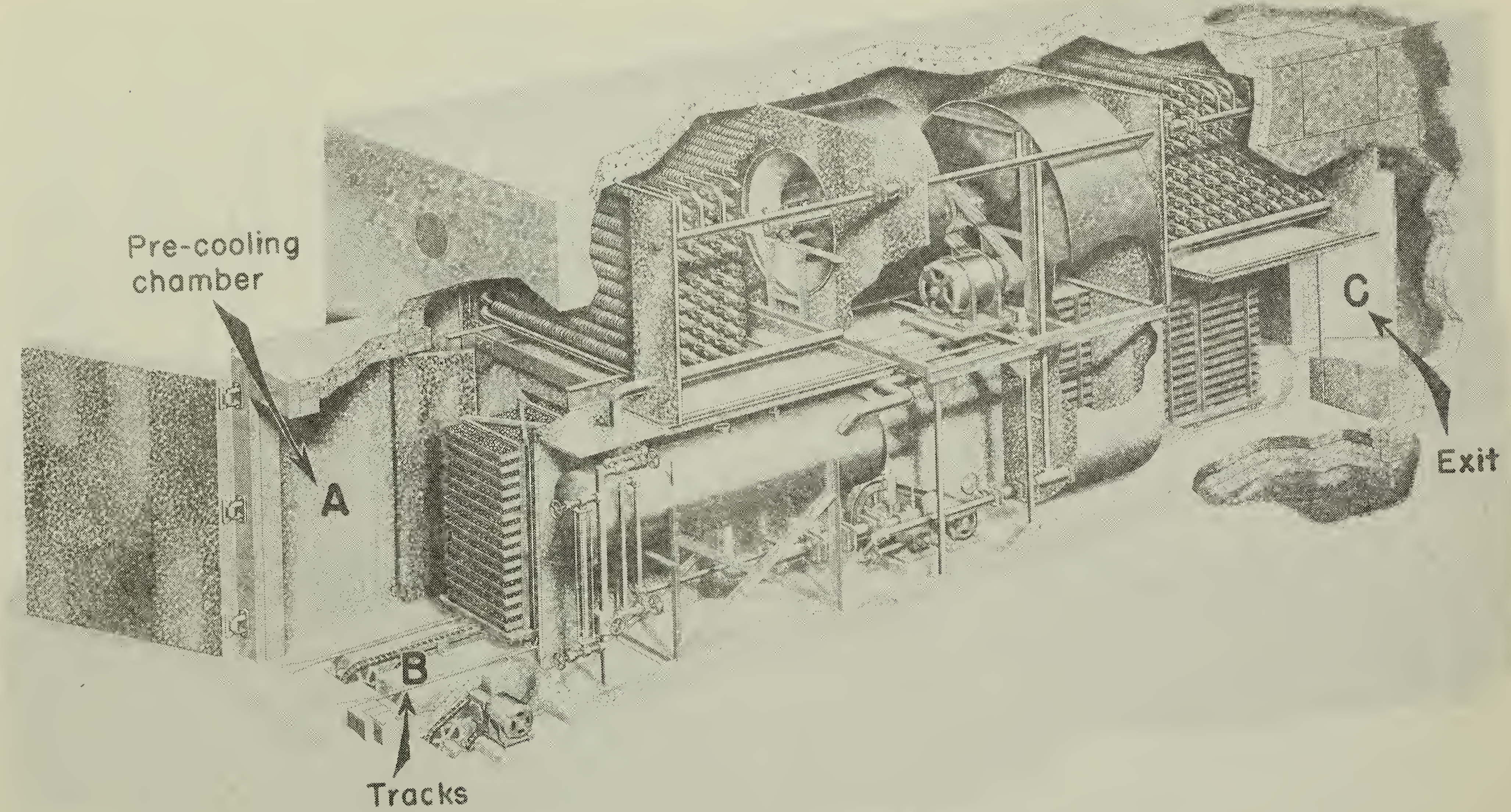


Figure 20. - In this truck-and-tray type freezer the products may be frozen either loose or packaged. Wire-bottomed trays of the product are loaded on trucks and pushed by hand into the precooling chamber (A), where each truck, guided through the tunnel by angle-iron tracks (B), is picked up by an endless chain conveyor operated by a time clock to control freezing time. As a truck moves from the precooler into the freezing chamber those ahead of it advance the length of one truck. This operation is repeated every 5 or 10 minutes, and a truckload of frozen product is delivered each time at the exit (C). The evaporator coils and fans are located over the trucks containing the trays. The air flow is lengthwise of the tunnel, passing over the product at a velocity of about 2,000 feet per minute. When the refrigerant pump is stopped the evaporator coils, which are operated flooded, are immediately drained of refrigerant, permitting rapid defrosting by hot gas, without removing the product from the tunnel.

approximately 1,000-1,200 feet per minute is circulated through the four middle stages and the air over the product is reversed in each succeeding stage. There is no forced air circulation in the precooling and tempering stages.

The loaded trucks are pushed into the precooling stage by hand, and from there on are carried through the system by a chain conveyor with speed adjusted to the proper freezing time for the particular product being frozen. The trucks have an air-tight metal wall on one end and this wall completes the closing off of each stage as the trucks progress through the freezer. In addition, each truck is equipped with adjustable air baffles on each side of the trays and these are arranged so as to force air up and down through the product on the trays. This up and down movement of air is reversed in the next stage.

IMMERSION

An immersion freezing system, known as the Taylor Tennessee Method or the T.V.A. freezer because of participation of the Tennessee Valley Authority in the experimental work, was leased in 1939 to a Tennessee cooperative association. During 1940 this cooperative packed 100,000 pounds of individually frozen strawberries and 200,000 pounds of sugar-packed strawberries. It also packed by immersion 40,000 pounds of lima beans, 17,000 pounds of garden peas, 10,000 pounds of corn, 15,000 pounds of string beans, and about 3,000 frying chickens.

In the immersion system, freezing is accomplished by employing a liquid as the medium of heat transfer, and the close contact of the liquid with the product permits rapid freezing without the use of extremely low temperatures. The mechanical process involves pumping a continuous stream of the refrigerant solution past the product to be frozen, in direct contact with it, or the reverse process of carrying the product through the refrigerant solution.

The immersion method is suggested for specialized uses, as berries, whole vegetables which do not have cut surfaces to leak, and even for whole chickens, properly wrapped.

The solution used for strawberries contains invert sugar of a strength of about 57° Brix., which is maintained at a temperature slightly above 0° F. Before immersion in the solution the individual pieces of the product are usually coated or treated to prevent loss of juices or flavors and also to prevent excessive penetration of the refrigerant solution. The solution is clarified, filtered, and automatically maintained at the proper level of concentration.

After the freezing period the product is removed from the solution and placed in a specially designed centrifuge, where the excess sirup is removed from the individual product.

The immersion system is adapted to operations of any size. It has been suggested for a small-scale operation with a relatively low investment in plant and equipment, and for supplementing cannery operations by the addition of freezing operations. It has also been suggested that portable immersion-freezing machines of varying capacities might be developed.

The University of Texas has another variation of the immersion system, known as the Bartlett Polyphase Quick-Freezer. The term "polyphase" derives from the fact that the refrigerating medium is in the liquid, solid, and gaseous state during the process. One type of such media employed is a water solution of invert sugar which has been chilled and simultaneously agitated until finely divided ice is formed and uniformly dispersed throughout the liquid. A salt solution has also been used. It is adapted to the quick-freezing of foods which are not usually flavored with sugar.

The freezing operation is conducted in a machine which consists of a refrigerant jacketed horizontal tube partially filled with the polyphase medium which is impelled through the tube by a screw conveyor. Suitable feed and discharge compartments connected by a return tube are provided, so that continuous circulation is permitted. In operation, food is floated upon the surface of the medium in the feed compartment and is carried by the motion of the screw into the refrigerated tube. Heat is rapidly abstracted by contact with the chilled fluid, which in turn delivers this heat to the refrigerant jacket. After freezing is completed, the stream of medium flows into the discharge compartment where the food is removed by a screen or grid and packaged after a short drainage period.

OTHER TYPES

Several types of quick-freezing machines have been developed by Birdseye. The Birdseye multiplate freezer consists of a number of superimposed refrigerated vacuum metal plates actuated by means of hydraulic pressure in such a manner that they may be opened to receive products between them and then closed on the product with any desired pressure. The entire freezing apparatus is enclosed in an insulated cabinet. Smaller machines are self-contained and have the compressor, compressor motor, condenser, and other parts of the apparatus located beneath the insulated freezing chamber, while the larger machines require separate refrigerating systems. The refrigerant circulates through passages in the plates, which are so constructed that as pressure is applied to the under side of the first plate, it lifts the load until it meets the second plate, which in turn, is raised with its load, and so on up. Products are left in the machine until they reach a temperature of about 0° F. Thickness of the package and type of product cause the freezing time to vary.

A freezer, which is considered particularly flexible because either packaged or loose commodities can be frozen and it can be constructed on any scale desired, is the Murphy Quick-Freezing System. This is an insulated chamber which contains shelves made of coils of brine pipe arranged one above the other in staggered fashion to provide a sinuous passage for cold air. The product, in either loose or packaged form, is placed in trays which are put on the coil shelves. Blower fans at the ends of the insulated chamber keep the cold air in rapid motion and increase speed of freezing. The product is thus frozen by contact on the lower side and cold air on the upper side. The air circulates from the bottom upward over each coil until it reaches the cooling coil at the top which lowers its temperature and it is again returned to the system for recirculation.

