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Quality in FROZEN FRUITS AND VEGETABLES

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Quality in Frozen Fruits and Vegetables[1]

J. D. Winter

THE RAPID development of cold storage lockers in the United States has brought with it the need for careful study of factors involving the maintenance of quality in the stored products. Investigations in this field were begun at the University of Minnesota Agricultural Experiment Station in 1936 and have been continued without interruption.

The first cold storage locker in Minnesota was established in 1935. The state is now one of the leaders in the number of locker plants, having 407 in operation in June, 1942. This is almost 10 per cent of the total for the United States.

The investigations which are summarized in this bulletin deal entirely with the problems of freezing fruits and vegetables under conditions applicable to locker storage practice. Considerable quantities of fruits and vegetables are frozen by locker patrons and the volume is rapidly increasing as proper methods for preparing and freezing these products become better known to local locker patrons and operators.

Definition of Terms

A few technical terms are mentioned in this bulletin to avoid repeating lengthy descriptions. For convenience, these technical terms are defined and described here.

Sucrose—Ordinary granulated cane or beet sugar is referred to as sucrose, except in the general recommendations for freezing, because other sugars such as dextrose, levulose, and maltose are found in other sweetening materials used.

4+1 Pack—A pack consisting of 4 pounds of the product to 1 pound of sucrose. Other proportions are listed in a similar manner.

Degrees Brix (sirups)—Concentrations of sirup are measured by means of a hydrometer in degrees Brix. These readings are on a percentage basis, corresponding to proportions by weight. For example, a 40° Brix sucrose sirup would be made by mixing four parts by weight of sucrose in six parts by weight of water. This also may be referred to as a 40 per cent sirup.

Enzymes—Complex substances that occur naturally in all tissues. Formerly known as ferments. They are capable of accelerating changes in the products, but their action is independent of life processes.

Enzyme-converted—A new manufacturing process, as applied to corn sirup, involving the use of enzymes in the production of dextrose, maltose, and other sugars from corn. Enzyme-converted corn sirup is much sweeter than ordinary (acid conversion) corn sirup.

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Locker plant—a commercially operated establishment for the processing, freezing, and low temperature storage of foods for individual users or patrons.

Organoleptic ratings—Personal-opinion ratings determined by inspection and sampling of the products.

Sources of Products

Vegetables used in these experiments were, with very few exceptions, grown under the supervision of Dr. T. M. Currence and Dr. A. E. Hutchins of the Division of Horticulture, University of Minnesota, University Farm. All fruits except a few unobtainable locally were secured from the University of Minnesota Fruit Breeding Farm and from local commercial growers. In all instances, varieties were carefully checked by some person familiar with varietal characters.

Selection of Products

Every effort was made to select products at the proper stage of maturity for freezing. When products were purchased, special arrangements usually were made with the grower to harvest the material at the desired degree of ripeness. Most of the peas and lima beans used were graded for maturity by brine flotation as described elsewhere in this bulletin.

Harvesting, Handling, and Packing

Most of the vegetables were packed and frozen within a few hours after picking, except when longer delays were intentionally arranged for experimental purposes. Fruits were packed and frozen on the day harvested or on the following day, with the exception of peaches shipped from California and Colorado and some blueberries from northern Minnesota.

The usual procedures in preparation and packing were followed except when varied for experimental purposes. Vegetables were scalded in a 10-quart pail or in a 13-gallon wash boiler, using a tinned wire mesh basket holding 1 to 2 pounds of the product. The volume of the product at the time of scalding was regulated so that the water temperature did not fall below approximately 198° F. The products were cooled in running tap water immediately after scalding.

Fruits were packed by mixing with sucrose or by pouring a sucrose solution over them after the container was filled. A Brix scale for sugar, graduated from 30°-60° F., was used to determine the density of sucrose sirups in which products were packed. In some instances, where noted, the fruits were packed dry without the addition of any sweetening material. During the period 1936-1939 sucrose was added by sifting it onto the fruit as the containers were packed. Since 1939 the sucrose was mixed with the fruit before the containers were filled in order to secure a more uniform coating on the fruit of the sucrose dissolved in fruit juices.

Very few vegetables were included in these experiments prior to 1939. Some of the vegetables used in 1939 were packed in a 2 per cent salt brine solution, and the remainder were drained after scalding and cooling and were packed without any added liquid. The latter procedure (packed without added liquid) was followed with all vegetables packed since 1939.

Containers—Liquid measure pint containers were used in most instances, except for corn packed on the cob which required larger containers. Several types of containers were used, all paperboard types being made especially for the storage of frozen foods. No containers, except those made of glass, were re-used. Very few glass containers were used as they are bulky and awkward to handle at low temperatures although very satisfactory

from the standpoint of food preservation. No hermetically sealed cans were included.

Freezing

The products were frozen in several different places. In all instances the room used was maintained at a temperature not higher than 0° F. and most of the freezing was done at −5° to −10° F. No fans were used. The packed containers were transferred to the freezing room within a few hours after packing, usually within two to three hours.

Storage

All products were stored at approximately 0° F. except when otherwise noted. Storage space in commercial locker plants was used for part of the products packed during 1939, and for all lots packed after the 1939 crop season.

Relative Humidity

The relative humidity maintained in a locker storage room is important, as low relative humidity will accelerate the rate of desiccation of the stored product. Most of the products used in these experiments were stored at a relative humidity of about 80 per cent, according to determinations made by a commercial firm, which is considered a satisfactory relative humidity from the standpoint of refrigerated locker storage.

Methods of Judging

All products to be eaten without cooking were judged immediately after thawing, and those requiring cooking were judged when ready to be served. Score cards were adopted for rating the products on appearance, texture, and flavor. Color and shape were considered separately under appearance. Products packed in sugar or other sweetening materials were rated separately on intensity of flavor and on degree of sweetness.