A quick-freezing system developed by M. T. Zarotschenzoff, and known as the "Z process," employs an atomized liquid refrigerant, which is sprayed over the product. Originally this system was developed in Europe for the freezing of unpackaged fish, but more recently in improved form it is used extensively for the freezing of packaged fish, meat, and poultry. The process has been suggested for the freezing of a number of fruits and vegetables. Sodium chloride brine at -3° F. is generally used, but other solutions have been employed.

One cooperative association visited during this study was freezing fruits in the 1938 season with the "Z" process. The association's major frozen pack was strawberries, although some peaches, raspberries, and grapes were frozen. A sugar solution was sprayed over the products as they traveled on belts through a tunnel. As inadequate volume made the operation uneconomical, the quick-freezing operation was discontinued.

Whatever type of equipment is selected by the cooperative freezer, it should have the following qualifications. It should be economical in cost of mechanical operation and should likewise be economical in use of labor. It should be capable of operation without serious loss of efficiency or time for defrosting or other reasons. Shrinkage of the product due to dehydration should be kept at a minimum.

REFRIGERATION SYSTEMS

Brief descriptions of the more common types of refrigeration systems in use may be helpful to the association making its choice of equipment, and the discussion here is intended merely to call attention to certain general considerations. No attempt is made to develop from an engineering point of view specific recommendations for a refrigeration plant nor to supply information which will furnish an adequate basis for making decisions relative to the type of equipment to purchase. Reputable refrigeration machinery firms can furnish information and estimates on specific types of installations.

Mechanical refrigeration, explained in simplified terms, is based on the principle that whenever a substance changes its form from a liquid to a gas or a vapor, heat must be absorbed to produce that change, just as adding enough heat to water causes it to boil and change from a liquid to a vapor or steam.[7] Certain substances boil or evaporate at extremely low temperatures and thus pick up heat from surrounding materials. Refrigeration systems are designed for the use of some particular refrigerant that boils at a low temperature as ammonia, which boils at -28° F.; or Freon-12, which boils at -22° F.

In the refrigeration cycle, this principle of a liquid evaporating, the vapor cooling off and so absorbing heat from its surroundings, is endlessly repeated by use of a refrigerant capable of giving up a great deal of heat when liquefied and of absorbing a great deal of heat when allowed to evaporate. The vapor-compression system, said to have received its first practical application about a hundred years ago, is the principle upon which more than 90 percent of all refrigeration is based today. Most of

[7]For a scientific discussion, see Cook, Samuel Richard. Heat in Theory and Practice Essential to Refrigeration and Air Conditioning, 228 pp., 1941.

the remaining 10 percent is based on the absorption system (used in gas refrigerators), which employs heat energy to condense and evaporate ammonia gas in a closed circuit.

AMMONIA SYSTEM

This system was found to be the one most commonly in use by the cooperative associations visited in the course of the study made. In this system an electric motor or a Diesel, natural gas, or steam engine drives the compressor, which pumps the heat-laden gas from the cooling system. As the compressor pumps the ammonia vapor from the low-pressure side of the system, it serves the double purpose of maintaining a low pressure in the cooling unit and compressing a large volume of low-pressure vapor. The resultant high-pressure gas is then forced through a condenser which removes the heat of compression and the latent heat of evaporation by a cooling agent, such as water or air forced through the condenser, which carries away the heat.

When the heat has been removed from the compressed gas, the gas condenses into a liquid and is collected in a receiver. From the receiver, the high-pressure liquid is expanded into the low side through a fixed outlet or adjustable expansion valve. Upon entering the low-pressure area in the evaporator after passing through the expansion valve, or some type of automatic valve - of which there are several in use - a portion of the liquid immediately vaporizes, cooling the remainder of the liquid entering the evaporator. In passing through the expansion coils, the vapor takes up the heat by conduction through the metal of the coils (figure 21).

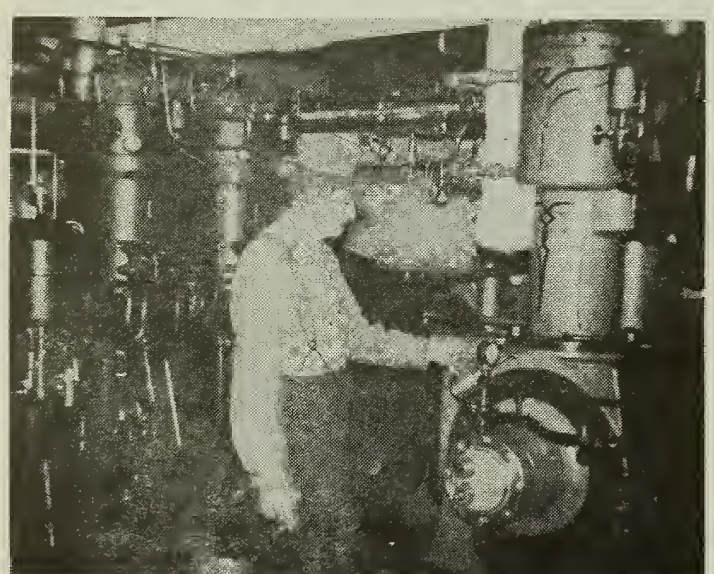


Figure 21. - This compressor is driven by a 90 h.p. Diesel engine. Fuel and lubricating oil cost about 26 cents per hour. This represents very economical operation.

Compressors may be operated in series or by stages. Only two stages are used for ordinary refrigeration work; that is, in systems where the lowest refrigerant temperature is about 30° F. below zero. It is economical to bring down the temperature of the gas passing from one stage to another by means of an inter-cooler. The two stages may be contained in one machine, with a low pressure and a high pressure cylinder, or the two stages may be embodied in separate units, in which case the low pressure compressor is known as a booster.

Refrigeration plants are frequently designed to have as many condensing units as there are different temperatures to be provided. These may be arranged so that the different units can be interconnected and, in emergencies, part of the machinery can carry the whole load. In small plants, it may be more economical to use only two compressors. Where freezing-room temperatures as well as chill-room temperatures are to be maintained, it is usually considered impractical to use less than two compressors. In this case, one compressor would carry the

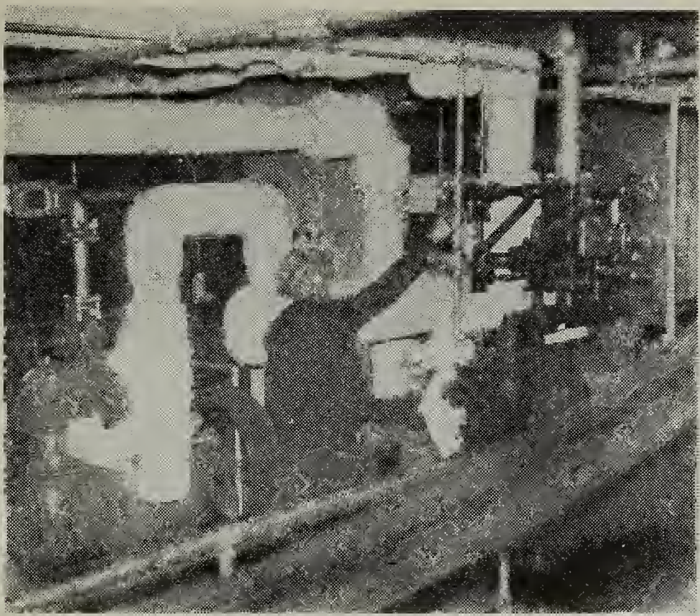


Figure 22. - This cooperative plant operates two 40-ton compressors and one 48-ton compressor, together with two booster compressors. This equipment provides enough refrigeration to freeze 300,000 pounds of fruit per day.

low-temperature load, while the other would carry the chill-room load.

THE ABSORPTION SYSTEM

The principle of the ammonia absorption system may be stated as the alternate repulsion and absorption of ammonia gas by the alternate heating and cooling of ammonia water. The essential difference between the absorption and the compression systems is in the method of increasing the pressure between the evaporator and the condenser. The evaporator, the condenser, and the expansion valve may be the same in the two systems. In the compression system, the compressor gives the increase in pressure by mechanical means. In the absorption system, the increase in pressure is produced by heat supplied in large installations by means of steam which circulates through a pipe coil and in small refrigerators by a small gas flame.

While there has been some indication that the absorption system might be of interest to canneries because of the economical supply of heat, only one cooperative canning and freezing plant visited during our study employed this system.

DIRECT AND INDIRECT SYSTEMS

In the direct method the refrigerant absorbs heat direct from the materials to be cooled and the evaporator coil is placed in the room to be refrigerated. This system is usually employed in small units. In the indirect or brine system, the refrigerant absorbs the heat which the brine, in turn, has absorbed from the materials to be cooled. Thus, the place to be refrigerated is cooled by cold brine, such as calcium chloride brine, which has been cooled by the refrigerant.

EVAPORATORS

The evaporator or coil takes up the heat from the air in a refrigerator, from the water in a water cooler, or from whatever material it is desired to cool. The heat thus taken up by the evaporating coils causes the refrigerant in the unit to evaporate and change from liquid to gas.

There are two general types of evaporators with regard to the refrigerant feed: (1) dry expansion and (2) flooded. The term "dry expansion evaporator" is usually applied to series type coils, often called direct expansion coils, in which the liquid is fed into one end, and theoretically, evaporation is complete and the refrigerant is dry or superheated by the time it reaches the other end. Dry expansion coils are generally used where the cost of installation is to be held at a minimum and where the load is fairly constant. The flooded, or recirculating refrigerant type of evaporator

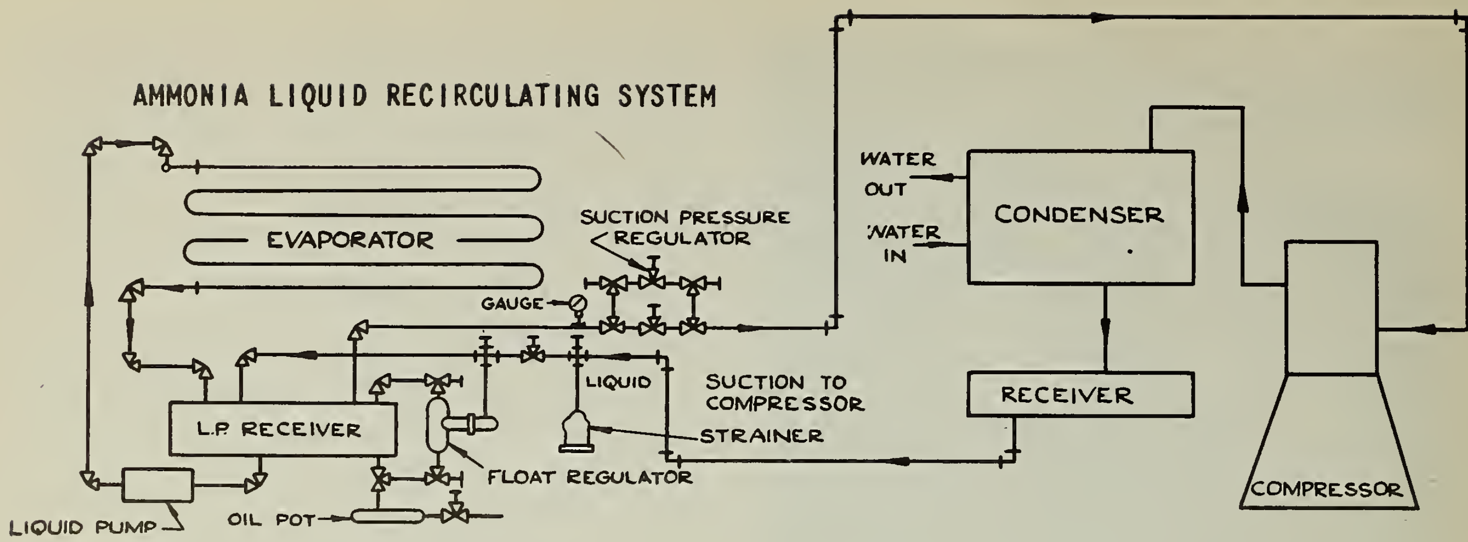


Figure 23. - The float regulator maintains a constant level of liquid ammonia in the low pressure receiver, where it is precooled to evaporating temperature and is available for instant use. It is pumped to the ammonia connection or distributing header at the top of the evaporator from where it flows by gravity through the evaporator tubes. The unevaporated liquid ammonia and gas return to the low pressure receiver. The liquid is recirculated through the evaporator and the gas is returned to the compressor.

(figure 23), is designed with short runs of parallel pipe connections, so arranged that a considerable portion of the evaporator is filled with liquid refrigerant which is recirculated by a gas-lift effect, due to the boiling action within the coil. Equipped with ample accumulator or surge drum capacity, the flooded evaporator has the advantage of being highly stable under greatly fluctuating loads. This system also permits the full utilization of compressor capacity by providing an accumulated load of gas in the surge drum.

CONTROLS

Automatic refrigerant controls are an important part of the refrigerating system and their efficient operation and maintenance are essential in securing greatest economy in the plant. There are controls which start and stop the compressor as needed to hold the desired temperature, and a regulator controlling the water flow through the condenser. The feeding of the refrigerant into the evaporators may be by an expansion valve type of control or by means of a float valve, in which the amount of liquid ammonia fed to the evaporator is dependent upon the rate of evaporation.

REFRIGERANTS

Refrigerants for industrial use should have the following characteristics: (1) low boiling point, (2) low condensing point, (3) noncorrosive on metals, (4) noninflammable and nonexplosive, and (5) should be economical in cost.

Ammonia has been widely used by large commercial refrigerating plants. It is especially satisfactory because its boiling point is -28° F., its use entails little danger of explosion, and its corrosive effect is negligible. Another distinct advantage is that its definitely acrid odor permits ready discovery of a leak when it occurs in the system.

Freon-12 is a newer refrigerant widely used in household machines and well adapted to air-conditioning uses. It is noninflammable and nonexplosive, as well as nontoxic. It likewise possesses the desirable feature of being noncorrosive to metals. Its boiling point is -22° F.

Freon-22, another new refrigerant, is expected by many to play an increasingly important part after the war in the preservation of foods and to be used also for other low-temperature requirements.

Other refrigerants include methyl chloride, methylene chloride, carbon dioxide, and sulfur dioxide, none of which is used to any great extent in commercial refrigeration.

APPENDIX A

STATISTICAL AND HISTORICAL DATA

The preservation of foods by freezing is believed to be of ancient origin.[8] Cooling by evaporation of water was employed in Egypt as early as 2500 B.C. Possibly the earliest recorded processing of ice for later use appears in a collection of Chinese poetry of the 11th century B.C., which describes the hewing of ice from crevices in hills or mountains, the conveying of it to an ice house, and its use later in the year. Salt or saltpeter mixed with snow or ice was not employed by scientists until about the 16th century A.D., although knowledge of the endothermic property of salt in water was recorded in Indian literature of the 4th century.

Manufacture of ice by mixing salt with snow to freeze water in a glass occurred sometime after 1607. Manufacture of ice by the expansion of vapors came about 1755, when a machine was invented to produce refrigeration by the evaporation of water under reduced pressure. The liquefying of ammonia and carbon dioxide was begun by Faraday in the early 1800's and a little later a machine making use of the refrigeration cycle was invented.

The commercial freezing of berries by the cold pack method was begun about 1910 in the Pacific Northwest. Quick-freezing, that is, the complete freezing of a product within a few hours or less, was first used on a commercial basis with fish in the 1920's. A little later this method of preservation was applied to fruits, and since 1929 to vegetables.

In 1925 total production of frozen fruit was about 12½ million pounds. This increased to nearly 85 million pounds in 1930. From 1931 through 1936 there was considerable variation from year to year. In 1937 total production jumped to 111 million pounds and since then it has increased each year topping 214 million pounds in 1943. The preliminary figure on frozen fruit for 1944 indicates a total commercial pack of slightly over 330 million pounds (table 1). This tremendous increase over 1943 resulted primarily from vastly expanded packs of apples and applesauce, apricots, red sour pitted cherries, and peaches. Almost every other item except red raspberries, prunes, and grapes showed an increased pack in 1944 (figure 24).

All regions of the country, according to statistics of the National Association of Frozen Food Packers, participated in the increased volume of the 1944 pack, but the

[8] Cook, S. R. Heat in Theory and Practice Essential to Refrigeration and Air Conditioning. Nickerson and Collins Co., Chicago, 1941, 228 pp.

Table 1. - Frozen fruit pack by kinds, 1937-44
(Revised estimated U. S. commercial pack)[a]

Net Frozen Weight

YEAR	STRAW-BERRIES	RASP-BERRIES (REDS AND BLACK CAPS)	BLACK-BERRIES (INCLUDES DEWBERRIES)	BLUE-BERRIES[b]	OTHER BERRIES[c]	TOTAL BERRIES	CHERRIES	APPLES AND APPLE SAUCE
	Million Pounds							
1937.......	43.5	11.5	6.8	.3	2.9	65.0	33.3	2.3
1938.......	55.5	10.5	4.0	1.7	3.0	74.7	29.0	1.1
1939.......	50.8	10.4	7.4	1.1	7.3	77.0	39.7	2.1
1940.......	62.3	16.5	9.6	2.6	14.2	105.2	40.0	4.0
1941.......	79.5	22.3	9.0	2.2	9.9	122.9	43.7	10.0
1942.......	64.0	20.5	9.6	1.7	7.5	103.3	46.0	15.1
1943.......	30.0	20.0	10.0	4.5	8.0	72.5	24.0	34.0
1944[d]......	34.8	18.7	16.2	5.0	11.8	86.5	56.4	51.6

Percentage of Annual Pack

YEAR	STRAW-BERRIES	RASP-BERRIES (REDS AND BLACK CAPS)	BLACK-BERRIES (INCLUDES DEWBERRIES)	BLUE-BERRIES[b]	OTHER BERRIES[c]	TOTAL BERRIES	CHERRIES	APPLES AND APPLE SAUCE
	Percent							
1937.......	39.1	10.3	6.1	.3	2.6	58.4	29.9	2.1
1938.......	43.0	8.1	3.1	1.3	2.3	57.8	22.4	.8
1939.......	36.1	7.4	5.3	.8	5.2	54.8	28.3	1.5
1940.......	36.1	9.6	5.6	1.5	8.2	61.0	23.2	2.3
1941.......	38.2	10.7	4.3	1.1	4.8	59.1	21.0	4.8
1942.......	29.0	9.3	4.3	.8	3.4	46.8	20.9	6.8
1943.......	14.0	9.3	4.7	2.1	3.7	33.8	11.2	15.9
1944[d]......	10.5	5.7	4.9	1.5	3.6	26.2	17.1	15.6