In addition, a general rating was given based on the degree of attractiveness and palatability of the product as a whole. A product may maintain a high rating for color, shape, and texture but be seriously deficient in flavor. Such a product might show a relatively high score but a low general rating. However, in most instances the total average score was in agreement with the general rating. This score card was used during the progress of these experiments except in some of the earlier phases of the work. All scores reported in this bulletin have been adjusted to a maximum possible score of 100.

In examining the material, the products were prepared ready for sampling by placing them on a table under good light. Each product was given a key number so that the judges could not learn its identity. The quality of natural light was found to differ greatly at the various hours when judging was performed. More uniform conditions were obtained with a combination of natural and artificial light. No regular examination was made of the vegetables prior to cooking.

Use of a small number of experienced judges proved to be the most satisfactory method for judging work. Usually three judges were used, and seldom more than five, except for periodic checks by larger numbers consisting of staff members and others available. Due to the extended period covered (1936-1942) a number of changes in personnel occurred.

The cooking was done under standard procedures, and the same experienced cook handled almost all the cooking from February, 1940, to June, 1942. All lots except corn on the cob were thawed by emptying the frozen material into boiling water. No salt, butter, or other seasoning was added before or after cooking.

Relation Between Variety and Quality

THE QUALITY of any frozen fruit or vegetable at the time it is used is controlled by a long chain of factors beginning with the selection of variety, and continuing through planting, culture, harvesting, and subsequent handling. One of the problems in testing variety adaptation to freezing is the fact that seasonal growing conditions or harvesting at an improper stage of maturity may obscure the true quality of the product. For this reason, an investigator should be reluctant to conclude that a variety is unsuitable for freezing except on the basis of extended trials. However, a variety may not be well enough adapted to local growing conditions to develop good quality at harvest time with reasonable regularity. In this event it may be concluded that such a variety is locally unsatisfactory for freezing no matter how good may be its quality for freezing when grown in other regions.

During the course of these investigations certain varieties were consistently given a high rating from year to year, while others were given a good rating one year but only a fair rating another year. The influence of growing conditions on freezing quality is well illustrated by the everbearing strawberry variety, Wayzata, which rated well for three consecutive years, but was followed by two years of mediocre rating due to drouth and high temperatures affecting the fresh fruit quality of the fall crop.

A summary follows of ratings given fruit and vegetable varieties tested, 1936-1942, indicating the years during which each variety was harvested and packed for freezing and subsequent examination. Storage periods varied from 2½ to 14 months. Preferred varieties are indicated by blacker type.

FRUITS

Peaches

Good to very good—Elberta (1941) and J. H. Hale (1941).

Red Raspberries

Good to very good—Chief (1936-38, 1940), King (1937, 1940), **Latham** (1936-41), Marcy (1937), Tahoma (1941), Taylor (1938, 1940), and Viking (1937, 1938).

Fair to good—Indian Summer (1937, 1938), Marcy (1938), Newburgh (1937, 1938), Ranere (St. Regis) (1937), and Taylor (1937).

Purple Raspberries

Good to very good—**Sodus** (1941).

Strawberries

Good to very good—Beaver (1937, 1938, 1940), Catskill (1937, 1941), Culver (1936-38), **Dorsett** (1936, 1937, 1940), **Dunlap** (1936, 1937, 1939), Fairfax (1936), Gem (1937), Jumbo (1940), **Minn. No. 1192** (1937, 1938, 1940, 1941), Pathfinder (1938), **Premier** (Howard) (1936, 1938-41), Tonka (1938, 1940), and Wayzata (1937-39).

Fair to good—Beaver (1936), Blakemore (1936, 1937), Catskill (1940), Fairfax (1937, 1940, 1941), Green Mountain (1937), Marvel (1936), and Wayzata (1940, 1941).

Poor to fair—Aberdeen (1936, 1937), Clermont (1937), Gibson (1936), and Minnehaha (1936).

VEGETABLES

Asparagus

Good to very good—Washington (1939-41).

Cantaloup

Good to very good—Beauty Osage (1939, 1941), Bender's Surprise (1939), Golden Gopher (1939, 1941), Sugar Rock (1939, 1941), and Sunrise (1940).

Cauliflower

Good to very good—Snowdrift (1940) and White Mountain (1940).

Lima Beans

Good to very good—**Baby Fordhook** (1940), **Burpee's Improved Bush** (1941), New Philadelphia (1939, 1940), and **Fordhook Bush** (1940).

Fair to good—Baby Potato (1939, 1940), New Philadelphia (1941), Henderson Bush (1939, 1940), and Wood's Prolific (1939, 1940).

Poor to fair—Jackson Wonder (1939).

Peas

Good to very good—**Alderman** (1939, 1940), **Dark Podded Thomas Laxton** (1939, 1941), Glacier (1939), Little Marvel (1939), Laxton's Progress (1941), Teton (1939, 1940), **Thomas Laxton** (1939, 1941), and World's Record (1939).

Rhubarb

Good to very good—**Crimson Delicious** (1939), **McDonald Crimson** (1939-41), and Ruby (1939-41).

Snap Beans (green podded)

Good to very good—**Stringless Green Pod** (1940, 1941), **Giant Stringless Green Pod** (1939, 1940), and Tendergreen Stringless (1939).

Fair to good—Plentiful (1941) and Tendergreen Stringless (1940).

Poor to fair—Bountiful (1940), Refugee (1941), and Stringless Black Valentine (1939, 1940).

Snap Beans (yellow podded)

Good to very good—**Brittle Wax** (1939, 1940) and Pencil Pod Black Wax (1939).

Fair to good—Pencil Pod Black Wax (1940), Reliable Black Wax (1939, 1940), and Unrivalled Wax (1939, 1940).

Soybeans (vegetable type)

Good to very good—Emperor (1941), Giant Green (1941), and Sousei (1941).

Fair to good—Etum (1941), Hokaido (1941), Tastee (1941), and Waseda (1941).

Poor to fair—Early Selection (1941), Fuji (1941), Hakote (1941), Suru (1941), Toku (1941), and Willomi (1941).

Spinach

Good to very good—Bloomsdale (1940).

Sweet Corn

Good to very good—Earliest Golden Sweet (1941), Early Aristogold Bantam (1940), Golden Bantam (1939-41), Golden Cross Bantam (1940), Kingscrost Hybrid (1940, 1941), and Minhybrid 202 (1939).

Fair to good—Bantam Evergreen Hybrid (1940), Carmelcross (1940), Early Golden Market (1941), Golden Giant Evergreen (1939), Ioana (1941), Marcross (1941), Sencross (1940), Seneca Golden (1940), and Stowell's Evergreen (1939).

Relation of Storage Temperature to Quality

TRIPLICATE lots of fruits and vegetables from the 1939 crop were packed in pint containers and stored in three different locker plants for periods of 3 to 10 months. These locker plants are designated as A, B, and C, respectively.

The storage room of locker plant A was held at approximately 0° F. with a normal range of 0° to −4° F. Locker plant B was operated at approximately +5° F., with a normal range of 3° to 7° F. Locker plant C was operated at approximately +10° to 12° F. until December 18, 1939, but was subjected to fluctuations of temperature from 8° to 16° F. After this date the temperature was held at approximately +5° F., with a normal range of 2° to 6° F. Temperatures were checked at frequent intervals by maximum and minimum thermometers placed in the locker with the frozen products.

A summary of the judging scores is shown in table 1. This indicates a definite trend toward lower quality at higher storage temperatures. However, the quality of the stored products differed only by relatively small margins, especially those stored in locker plants A and B. When the experiment was started it was expected that locker plant C would continue to operate at approximately +10° to 12° F., but temperature records taken during the progress of this work and other factors caused the management to lower the operating temperature.

Another study of storage temperatures was made during the 1940 crop season by placing frozen fruits and vegetables in two different locker plants, designated as B and D, respectively, for 9 to 14 months. Locker plant B was the same one given this designation in 1939 and was operated at approximately the same temperature, about +5° F. The storage room of locker plant D was operated at approximately 0° F. Temperatures in

Table 1. Rating of Products Stored in Different Locker Plants, Crop of 1939

Product	Number Times Judged	Summary of Average Scores		
		Locker A	Locker B	Locker C
BRINE AND DRY PACKS				
Asparagus	6	91.0	90.5	89.5
Lima beans	12	81.0	80.5	80.5
Snap beans	52	90.7	89.5	89.7
Cauliflower	5	86.5	86.5	83.5
Peas	24	93.0	93.0	92.5
Sweet corn (cut)	19	92.5	92.5	90.5
Weighted average		**90.3**	**89.7**	**89.2**
SUCROSE PACKS				
Red raspberries	12	94.0	92.7	91.7
Rhubarb	18	94.6	93.7	93.3
Strawberries	12	88.0	86.0	86.0
Weighted average		**92.5**	**91.2**	**90.7**

Table 2. Rating of Products Stored in Different Locker Plants, Crop of 1940

Product	Number Times Judged	Months in Storage	Summary of Average Scores	
			Locker B	Locker D
DRY PACKS				
Asparagus	1	12½	92.5	92.5
Corn	9	10-10½	77.0	76.5
Lima beans	1	9½	84.0	83.0
Peas	3	11-11½	84.0	87.0
Snap beans	13	10-11	78.5	81.0
Spinach	2	12	95.0	96.0
Weighted average			**80.4**	**81.7**
SUCROSE PACKS				
Blueberries	5	10-11	94.8	94.8
Cantaloup	3	10	81.2	81.2
Raspberries	17	10½-11½	87.2	87.6
Rhubarb	8	13-14	90.4	89.6
Strawberries	13	9-12	79.2	81.6
Weighted average			**85.9**	**86.6**

Table 3. Reduction of Microorganisms During Storage at 0° to +5° F.

Product and Year Packed	Delay in Packing (days)	Months in Storage	Number of Samples	Bacterial Count per Gram		Yeast Count per Gram		Mold Count per Gram	
				When packed	After storage	When packed	After storage	When packed	After storage
Strawberries (1940)	0*	4	3	540	437	866	200	666	175
Strawberries (1941)	0*	5	2	370	275	330	75	675	20
Strawberries (1940)	1	4-9	7	2,601	363	1,600	164	2,394	460
Strawberries (1941)	1	5	2	1,930	250	900	180	1,650	145
Strawberries (1940)	2	5-10	8	1,820	259	1,945	465	1,322	149
Raspberries (1940)	1	7-11	2	30,250	45	6,950	45	325	10

* Packed same day picked.

both these locker plants were checked regularly by a portable recording thermometer as well as by maximum and minimum thermometers placed in the lockers.

As in the previous year, relatively slight differences were found in the quality of products stored at about 0° and +5° F. This is shown in table 2. It may be concluded that organoleptic tests will not indicate any marked differences in quality between properly prepared fruits and vegetables stored in well-operated locker storage plants at 0° and +5° F., respectively.

Effect of Low Temperature on Microorganisms

Marked reductions in the count of bacteria, yeasts, and molds were evident during storage of strawberries and raspberries at 0° to +5° F. for periods of 4 to 11 months (Table 3).

Effect of Different Packing and Freezing Methods

Type of Container

Duplicate lots of fruits and vegetables from the 1939 crop were packed and frozen in different types of containers and were stored at approximately 0° to −5° F. The products were withdrawn from storage after 6 to 10 months.

The containers used were recommended for the storage of frozen foods by the respective manufacturers. Type 1 was a cylindrical paperboard container lined with transparent cellulose film. Type 2 was a can with friction lid, inside coated with fruit enamel. Type 3 was a heavily waxed cylindrical paperboard container. Type 4 was a rectangular container enclosing a cellulose film bag (No. 300 M.A.T. film).

Each product was packed in two different types of containers, selected from the four types described. Each type of container was found to be satisfactory for maintaining the quality of the frozen product for which it was used, and no appreciable differences in quality of the duplicate lots were noted in any instance. The results of this experiment with different containers are shown in table 4.