Net Frozen Weight

YEAR	APRICOTS	PEACHES	TOTAL OF FOUR FRUITS	GRAPES	PRUNES AND PLUMS	OTHER[f]	TOTAL FRUITS AND BERRIES
	Million Pounds						
1937.......	.2	1.0	36.8	3.6	.5	5.4	111.3
1938.......	.2	4.4	34.7	7.1	.2	12.5	129.2
1939.......	.3	6.8	48.9	8.8	-	5.9	140.6
1940.......	.2	5.4	49.6	10.0	-	7.6	172.4
1941.......	.7	6.6	61.0	16.8	.4	6.7	207.8
1942.......	5.3	14.3	80.7	20.0	3.0	13.4	220.4
1943.......	10.0	17.0	85.0	[e]17.5	22.0	17.1	214.1
1944[d]......	41.4	45.6	195.0	11.4	19.8	17.6	330.3

Percentage of Annual Pack

YEAR	APRICOTS	PEACHES	TOTAL OF FOUR FRUITS	GRAPES	PRUNES AND PLUMS	OTHER[f]	TOTAL FRUITS AND BERRIES
	Percent						
1937.......	.2	.9	33.1	3.2	.4	4.9	100.0
1938.......	.2	3.4	26.8	5.5	.2	9.7	100.0
1939.......	.2	4.8	34.8	6.2	-	4.2	100.0
1940.......	.1	3.2	28.8	5.8	-	4.4	100.0
1941.......	.4	3.2	29.4	8.1	.2	3.2	100.0
1942.......	2.4	6.5	36.6	9.1	1.4	6.1	100.0
1943.......	4.7	7.9	39.7	8.2	10.3	8.0	100.0
1944[d]......	12.5	13.8	59.0	3.5	6.0	5.3	100.0

[a] Excludes quantities of fruit frozen by industrial users or other types of processors who use all or the largest portion of their frozen pack as raw material for the manufacture of jams, jellies, and other fruit spreads.

[b] Includes huckleberries. Does not include imports; approximately 20 million pounds in 1943, 10 million pounds in 1944.

[c] Includes boysenberries, elderberries, gooseberries, loganberries, olympeaberries, youngberries, etc.

[d] Revised estimate, March 1945.

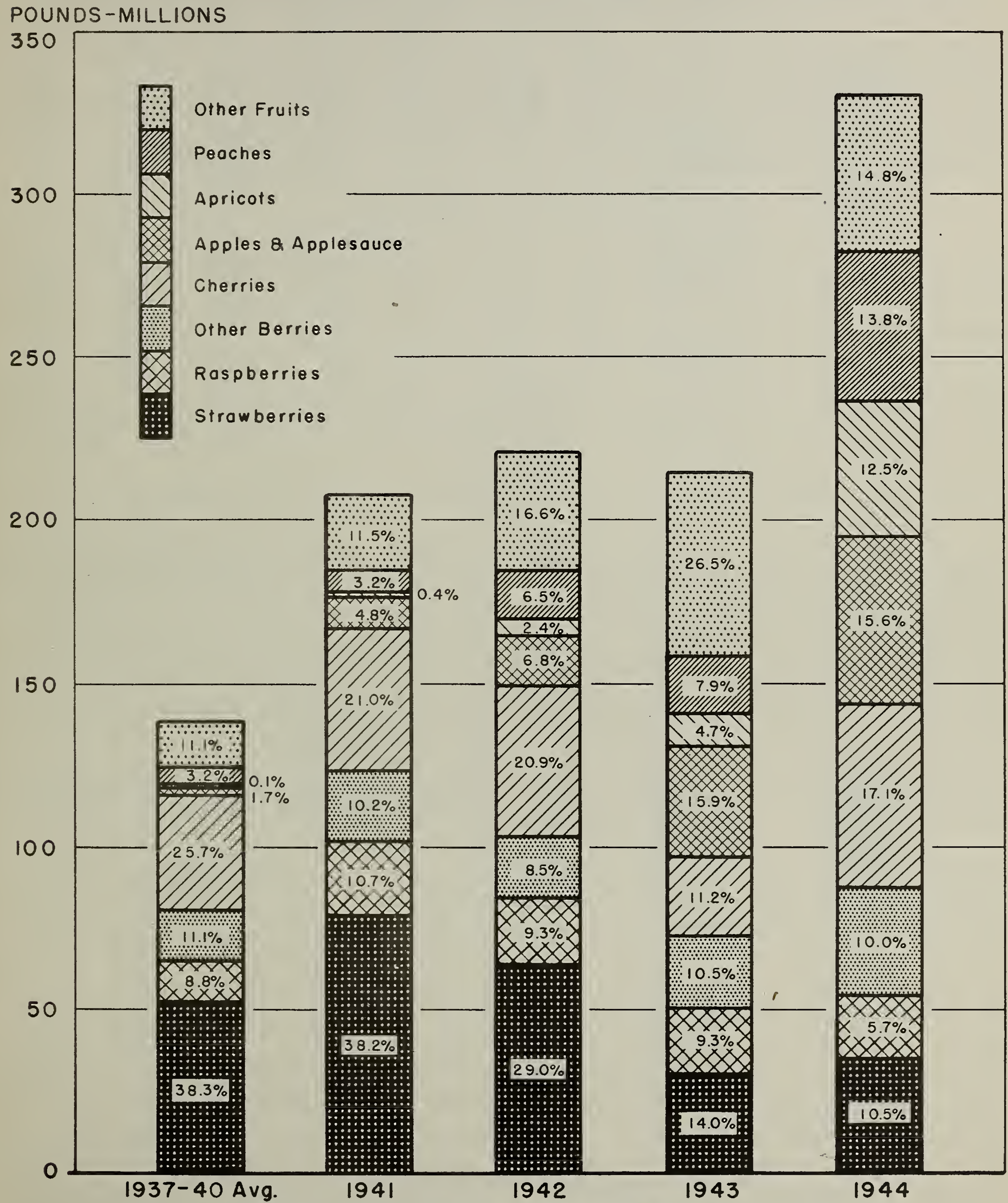
[e] Eight million pounds processed by preservers in addition to amount shown.

[f] Includes currants, fruit juices, and miscellaneous fruits.

Source: Data for 1937-44 pack from Bureau of Agricultural Economics, U. S. Dept. Agr.

FIGURE 24

FROZEN FRUIT PACK, BY KINDS, AS A PERCENTAGE OF TOTAL, U.S., 1937-40 AVG. AND 1941-44 PACKS



Source: Bureau of Agricultural Economics, U.S. Department of Agriculture

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Table 2. - Frozen vegetable pack, by kinds, 1937-44

Net Frozen Weight

YEAR	ASPAR-AGUS	SNAP BEANS	LIMA BEANS	CUT CORN	PEAS	SPINACH	OTHERS[a]	TOTAL
	Million Pounds							
1937	6.3	7.3	18.0	4.1	26.2	4.3	6.3	72.5
1938	8.0	9.4	19.6	5.7	34.1	3.8	9.2	89.8
1939	7.4	6.0	15.4	3.0	26.6	3.8	10.4	72.6
1940	6.0	6.0	16.8	4.5	35.8	4.1	10.1	83.3
1941	7.5	8.8	20.5	6.9	44.1	4.9	14.5	107.2
1942	6.0	13.8	31.0	10.0	66.2	16.6	19.8	163.4
1943	10.2	28.0	21.0	21.5	75.0	26.7	40.9	223.3
1944[b]	12.3	21.0	30.0	21.0	80.0	32.0	39.3	235.6

Percentage of Annual Pack

YEAR	ASPAR-AGUS	SNAP BEANS	LIMA BEANS	CUT CORN	PEAS	SPINACH	OTHERS[a]	TOTAL
	Percent							
1937	8.7	10.1	24.8	5.7	36.1	5.9	8.7	100.0
1938	8.9	10.5	21.8	6.3	38.0	4.2	10.3	100.0
1939	10.2	8.3	21.2	4.1	36.7	5.2	14.3	100.0
1940	7.2	7.2	20.2	5.4	43.0	4.9	12.1	100.0
1941	7.0	8.2	19.1	6.4	41.2	4.6	13.5	100.0
1942	3.7	8.4	19.0	6.1	40.5	10.2	12.1	100.0
1943	4.6	12.5	9.4	9.6	33.6	12.0	18.3	100.0
1944[b]	5.2	8.9	12.7	8.9	34.0	13.6	16.7	100.0

[a] Includes broccoli, brussels sprouts, carrots, cauliflower, corn on cob, peas and carrots (mixed), squash, rhubarb, and miscellaneous vegetables.

[b] Revised estimate, March 1945.

Source: Data on 1937-44 pack from Bureau of Agricultural Economics, U. S. Dept. Agr.

biggest gain was indicated for Western States where the pack increased 88 million pounds or more than 75 percent. On a percentage basis, however, the greatest increase was reported for the Middle West where production advanced by 193 percent.

Frozen vegetables increased from practically none in 1930 to more than 223 million pounds in 1943. The preliminary estimate for 1944, approximately 236 million pounds (table 2), indicates a still greater increase. This increase reflected larger packs of green peas, lima beans, spinach, and asparagus. These increases more than offset a minor reduction in the pack of frozen cut corn and a somewhat greater reduction in the pack of frozen snap beans (figure 25).

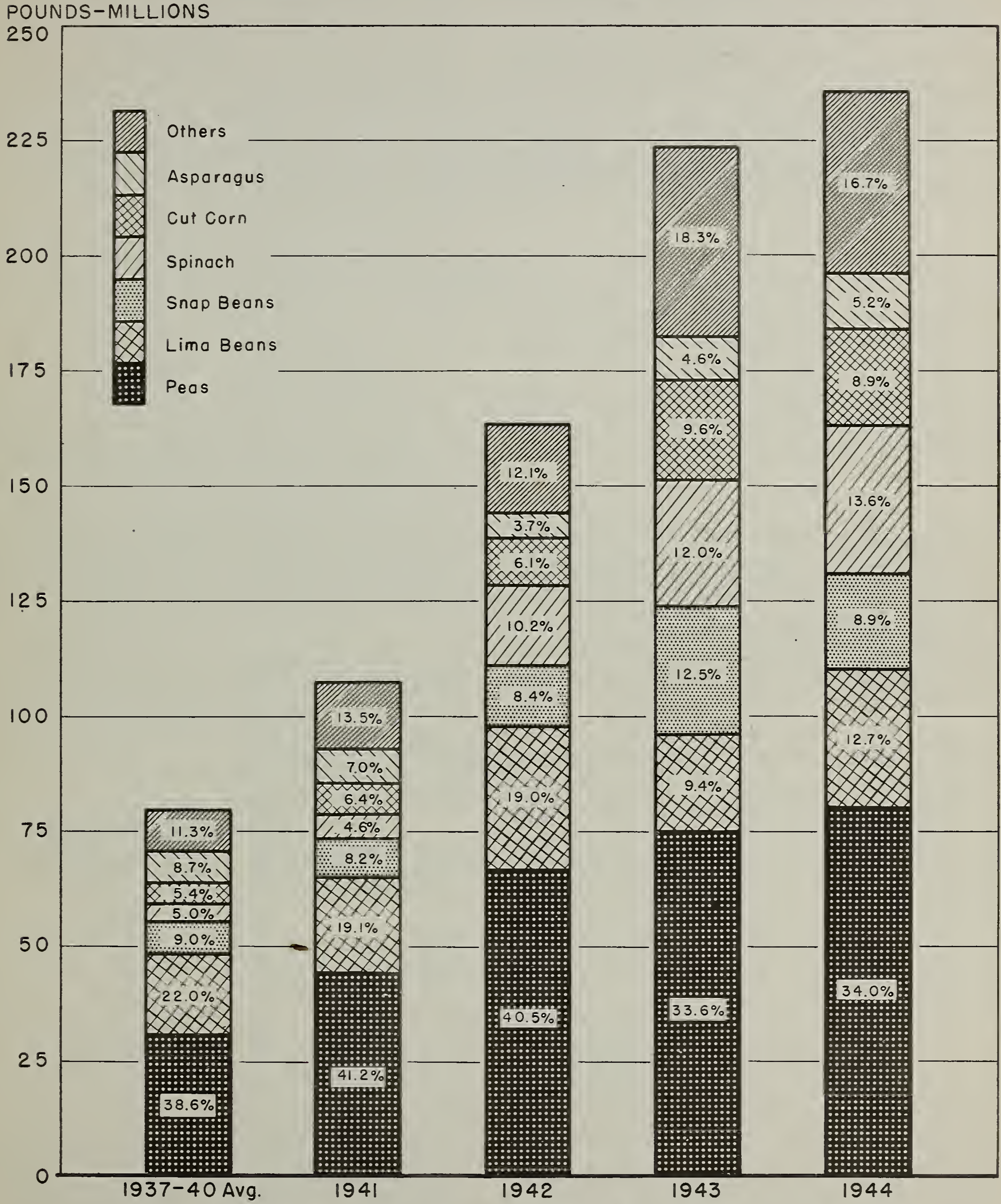
On a regional basis the most significant increase in frozen vegetable packs was indicated for Western States where an 18 percent gain was reported. The frozen vegetable pack also increased in Eastern and Southern States by about 10 percent, but a slight decrease was reported for the pack in Middle Western States.

In 1943 and 1944 frozen strawberries were down to the lowest level for the period shown in table 1 largely because economic conditions resulting from wartime controls and labor shortages made their production unprofitable. In the Northwest, which has consistently produced a large part of the entire pack, many acres have been taken out of strawberry production. It will be some time after wartime regulations are removed before this acreage can be replanted and again come into production.

Cherries which have continued to rank second to strawberries showed a decline in frozen production in 1943 due to a short crop, but resumed their upward trend in 1944.

FIGURE 25

FROZEN VEGETABLE PACK, BY KINDS, AS A PERCENTAGE OF TOTAL, U.S., 1937-40 AVG. AND 1941-44 PACKS



Source: Bureau of Agricultural Economics, U.S. Department of Agriculture

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Frozen apples and applesauce, apricots, and prunes and plums showed large percentage gains during the war years over the 1937-40 averages. Wartime processing and container restrictions may have influenced the increasing volumes of these frozen products. A short crop and congested freezer space in refrigerated warehouses accounts for the decline in 1944 over 1943 for plums and prunes.

Frozen peaches have shown consistent and substantial increases during the war years. While only freestone varieties have been used heretofore, a sizable pack of clingstone varieties was frozen in 1944 because of the shortage of berry and other fruit production (figure 26).

Frozen peas have run far ahead of other frozen vegetables in volume. It has been possible to develop highly mechanized operations for this product which have resulted in lower production costs and greater volume.

Lima beans, previously second in importance to peas, showed a decline in 1943 as compared with 1942, but preliminary figures indicate production was up again in 1944. The production of frozen snap beans has shown large increases during the war years over the 1937-40 average, although a decrease over 1943 pack was reported for 1944.

The annual production of cut corn has increased in the period between 1937 and 1944 by almost 17 million pounds. Spinach has rapidly increased in importance from the 1937-40 average of 4.0 million pounds to 32.0 million pounds, ranking second to peas in 1944 (figure 27).

Civilian per capita consumption of frozen vegetables increased from 0.4 pound in 1937 to 1.0 in 1942 (table 3). The decrease to 0.7 pound in 1943 is accounted for by large January 1 carry-over stocks and by military requirements. The preliminary figure of 1.7 pounds for 1944 shows a substantial increase in civilian per capita consumption. This is, no doubt, attributable in large measure to the lack of certain canned foods, to increased purchasing power resulting from the high rate of employment, and the desire to purchase nonrationed foods (figure 28).

Civilian per capita consumption of frozen fruits has increased from 0.4 pound in 1937 to 1.5 pounds in 1944. The high point was reached in 1942 with 1.6 pounds. The shortage of certain frozen fruits, particularly berries, probably accounts for the slightly lower figures in 1943 and 1944.

Table 3. - Apparent per capita consumption of frozen fruits and vegetables

Net Frozen Weight

YEAR	APPARENT CIVILIAN CONSUMPTION PER CAPITA	
	Fruits	Vegetables
	Pound	
1937.............	0.4	0.4
1938.............	1.0	.4
1939.............	1.1	.5
1940.............	1.2	.6
1941.............	1.3	.7
1942.............	1.6	1.0
1943.............	1.4	[a] .7
1944[b].............	1.5	1.7

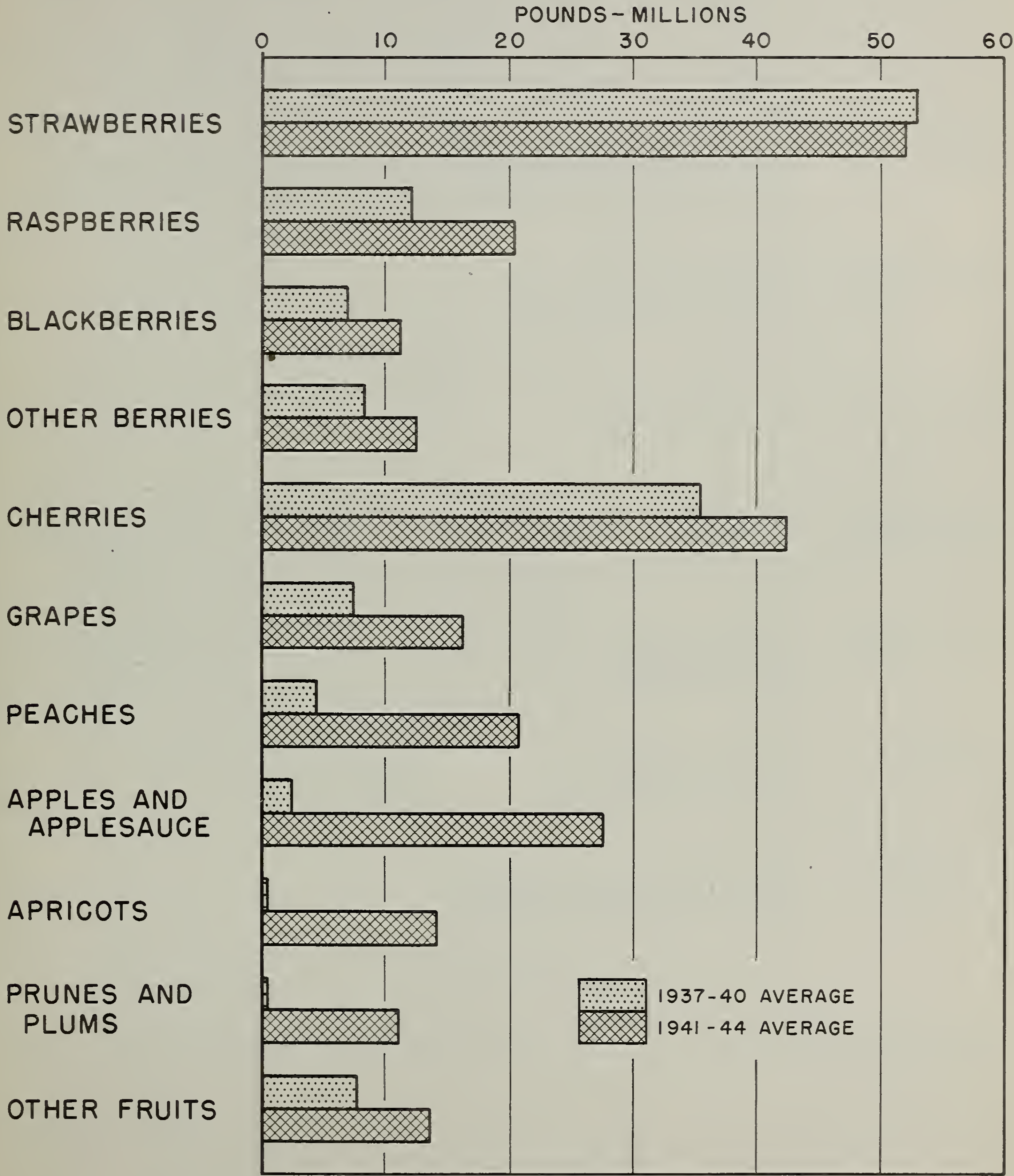
[a]Large January 1 carry-over stocks and military requirements resulted in a decrease in civilian consumption in 1943 compared with 1942.