Salt Brine vs. Dry Packs

Duplicate lots of vegetables from the 1939 crop were packed dry and in a 2 per cent solution (by weight) of sodium chloride. Standard methods of preparation and packing were used and the products were stored for 6-10 months at approximately 0° to −5° F. No appreciable difference in quality was found between the two methods of packing. Brine packs of asparagus in enamel lined cans were unsatisfactory and had to be discarded.

Method of Preparing Sirup

An experiment was conducted during the 1941 crop season to determine whether heating sucrose sirup in preparation for packing had any effect on the quality of the frozen product. Sixteen lots of products packed in 50° Brix sucrose sirup, consisting of cantaloup and peaches, were used in these experiments. One half the lots were packed in sirup prepared by stirring the sucrose and water without heat. The remaining lots were packed in sirup prepared by heating the sucrose and water to 120° F. and then cooling. The lots were judged after 4½ to 6

Table 4. Rating of Products Frozen in Different Containers

Product	Number Times Judged	Average Score of Different Containers			
		Type 1	Type 2	Type 3	Type 4
Cantaloup	6	83.0	.....	.....	83.0
Lima beans	9	.....	.....	79.5	79.5
Snap beans	45	.....	.....	89.5	90.5
Peas	4	.....	.....	80.5	82.0
Strawberries	9	83.5	.....	.....	83.5
Raspberries (in sirup)	9	.....	96.0	96.0	.....
Raspberries (in sugar)	9	.....	.....	89.5	88.0

Table 5. Comparison Between Brine and Dry Packs for Vegetables

Product	Number Times Judged	Summary of Average Total Scores	
		Brine pack	Dry pack
Asparagus	9	89.0	91.5
Cauliflower	7	85.5	85.0
Lima beans	10	78.0	79.5
Snap beans (green podded)	27	92.0	92.0
Snap beans (yellow podded)	30	90.5	90.0
Peas	36	93.0	92.5
Sweet corn (cut)	25	93.0	91.5
Weighted average		**90.6**	**90.4**

months in storage. Each group received an average score of 89.6, indicating no difference in quality resulting from the method of preparation of the sirup.

Washing Strawberries

One lot of strawberries picked the previous day and another lot picked two days previously were taken, and each lot was divided into two parts. One part was thoroughly washed before removing the hulls and the remaining berries were washed in the same manner after hulling. Samples were taken after hulling and washing, and in both instances the microorganism count was higher in the berries washed before hulling. However, more extensive tests would be required before definite conclusions could be drawn. The average count per gram of the two lots was as follows:

	Washed before Hulling	Washed after Hulling
Bacteria	**2,200**	**940**
Yeasts	**1,650**	**1,200**
Molds	**7,775**	**4,580**

Chopped vs. Whole Strawberries

Sixteen lots of strawberries from the 1941 crop, comprising five varieties, were chopped in preparation for freezing and stored in a 4+1 sucrose pack at 0° F. Similar lots were packed without chopping and stored in the same frozen food locker. The chopping was done with a kitchen food chopper having two stainless steel blades.

The fruit was removed for judging over a period of 2½ to 8 months from the date of packing. The average rating of the chopped berries was 86.4, while the whole berries scored 83.6. The difference in score was due almost entirely to a higher rating given to the chopped berries on flavor, indicating that chopped strawberries retain their flavor a little better than the whole fruit.

Grading Peas and Lima Beans

It is difficult to find a satisfactory scalding time for ungraded vegetables that differ materially in size or maturity. For example, very small young peas may collapse and split as a result of using a scalding time required for more mature peas.

Tests were made during 1940 and 1941 in grading peas for maturity by floating the product in a salt brine solution of sufficient density to float the more tender peas but allow over mature peas to sink. This was tried both before and after scalding. The brine concentration was determined by means of a salometer for sodium chloride graduated from 0° to 100°. Each degree salometer is equal to one-fourth per cent of salt by weight.

The United States Standards for grades of canned peas provide that, in

grading for maturity, "very tender" shall mean that not more than 10 per cent by count of the peas will sink immediately in a salt solution of 10 per cent pure salt and not more than 2 per cent by count will sink in a salt solution of 11 per cent.

In comparative tests, with 14 lots and three varieties, peas floated in 44° salometer (11 per cent) brine after scalding were given an average score of 88.5, as compared to a score of 87.5 for those floated in 4° salometer brine before scalding and a score of 86.5 for those floated in 8° to 10° brine before scalding. A total of 6.6 per cent by weight of the peas that floated in 4° salometer brine before scalding were found to sink in 44° salometer brine after scalding. Similarly, 28 per cent by weight of the peas that floated in 10° salometer brine before scalding sank in 44° salometer brine after scalding.

Under the conditions of these experiments, brine flotation after scalding gave slightly better results in grading for maturity than flotation before scalding. However, flotation before scalding appears the more practicable for locker storage use because it requires much less salt and the operation is more convenient to perform before scalding than afterward. A 10° salometer (2½ per cent) brine used before scalding did not permit peas to float that were noticeably mature when judged after three to eight months in storage. A 10° salometer brine is made by adding approximately one-half cup of table salt to one gallon of water.

Similar tests were conducted after scalding lima beans. Using the variety Burpee's Improved Bush, 88.6 per cent by count of the green beans tested were found to float in 62° salometer brine and 89.8 per cent of the white beans sank. However, tests with the variety New Philadelphia in 47°, 50°, and 60° salometer brine were unsatisfactory in separating the white and green beans, requiring much additional hand sorting. This variety evidently loses color relatively early in its development.

Turning Containers During Freezing

An experiment was conducted, using strawberries packed in sucrose, to determine whether better quality could be obtained by turning the containers during the initial freezing period. A 4+1 pack was used and the berries and sucrose were thoroughly mixed before packing. The containers were placed in the freezing room at ½, 1, 1½, 2½, 3, and 4½-hour intervals after packing. Some lots were inverted when placed in the freezing room and other lots were not turned. Certain lots were not turned again and other lots were turned once more at intervals of ½ to 3½ hours after reaching the freezing room. A total of 24 one-pint containers were used.