[b]Preliminary.

Source: Data from Bureau of Agricultural Economics, U. S. Dept. of Agr.

FIGURE 26

PRODUCTION OF FROZEN FRUITS, U. S. PREWAR AND WAR YEARS



Source: Bureau of Agricultural Economics, U. S. Department of Agriculture

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COOPERATIVE RESEARCH AND SERVICE DIVISION

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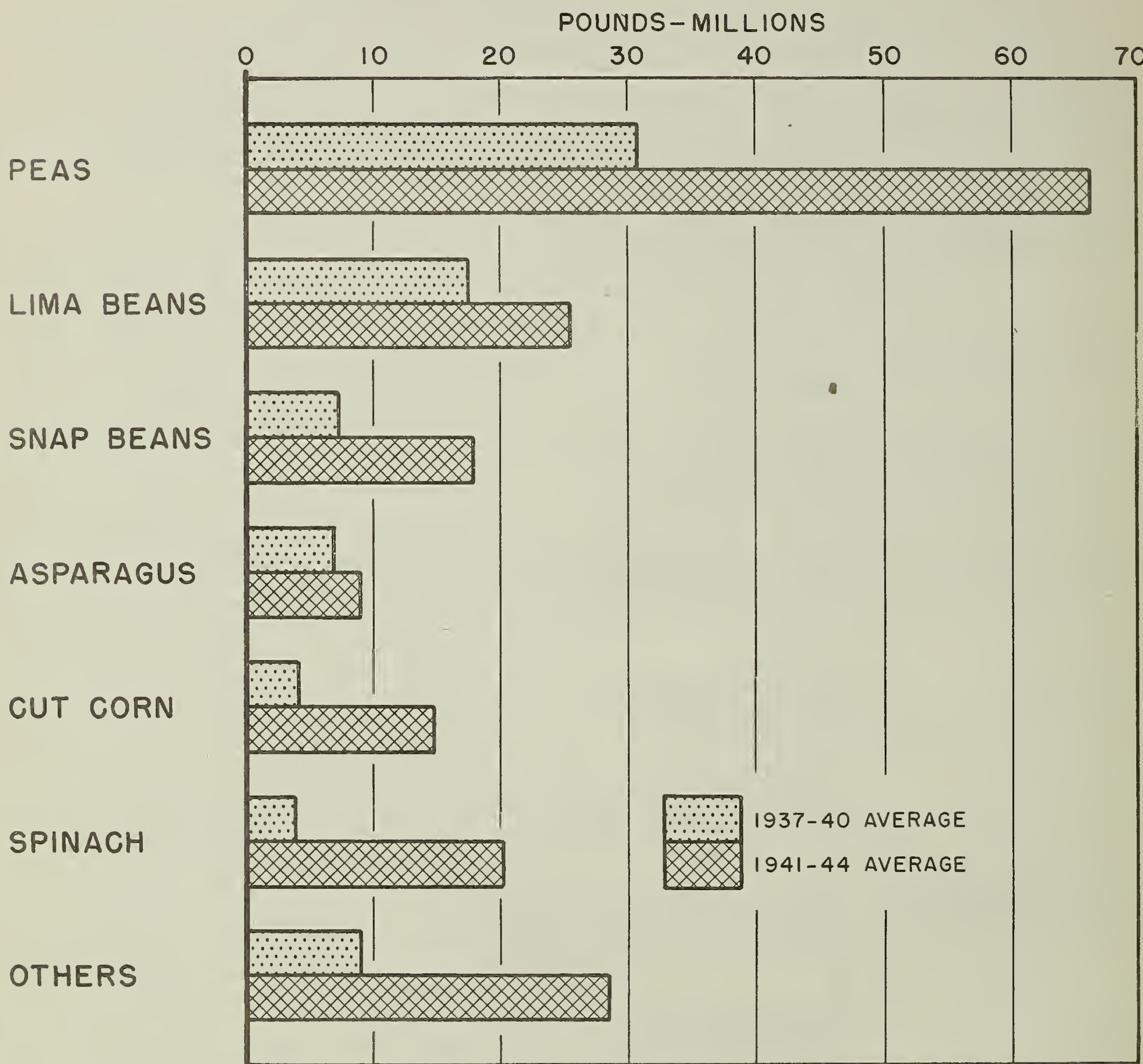
FIGURE 27

PRODUCTION OF FROZEN VEGETABLES, U. S.
PREWAR AND WAR YEARS



Source: Bureau of Agricultural Economics, U. S. Department of Agriculture.

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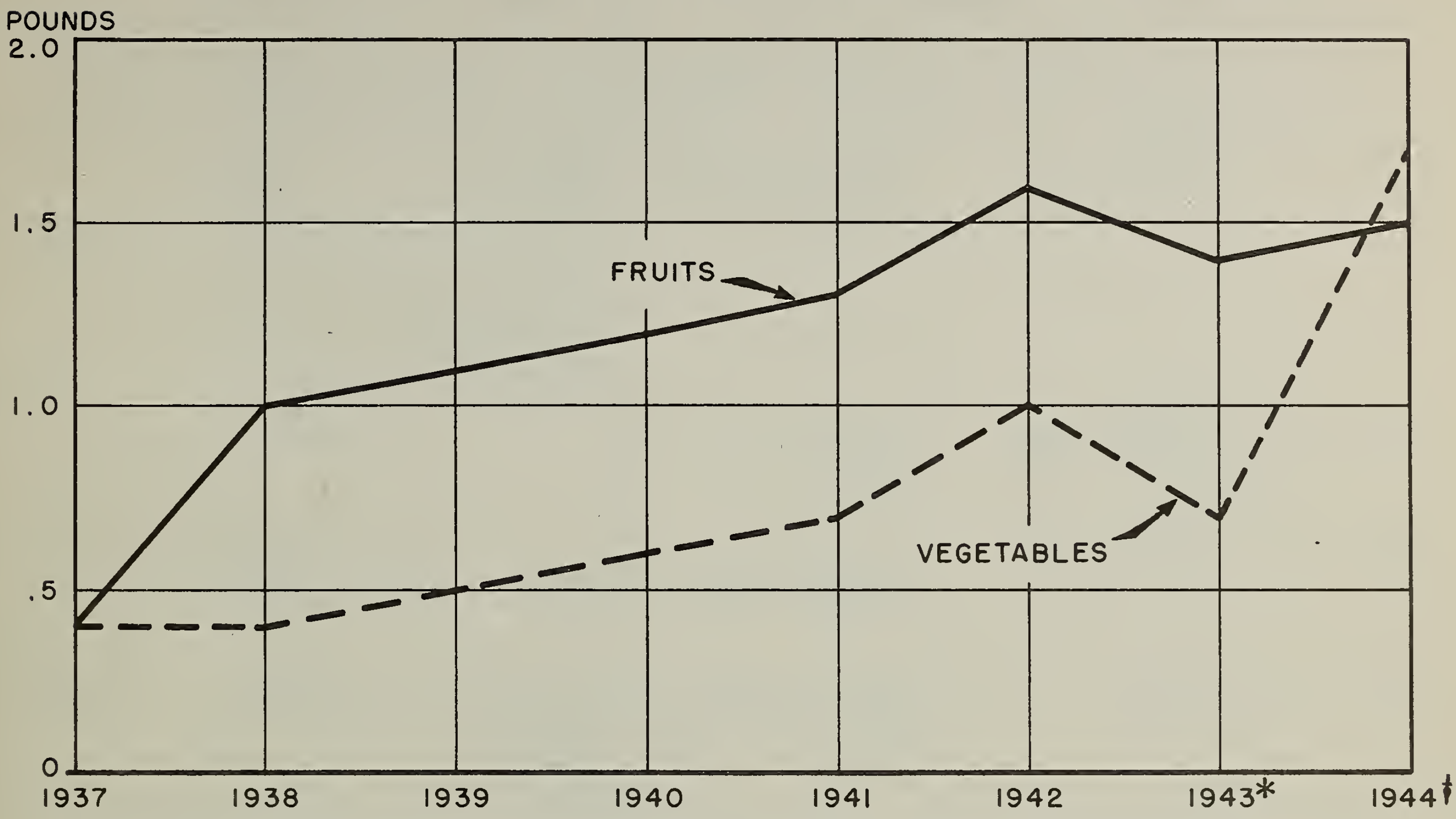
FIGURE 28

APPARENT CIVILIAN PER CAPITA CONSUMPTION OF FROZEN FRUITS AND VEGETABLES, U. S., 1937-44



* LARGE JAN. I CARRY-OVER STOCKS AND MILITARY REQUIREMENTS RESULTED IN DECREASE.
† PRELIMINARY.

Source: Bureau of Agricultural Economics, U.S. Department of Agricuture.

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APPENDIX B. - VARIETIES SUITABLE FOR FREEZING

Table 4. - Varieties of fruits suitable for freezing in sections where grown

FRUIT	CALIFORNIA[a]	PACIFIC NORTHWEST[b]	OTHER AREAS[c]	
			EXCELLENT	VERY GOOD
Apples	Newtown Pippin, Gravenstein	Yellow Newton, Winesap, Spitzenburg, Stayman Winesap, Jonathan	Greening 1, 2 Baldwin 1, 2 Northern Spy 1, 2 Wealthy 1, 2 Oldenburg 1, 2 Rome Beauty 1, 2, 4 Stayman Winesap 1, 2, 4 York Imperial 1 Grimes Golden 1, 4 Jonathan 4	Stark 5 Cortland 5
Apricots	Blenheim, Royal Tilton, Moorpark	Wenatchee Moorpark (Hemskirk), Blenheim, Royal, Tilton		
Blackberries	Lawton, Wilson	Oregon Evergreen, Brainard, Joy, Mersereau, Texas, Himalaya		Eldorado 3
Blueberries		Rancocas, June, Concord, Katherine, Jersey, Rubel, Alaska	Concord 5, 6 Rubel 5, 6 Pioneer 5, 6 Rancocas 5, 6 Cabot 5, 6 Jersey 6 Wild 8	
Dewberries	Young, Boysen, Logan, Lucretia	Lucretia, Olympic, Young, Boysen, Nectar, Logan		
Cherries, sour	Montmorency	Montmorency, Early Richmond, Late Duke, English Morello	Montmorency 4, 5	English Morello 4, 5
Cherries, sub-acid			Royal Duke 5 May Duke 5	Riene Hortense 5 (poor yield)
Cherries, sweet	Royal Anne (Napoleon), Bing, Lambert, Young's Black, Tartarian	Bing, Lambert, Republican, Tartarian, Deacon, Royal Anne (Napoleon)		
Cranberries		McFarlin, Howes Centennial	All varieties	freeze well
Currants			All varieties	freeze well
Figs	Black Mission, Calimyrna, Kadota			
Gooseberries			All varieties	freeze well
Grapes			Thomas 3	
Nectarines	Stanwick, Tioga, Gower			
Oranges for juice	Valencia			
Passion fruit	Passiflora edulis			

Table 4. - (Continued)

FRUIT	CALIFORNIA[a]	PACIFIC NORTHWEST[b]	OTHER AREAS[c]	
			EXCELLENT	VERY GOOD
Peaches, freestone	Rio Oso Gem, Elberta, J. H. Hale, Lovell, Indian Blood	J. H. Hale, Candoka, Gold Medal, Late Crawford, Elberta Salway, Slappey, Rochester, October Krummel, Carmen	Hale Haven 1, 5 J. H. Hale 1, 2, 3, 5 South Haven 1, 5 Oriole 2 Eclipse 2	Elberta 1, 3, 5 Ideal 1, 5 Massasoit 1, 5 Marigold 1, 5 Vedette 1, 5 Veteran 1, 5
Peaches, clingstone	Palora, Gaume, Phillips, Sims, Tuscan			
Pears	Bartlett, Hardy		Kieffer 3	
Plums	Santa Rosa, Beauty, Red Duarte			Redwing 2, 4, 5 Damson 2, 4, 5, 7 Yellow Egg 2, 4, 5 Italian Prune 2, 4, 5 German Prune 2, 4, 5 Stanley 2, 5
Prunes	French, d'Agen, Imperial	Italian, Petite or Agen (French) Date Prune		
Raspberries, red	Ranere (St. Regis), Cuthbert	Cuthbert, Tahoma, Washington, Lloyd George, Viking, Cayuga, Latham, Newberg, Erskine Park, St. Regis, Ranere, Chief, King, Herbert, Antwerp, Utah, and Marlboro	Cuthbert 1, 2, 5, 8 Herbert 1, 8 Viking 5 Latham 2, 7 Chief 2, 7 Ranere(St. Regis)2, 7	Ranere 1, 8 Taylor 5 Lloyd George 5
Raspberries, black(Black-caps)		Cumberland, Plum Farmer, Munger, Gregg	Bristol 5 Cumberland 7	
Raspberries, purple			Sodus 5 Columbian 5	Marion 5
Strawberries	Klondike, Banner, Other Marshall types	Corvallis, Marshall, Clark Seedling, Redheart, Wray Red, Dosett, Ettersburg 121, Narcissa, Fairfax	Marshall 1, 8 Klondike 2, 7 Vanrouge 5 Howard Supreme 1, 8 King Edward 1, 8 Minnesota Seedling #1192 5 Fruitland 2 Big Joe 2 Big Late 2 Blakemore 7 Gandy 4 Early Jersey Giant 4 Dunlap 4	Howard 17, (Premier) 1, 4, 8 Bliss 1, 8, Culver 5 New Jersey #225 5 Dunlap 5 Clermont 5 Chesapeake 2, 5 Blakemore 2 Howard Supreme 2 Klondike 2 Kellogg's Delicious 4 Progressive 4 Parson's Beauty 4

[a]Compiled from unpublished information of the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Western Regional Research Laboratory, Albany, California. Utah-grown varieties tested and found suitable: Apricots - Large Early Montgamet; Cherries, sour - Montmorency; Cherries, sweet - same as for California; Peaches - Elberta, J. H. Hale; Raspberries - Latham (good), commercially frozen but not considered equal to Cuthbert grown in Pacific Northwest; Strawberries - Marshall. Colorado-grown fruit varieties tested and found suitable: Peaches - Elberta, J. H. Hale; Cherries, sour - Montmorency.

[b]Compiled from "Preservation of Fruits and Vegetables by Freezing in the Pacific Northwest," by H. C. Diehl, E. H. Wiegand, and J. A. Berry, U. S. Dept. Agr. Mimeo. Circ. 53, 1939.

[c]1 - New England, 2 - Middle Atlantic, 3 - South, 4 - Middle West, 5 - New York, 6 - New Jersey, 7 - Tennessee, 8 - Maine and Massachusetts. Compiled from available official sources by General Electric Consumers Institute, Bridgeport, Conn., and released in 1944.

Table 5. - Varieties of vegetables suitable for freezing

VEGETABLE	PACIFIC NORTHWEST[a]	TENNESSEE[b]	NEW YORK[d]	
			EXCELLENT	VERY GOOD
Asparagus	Martha Washington, Mary Washington, Palmetto	Mary Washington, Martha Washington	Mary Washington, Martha Washington	
Beans, lima	Baby Fordhook, Fordhook, Carpenteria, Holmes' Green Prolific. Seibert's Early	Fordhook, Burpee Improved, King of the Garden, Henderson Bush	Fordhook, Burpee's Bush	Challenger, King of the Garden, Henderson Bush, Baby Potato
Beans, snap	Blue Lake (White Creaseback), Kentucky Wonder, White Seeded Kentucky Wonder, Stringless Green Pod selection, Tender-green, Full measure, Stringless Valentine, Round Pod Kidney Wax, Pencil Pod Black Wax, Kenney's Stringless Kidney Wax	Kentucky Wonder, Early Refugee Stringless, Full Measure, Mosaic Resistant Refugee, McCaslan, Stringless Green Pod, Stringless Valentine	Kentucky Wonder, Blue Lake	Lowe's Champion, Wisconsin Refugee
Beets		Detroit Dark Red, Crosby	Detroit Dark Red, Crosby	
Broccoli, Italian or sprouting	Any deep green colored type, such as Green Calabrese	Italian Green Sprouting[c] (Calabrese)	Italian Ey Calabrese, Italian Green Sprouting	
Brussels sprouts		Half Dwarf Improved[c] Long Island Improved[c]		Half Dwarf Improved Long Island Improved
Cabbage	Copenhagen Market			
Carrots	The Chantenay and similar varieties	Nantes, Chantenay	Nantes Coreless, Amsterdam Coreless	Red Cored Chantenay
Cauliflower	Early Snowball, Extra Early Dwarf Erfurt, Earliest and Best, Danish Giant, Perfection	Snowball	Forbes, White Mountain	Perfection Snowball
Corn, sweet	Golden Cross Bantam, Golden Bantam, Top Cross Bantam, Top Cross Improved Golden Bantam, Extra Early Bantam, Burbank Top Cross, Purgold, Seneca Golden, Tendergold	Golden Bantam, Hybrids of Golden Bantam, Country Gentleman, Stowell Evergreen	8-row Golden Bantam, Golden Cross	10-14-row Golden Bantam, Purgold Seneca Golden T. C. Maine Bantam Indigold Aristogold Bantam
Kohlrabi				Early White Vienna
Mushrooms	Common White type (Agaricus Campestris)		Cultivated Agaricus Campestris	