The various lots were judged after 4½ months in storage and no appreciable differences in quality were found.

Freezing Products Before Packing

Several tests were made in 1941 by freezing asparagus, peas, and red raspberries placed on open, shallow trays in comparison with similar lots packed in standard containers. The freezing was done at an air temperature of approximately 0° F. without the use of a fan. The raspberries (Latham) were partly frozen, then rolled in dry sugar and replaced in the freezer.

The asparagus frozen on an open tray was unsatisfactory, but the peas frozen on a tray were given the same average rating in judging as those frozen in containers. The raspberries frozen on the tray were rated equal in quality to those frozen in containers in a 4+1 sucrose pack, but below the quality of those frozen in a 45° Brix sucrose sirup.

Effect of Scalding Procedures on Quality

Inactivation of Enzymes

Enzymes occur naturally in living tissues and are capable of greatly accelerating chemical reactions within the tissues. Some enzymes, functioning after the death of the tissues, cause disintegration known as autolysis when active alone but cause decay when both enzymes and microorganisms are present and active.

Retention of flavor in frozen vegetable products during storage is closely associated with the inactivation of oxidizing and hydrolyzing enzymes, thus preventing autolytic changes that are not arrested by low temperature storage. Inactivation of these enzymes by scalding is necessary in preparing vegetables for freezing.

During the 1939 crop season recommendations found in the literature as to time and temperature of scalding were tentatively followed. Catalase and peroxidase tests were made of almost all lots from the 1940 and 1941 crops at the time of packing, and again when the product was withdrawn from storage. Tests of catalase activity were made by placing a small piece of crushed tissue from the center of the product in a test tube with enough water to cover and adding approximately an equal quantity of 3 per cent hydrogen peroxide. Active catalase was evidenced by the visible evolution of gas bubbles at the surface of the vegetable within one to two minutes.

Peroxidase activity was determined by following the same procedure as for the catalase test, with the addition of tincture of gum guaiacum immediately after the hydrogen peroxide. The test tube is shaken before the tincture is added. Approximately equal volumes of hydrogen peroxide and tincture of gum guaiacum were used. Active peroxidase is evidenced by the appearance of a strong blue color within two minutes.

Close correlation appeared to exist in most of the vegetables between inactivation of enzymes as indicated by one or both of these tests and the quality of the stored product. However, asparagus appeared to retain better quality with longer scalding than either test indicated was necessary. A scalding time of two minutes appeared to inactivate the respiratory enzymes, even in the larger stalks, but higher quality ratings were obtained after scalding three to four minutes according to size of the stalks.

It seems possible that the number of enzymes responsible for accelerating changes in the quality of the stored product are more numerous than those for which tests are customarily made. In some instances a very slight evolution of gas bubbles from hydrogen peroxide continued after considerable overscalding, indicating that hydrogen peroxide may react slightly to enzymes which are not involved in the respiratory system.

Reference to the practice of "scalding in boiling water" needs some clarification. These recommendations usually state that the product should be immersed in boiling water and that the water should return to a boil within 60 to 75 seconds. Under the most careful kitchen practice, at elevations prevailing in Minnesota, the temperature of the water will fall to about 198° F. on immersion of the product. Recommendations in this bulletin, given on page

22, are based on a temperature drop of about 12° to 15° F. with return to "boil" in about 75 seconds.

Scalding Below Boiling

Studies were conducted during the 1941 crop season to determine whether improvement in quality would result from scalding peas and snap beans in water for four to five minutes at temperatures ranging approximately between 188° and 200° F. Comparable lots were scalded in boiling water for 2½ minutes at temperatures approximately between 198° and 210° F. Laxton's Progress and Thomas Laxton peas and Giant Stringless Green Pod and Plentiful snap beans were used.

Three lots of peas and eight lots of snap beans were judged after four to eight months in storage. No significant differences in the quality of these products were noted between lots scalded at 188° to 200° F. and those scalded in boiling water in the usual manner.

Use of Steam for Scalding

Studies were conducted during the 1941 crop season to determine whether improvement in quality would result from the use of steam in scalding asparagus and corn, using equipment ordinarily available in the kitchen. The products were suspended in a rack placed inside a covered wash boiler. Comparable lots were scalded in water in the usual manner. Varieties used were Washington asparagus and Early Golden Market, Earliest Golden Sweet, Kingscrost Hybrid, Golden Bantam, and Ioana sweet corn.

More time was required to inactivate properly the respiratory enzymes with steam than is required when the product is immersed in boiling water. Large stalks of asparagus and corn (to be cut) required five minutes in steam as compared to four minutes for asparagus and 3½ minutes for corn when scalded in water.

Four lots of each product were judged after storage of 4 to 10 months. No significant differences in the quality of these products were noted between the lots scalded in steam and those scalded in water.

Methods of Cooling Corn After Scalding

Studies were conducted during the 1941 crop season to determine whether cooling corn in air in front of a small electric fan after scalding would reduce sogginess in the product. Comparable lots were cooled in water in the usual manner. The corn was placed before a fan for 15 to 20 minutes, resulting in cooling of the product to approximately 90° F. The lots cooled in water were reduced to a temperature of approximately 80° F. in 7 to 10 minutes. Varieties used in these experiments were Early Golden Market, Earliest Golden Sweet, Kingscrost Hybrid, and Golden Bantam. All lots were cooled on the cob.

Ten lots of air cooled corn cut from the cob, and seven lots of corn frozen on the cob were judged after 3½ to 7 months in storage, together with comparable lots cooled in water. No significant differences in the quality of air cooled and water cooled lots were found.