Table 5. - Varieties of vegetables suitable for freezing (Continued)

VEGETABLE	PACIFIC NORTHWEST[a]	TENNESSEE[b]	NEW YORK[d]	
			EXCELLENT	VERY GOOD
Peas	World's Record, Improved Gradus, Thomas Laxton, Asgrow 40, Onward, Rogers' 95 Stratagem, Tall Alderman, Others worthy of consideration but not as thoroughly tested - Asgrow Glacier, Asgrow Teton, Zwaan's Confidence, Duchess of York, Duplex, Dwarf Alderman, Dwarf Champion, Dwarf Freezer, Extra Early Gradus, Kootenai, Dark Laxtonian, President Wilson, Rogers' Gilbo Improved Stratagem, Stratah, Stridah	Gradus, Laxtonian, Laxton Progress, Thomas Laxton	Dark Podded Thomas Laxton, Thomas Laxton	Gradus, World's Record, Improved Gradus, Laxton's Progress, Glacier, Morse's Market, Stratagem (Potlatch), Hundred Fold, Onward Stridelong, Dwarf Alderman, Little Marvel, President Wilson, Banqueteer, Alderman or Telephone
Rhubarb	Wine, Strawberry, Victoria			MacDonald, Ruby, Linnaeus
Spinach	Virginia Savoy, Long Standing Bloomsdale Savoy, Giant Nobel, Evergreen, Viking Viroflay	Bloomsdale Savoy, King of Denmark	Nobel, Hollandia, King of Denmark Viking, Virginia Savoy (fall spinach)	Old Dominion, Princess Juliana, Prickly Winter, Viroflay, Broad Flanders, Long Standing Bloomsdale
Squash, winter		Boston Marrow	Golden Delicious, Golden Hubbard	Green Hubbard Blue Hubbard
Swiss Chard			Lucullus	Fordhook
Turnips			Purple Top Strapleaf White Globe	

[a]Compiled from "Preservation of Fruits and Vegetables by Freezing in the Pacific Northwest," by H. C. Diehl, E. H. Wiegand, and J. A. Berry, U. S. Dept. Agr. Mimeo. Circ. 53, 1939.

[b]Compiled from "The Frozen Food Industry," by Harry Carlton, Tenn. Univ. Press, Knoxville, Tenn. 1941.

[c]Broccoli and brussels sprouts are not grown to any great extent in Tennessee, but these varieties were suggested for trial.

[d]Compiled from "Freezing and Storage of Foods in Freezing Cabinets and Locker Plants," by D. K. Tressler and C. W. Du Bois, New York State Agr. Expt. Sta. Bul. 690, 1940. The studies on which this selection of varieties was made were carried out through the cooperation of the Vegetable Crops Division of this station and the Frosted Foods Investigators. These varieties are suggested for use for freezing in cabinets and lockers in New York State. When grown in other sections of the country they may not be equally desirable. They are not necessarily the varieties which should be selected for commercial freezing.

NOTE - Information on varieties of vegetables that are grown in California suitable for freezing is not available from the Western Regional Research Laboratory of the U. S. Department of Agriculture.

APPENDIX C
ADEQUACY OF BLANCHING

November 1943 AIC-34

INFORMATION SHEET ON A TEST FOR ADEQUACY OF BLANCHING IN FROZEN VEGETABLES

Western Regional Research Laboratory, Albany, California
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
U. S. Department of Agriculture

The test for adequacy of blanching in frozen vegetables described below is based upon the determination of peroxidase activity by a method which has given good correlation with the keeping quality of certain frozen vegetables held in freezing storage for a period of 4 years.

Present knowledge concerning the test indicates that it is applicable to frozen peas, snap beans, lima beans, asparagus, and cut corn. There is no reason to believe that it will not prove applicable to other frozen vegetables also.

REAGENTS

1. Distilled water.
2. 0.5 percent guaiacol in 50-percent ethyl alcohol solution.
3. 0.08 percent hydrogen peroxide (2.8 cc. of 30-percent hydrogen peroxide per liter). Keep in refrigerator in dark bottle, and renew each week.
4. Clean sand.

APPARATUS

1. Test tubes, 3/4 or 7/8 inch in diameter.
2. Three-inch diameter funnels.
3. Six-inch cotton milk filters.
4. Porcelain mortar (4 to 6 inches in diameter) and pestle.
5. Fifty-cc. graduated cylinder.
6. One- and 2-cc. pipettes.
7. Timer or watch with secondhand.
8. Test-tube rack.
9. Balance which will weigh 10-gram samples to $\pm$0.1 gram. Any triple-beam-type balance is recommended in preference to the single-beam, Harvard type.

PROCEDURE

1. Cut tissue to be tested into small pieces and weigh out representative 10-gram sample.
2. Place 30 cc. distilled water in graduated cylinder.
3. Place sample in mortar with a little clean sand, add minimum amount of water from graduated cylinder to give best consistency for thorough maceration and grind for 3 minutes. Add remainder of water from graduate and mix.
4. Filter through cotton milk filter.
5. Add 2 cc. of filtrate to 20 cc. of distilled water in test tube.
6. Add 1 cc. of 0.5-percent guaiacol solution without mixing.
7. Add 1 cc. of 0.08-percent hydrogen peroxide without mixing.
8. Mix contents thoroughly by inverting and watch for development of color. If none develops in 3-1/2 minutes, consider the test negative, and the product adequately blanched. In the case of a positive test, the color development will be of sufficient intensity to be easily recognizable. If color develops after 3-1/2 minutes the test is still considered negative.

9. In order to eliminate any question as to color development within the 3-1/2-minute period, it is well to prepare a tube without the addition of the guaiacol and hydrogen peroxide. This will serve as a comparison standard, and will not develop color.

SAMPLING

To insure good sampling, it is desirable to select the largest pieces from the package, since they are the most likely to be underblanched. With very large peas or the large-seeded lima beans, it is desirable to cut each seed in half equatorially, thus doubling the number of units represented in each sample. Vegetables made up of varying proportions of stem, leaf, or flower, etc., should be cut in sampling so as to secure the same proportions of each type of tissue as occur in the whole edible product, and to secure parts from as many units as practicable. With asparagus, for example, the following procedure is recommended:

1. Cut off and discard 3/4 inch from butt end.
2. Split stalks lengthwise, or, if very thick, quarter.
3. Use alternate 1/2-inch cuts from half or quarter of each stalk, starting with 1/2 inch from each end of stalk, discarding second 1/2 inch at each end, using the third, etc.

APPENDIX D

LIST OF PREPARATION EQUIPMENT[9]

STANDARD ONE LINE PEA PLANT WITH QUALITY GRADER

4 to 6 viners
pea boxes
scales
1 sample grader, 4 screens
1 gooseneck conveyor to feed cleaners, estimated 20 feet long, 12-inch buckets
1 cleaner with variable air regulator
1 separator and washer
1 gooseneck conveyor to feed grader, estimated 20 feet long, 12-inch buckets
1 twin-reel 6-section pea grader
7 No. 5 pea storage hoppers
1 gooseneck conveyor, 45 feet long, 12-inch buckets under grader to blancher
2 150-gallon brine tanks, noncorrosive
1 15-foot blancher without countershaft
1 countershaft
1 1½-inch self operating temperature control for blancher
1 No. 3 shaker washer, standard perforation
1 picking table after blancher, 16 feet long, 30 inches wide
1 gooseneck conveyor to filler estimated 19 feet long, 12-inch buckets
1 pea filler
1 No. 7 double storage hopper with gate for over pea filler

FOR QUALITY GRADE BY-PASS AND SECOND FILLER

1 gooseneck conveyor, 10 feet long, 12-inch buckets, to quality grader
1 quality grader and brine control and reels
2 No. 3 shaker washers
1 10-foot picking table
1 gooseneck conveyor to filler, 19 feet long, 12-inch buckets
1 No. 7 double storage hopper with gate
1 pea filler

[9]As suggested by a large food-machinery supply agency.

ONE LINE CORN PLANT

1 wagon and truck dump, motor drive, style B, standard current
6 huskers
1 30-inch wide, 60-foot long, inspection conveyor
6 Peerless corn trimmers
2 Peerless corn washers with countershaft
7 Universal cutters (whole grain and cream style)
1 9-inch diameter 27-foot long spiral conveyor
1 6-inch bucket 12-foot cut corn elevator
1 No. 8 silker
1 incline spiral to mixer and 12-inch extension legs on silker and special pan
1 mixer and pump connection brine tank
1 pump, cast iron
1 300-gallon blending mixer
1 temperature control for blending mixer $1\frac{1}{2}$ inches
1 filler
1 re-silker

ONE LINE STRING BEAN PLANT

1 bean grader, making 2 grades
1 bean cutter No. 2 with automatic hopper, or
1 string bean cutter, 1-inch cut
1 8-foot bean blancher without countershaft
1 countershaft
1 No. 2 shaker washer
1 10-foot picking table, 30 inches wide
1 No. 2 washer
1 gooseneck conveyor 12 inches wide, 12-foot length
4 automatic bean snippers, 32-inch diameter drum, with elevator and 8-foot picking table

BEET EQUIPMENT

1 topper
1 grader, six sizes
steamer
peeler
slicer
cube cutter

ASPARAGUS AND SPINACH EQUIPMENT

1 string bean and asparagus cutter
1 A-B paddle type (2 paddles) spinach washer

TRUCKS

4 roller bearing truck, 12-inch wheels

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