Sweetening Materials

Sugar Recrystallization

The progressive development of a white fondant-like mass during storage was observed frequently during these investigations in fruit packed in sucrose or in sucrose solutions of varying densities. This condition evidently resulted from a recrystallization of sugar. It was found at storage temperatures of approximately 0°, 5°, and 10° F., respectively, but usually was not noticeable until the product had been in storage for several months. Containers in which this occurred were much less attractive in appearance than those in which this condition did not occur.

In an effort to prevent this fondant-like formation a number of containers were packed during 1940 using enzyme-converted corn sirup in combination with sucrose in varying proportions. It was found that no fondant-like formation occurred when 25 per cent or more by weight of the sucrose was replaced by corn sirup. Typical fondant-like formation occurred in some lots held under identical storage conditions but sweetened entirely with sucrose.

The addition of corn sirup does not prevent recrystallization, but apparently it causes the sugar to crystallize as very fine crystals which readily redissolve when the fruit is thawed.

Corn Sirup as Replacement for Sucrose

An investigation of the use of corn sirup in packing fruits for freezing was conducted during the 1940 crop season. A light-colored, enzyme-converted corn sirup was used. The manufacturer's analysis shows this type of corn sirup contains about 70 per cent more dextrose, maltose, and higher sugars than ordinary (acid conversion) corn sirup, and its viscosity at 100° F. is rated at 58 poises as compared to 150 poises for ordinary corn sirup. The much lower viscosity of the enzyme-converted type facilitates the mixing of the fruit with the sirup in preparation for freezing when no added water is used.

The manufacturer of the enzyme-converted corn sirup used supplied the following analysis of this product on a basis of total weight.

	Per Cent
Dextrose and maltose	58.5
Higher sugars	13.1
Dextrins	9.9
Moisture	18.2
Ash	0.3
	100.0

Fruits and vegetables packed in sucrose, with and without added water, were judged in comparison with comparable lots packed in varying proportions of enzyme-converted corn sirup and sucrose. In some instances corn sirup alone was used. A general rating was given each product in each type of pack used. Rating No. 1 would be comparable to a rating of good to very good. Rating No. 2, fair to good, and rating No. 3, poor to fair. Rating No. 4 indicates very undesirable quality.

Tables 6 to 9 show the results of these experiments. In all instances where the corn sirup did not exceed the approximate amount of sucrose on a dry weight basis, the product was given the highest rating equal to the lots in which only sucrose was used. Raspberries and strawberries sweetened only with enzyme-converted corn sirup were rated 2 and 3, respectively.

On the basis of these results it appears that enzyme-converted corn sirup may replace sucrose in packing the fruits used in the experiments to the extent of one half the weight of sucrose with little if any noticeable dif-

Table 6. Rating of Sucrose Sirup Packs

Product and Year Packed	Number of Varieties	Degrees Brix or Per Cent Sucrose by Weight	Months in Storage	Number Times Judged	General Rating
Blueberries (1939)	1	30	3-8	5	1
Blueberries (1940)	1	40	7-9	3	1
Cantaloup (1939)	5	30	3-10	9	1(NS)
Cantaloup (1940)	2	35	6-10	4	2(NS)
Cantaloup (1941)	2	50	3-6	8	1(S)
Peaches (1941)	2	50	3-7½	6	1
Raspberries (1939)	1	45	3-10	18	1
Raspberries (1940)	3	45	7-11½	14	1
Raspberries (1940)	1	40	9-11½	3	1
Raspberries (1941)	3	45	3-8½	24	1
Rhubarb (1939)	3	45	3-10	15	1
Rhubarb (1940)	2	40	13-14	4	1
Rhubarb (1940)	2	35	13-14	4	2
Rhubarb (1940)	2	30	13-14	4	2
Rhubarb (1941)	2	45	5½-11½	4	1
Strawberry (1939)	3	45	3-10	27	1

S—Too sweet; NS—Not sweet enough.

Table 7. Rating of Dry Sucrose Packs (no added water)

Product and Year Packed	Number of Varieties	Amount Sucrose per Pound of Fruit	Months in Storage	Number Times Judged	General Rating
		ounces			
Blueberries (1939)	1	4.0	3-8	5	2
Blueberries (1940)	1	4.0	7-9	3	2
Cantaloup (1940)	2	3.2	6-10	6	1
Cantaloup (1941)	3	3.2	3-6	19	1
Peaches (1941)	1	4.0	3½-5	4	2
Raspberries (1939)	1	5.3	3-10	18	2(S)
Raspberries (1940)	3	4.0	7-13½	14	2
Raspberries (1941)	2	4.0	3½-8½	6	2
Rhubarb (1939)	3	5.3	3-10	3	2
Strawberries (1939)	3	5.3	3-10	18	1(S)
Strawberries (1940)	8	4.0	9-11½	29	1
Strawberries (1941)	5	4.0	2-8	14	1

S—Too sweet.

ference in quality. In most instances the replacement of a larger proportion of sucrose will depend largely on individual preferences and tastes. It is suggested that replacement be made on the basis of four parts by weight of corn sirup for three parts by weight of sucrose, or five parts by volume of corn sirup to replace six parts of sucrose, for packs containing some sucrose. When no sucrose is used replacement should be made with at least an equal volume of enzyme-converted corn sirup.

Enzyme-converted corn sirup packed for the retail market usually contains a small amount of added sucrose and is a little sweeter than the unblended product. Approximate composition of a blended, light-colored sirup is given by one manufacturer as follows:

	Per Cent
Dextrose	25.6
Maltose	23.4
Higher sugars	11.0
Sucrose	6.3
TOTAL SUGARS	66.3
Dextrins	8.3
Ash	.2
TOTAL SOLIDS	74.8
Moisture	25.2
	100.0

Table 8. Rating of Sucrose and Corn Sirup Packs, Packed in 1940

Product	Number of Varieties	Amount Sucrose per Pound of Fruit	Amount Corn Sirup per Pound of Fruit	Months in Storage	Number Times Judged	General Rating
		ounces	ounces			
NO WATER ADDED						
Blueberries	1	2.0	3.0	7-9	3	1
Blueberries	1	3.0	1.0	7-9	3	2(S)
Cantaloup	2	2.6	1.5	6-10	4	1
Strawberries	5	3.0	1.5	3-11½	11	1
Strawberries	3	3.0	3.0	3-9	4	1(S)
Strawberries	8	2.0	3.0	3-12	18	1(S)
Strawberries	4	0.0	6.0	3-9	6	3
		Per Cent by Weight				
		Sucrose	Corn Sirup	Water		
WATER ADDED						
Raspberries	3	32	14	54	7-11½	9	1
Raspberries	3	20	28	52	7-11½	9	1
Raspberries	3	0	52	48	7-11½	9	2

S—Too sweet.

Table 9. Rating of Dry Packs (no sucrose, sirup, or water added when packed)

Product and Year Packed	Number of Varieties	Months in Storage	Number Times Judged	General Rating
Blueberries (1939)	1	3-8	5	2
Blueberries (1940)	1	7-9	4	2
Cantaloup (1939)	5	3-10	9	4
Raspberries (1940)	3	7-9	3	3
Raspberries (1941)	1	3½-8½	8	3
Rhubarb (1939)	3	3-10	15	2
Rhubarb (1940)	2	5½-11½	4	2
Strawberries (1940)	2	4½-11	4	4

Table 10. Rating of Honey Packs with No Added Water and of Sucrose-Honey Packs with and without Addition of Water, 1941

Product	Number of Varieties	Amount Sweetening Used per Pound of Fruit		Months in Storage	Number Times Judged	General Rating
		Sugar and Honey				
		ounces				
HONEY PACKS						
Cantaloup	3	0	3.2	3-6	9	1
Cantaloup	2	0	4.0	3-6	9	2(S)
Cantaloup	1	0	5.3	3-6	5	3(S)
Peaches	1	0	4.0	3-7½	4	2
Peaches	1	0	5.3	3-7½	4	3(S)
Strawberries	1	0	5.3	2-5½	3	2(S)
SUCROSE-HONEY PACKS (No Water)						
Peaches	1	3.0	1.2	3-7½	4	2(S)
Strawberries	1	3.0	1.5	2-5½	3	1
Strawberries	1	2.4	3.2	2-5½	3	1(S)
		Per Cent by Weight				
		Sucrose	Honey	Water		
SUCROSE-HONEY PACKS (Water Added)						
Peaches	1	42½	18	39½	3-7½	4	1(S)

S—Too sweet.

Honey as Replacement for Sucrose

Some preliminary experiments were conducted during the 1941 crop season with the use of honey in packing fruits for freezing. A mild, light-colored honey was used having a moisture content of 18.4 per cent. The results of these experiments are shown in table 10. Packs comprising approximately two-thirds sucrose and one-third honey by weight received the highest rating with peaches and strawberries. A 5+1 pack of cantaloup and honey also received the highest rating. Relatively large proportions of honey caused excessive sweetness and objectionable dark color.

The acceptance of honey as replacement for sucrose in preparing fruits for freezing depends more on personal preference than when corn sirup is used. For those who wish to use honey for the purpose, replacement of sucrose may be made on a pound for pound basis.

Temporary Storage of Frozen Products

MANY of the more modern household mechanical refrigerators are equipped with enlarged ice cube compartments, some capable of holding 10 to 15 pounds of frozen products. Other more expensive models are equipped with special compartments for frozen foods at lower temperatures.

During the 1940 crop season, experiments were conducted to determine the length of time that frozen fruits and vegetables may be stored in an ice cube compartment after their removal from a locker storage. The refrigerator used for these tests was found to maintain a temperature of about 25° F. in this compartment with the cold control set at about the midway point.

Five lots of vegetables consisting of cauliflower, lima beans, and snap beans were stored for 10 to 14 days in the ice cube compartment at approximately 25° F. and then were judged with duplicate lots held at 0° F. A moderate loss of quality was found in the lots taken from the ice cube compartment, indicating that dry packed vegetables should not be stored in this manner for this length of time.

Similarly, 16 lots of sucrose-packed products consisting of blueberries, cantaloup, raspberries, strawberries, and rhubarb were stored for the same length of time at the same approximate temperature. The average score for the lots taken from the ice cube compartment was 86.8 as compared to 87.2 for the duplicate lots held at 0° F., indicating no significant loss of quality. However, eight lots of blueberries, raspberries, and rhubarb stored in the ice cube compartment for 26 days at approximately 20° F. (cold control set at the maximum) showed a moderate loss of quality in comparison to duplicate lots stored at 0° F.

Samples of seven of the sucrose-packed fruits stored for 10 to 14 days in the ice cube compartment were examined for bacteria, yeasts, and molds. No appreciable difference was found between these and duplicate samples stored at 0° F. The average count per gram was as follows:

	Lots Stored in Ice Cube Compartment	Lots Stored at 0° F.
Bacteria	92	133
Yeasts	19	19
Molds	46	80

General Recommendations

FREEZING FRUITS

If possible, pick fruits when fully ripe and freeze on the day of harvesting. If this is not practicable, the fruit may be held in a cool place or under refrigeration until the following day. With perishable fruits, such as berries, delay of more than a few hours at summer temperatures will result in lower quality of the frozen product. Choose varieties known to be suitable for freezing and pack in containers adapted for locker storage use. Make sure that the water supply is clean and pure. See that all utensils used are scrupulously clean and do not allow anyone to handle and pack the product until the hands are thoroughly washed in soap and water. See page 6 for list of suitable varieties.

Sugar Pack—Coat the fruit with dissolved sugar and fruit juice before freezing by stirring sugar and washed fruit together in a pan or large bowl. The normal amount of sugar used may be reduced, but the fruit's color and quality may not be protected if less than 1 pound of sugar to 5 pounds of fruit is used. This is referred to as a 5+1 pack. A 4+1 pack would mean 4 pounds of fruit to 1 pound of sugar.

Sirup Pack—Prepare by dissolving the right amount of sugar in clean, cold water. The sirup must be cold when poured over the fruit. Leave a space one tenth the height of the container for expansion. Sirups made by dissolving less than 12 cups of sugar in a gallon of water may not properly preserve color and quality. Sirups must be freshly mixed and should not be allowed to stand for more than a few hours unless under refrigeration. A sirup pack is not desirable for any product to be used for canning, preserves, or baking because of the added water. One gallon of sirup will pack about 40 pint containers.

Unsugared Pack—With few exceptions, fruit should not be frozen without adding some sugar or other sweet-

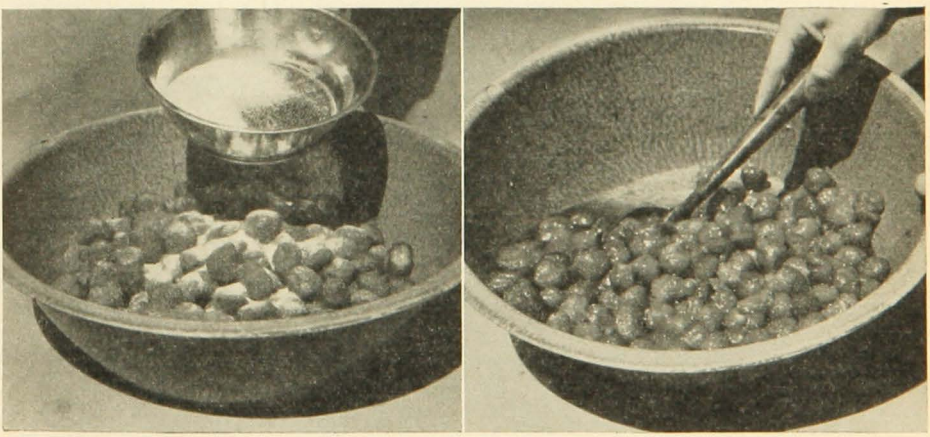

FIG. 1. METHOD OF MIXING SUCROSE WITH STRAWBERRIES

Left—Sugar first is sprinkled over fruit

Right—After waiting a few minutes for the sugar to dissolve, the berries and sugar are mixed

FIG. 2. IN PACKING WITH SIRUP THE FRUIT IS PLACED IN THE CONTAINER AND COVERED WITH LIQUID

ening material. Blueberries and raspberries may be frozen without sugar for cooking but a 4+1 sugar pack will retain quality better. If it is necessary to freeze strawberries without sugar, the fruit may be crushed so that the juices will retard excessive drying of the tissues during storage. It is much better, in most instances, to sweeten with corn sirup than to freeze the product without sugar. The use of saccharine is not recommended unless prescribed by a physician, in which case it may be added when the product is thawed.

PREPARING FRUIT FOR FREEZING

Apples—Apples may be sliced into cold water or light sugar sirup to avoid discoloring. Remove and scald in steam for six to eight minutes. A 4+1 sugar pack is preferred. For ordinary use, however, cellar or cold storage is preferable to freezing.

Apricots—Halve and then handle same as peaches.

Blueberries—Sort, remove immature fruit, wash, and pack in sirup for dessert use. A dry pack may be used if the fruit is to be cooked.

Cherries (sour)—Cherries are usually pitted and packed in a 3+1 sugar pack.

Peaches—Freestone varieties are preferred. Special care is necessary to avoid browning of the cut slices. Plunge the whole fruit into boiling water for one-half minute or until the skin loosens, then cool quickly in cold water in readiness for peeling. Peel, remove pit, and slice directly into cold sugar sirup, or drop into water to which has been added about 1 teaspoonful of lemon juice per pint of water. A weak citric acid solution (1 per cent by weight) may be used in place of the lemon juice and water.

Plums and Cherry Plums—Most local varieties are unsatisfactory for dessert use after freezing, but suitable varieties are very satisfactory for cooking. Plums may be frozen in sirup at the concentration recommended for peaches. According to tests at the Division of Home Economics and elsewhere the following varieties of plums and cherry plums are satisfactory for jam and preserves: La Crescent, Ember, Fiebing, Hennepin, Red Wing, Sapa, Superior, Underwood, and Pipestone. Satisfactory varieties for plum jelly are: Elliot, Fiebing, Hennepin, Monitor, Superior, and Pipestone.

Raspberries (black)—Usually considered too seedy for dessert use but good for jam and preserves. May be handled like red raspberries.

Raspberries (red and purple)—A sirup pack is preferred for dessert use.

Strawberries—After the berries are hulled and washed they may be packed whole or chopped. The chopped fruit usually retains a little better flavor. An ordinary kitchen food chopper with stainless steel blades may be used to chop the berries before sugar is added. A 4+1 sugar pack is preferred. Unsweetened strawberries are much less desirable except for persons who cannot eat sugared products.

SWEETENING MATERIALS

Table 11 gives the amount of sugar or other sweetening materials needed in freezing. These figures can be adjusted to meet various individual preferences.

Either extra-sweet (enzyme-converted) corn sirup or honey may replace sugar in the proportions shown. Extra-sweet corn sirup is a new product manufactured by a special process making it much sweeter than ordinary corn sirup (see explanation and analysis which are given on page 15).

In the following table **standard** pack refers to the regular sugar or sirup pack; there is little noticeable difference in this pack and the **medium sugar-saving** pack. The **maximum sugar-saving** packs contain a minimum amount of sugar. Many persons find these packs acceptable. Light colored extra-sweet sirup is preferable although the dark may be acceptable except in maximum sugar-saving packs.

Table 11. Sugar and Sirup Packs for Freezing

Product	Sugar	Extra-Sweet Corn Sirup	Honey
SIRUP PACKS			
(Measurements for sirup packs are for one gallon of water)			
	Cups	Cups	Cups
APRICOTS (halved)			
Standard pack	15	none	none
BLACKBERRIES			
Standard pack	15	none	none
BLUEBERRIES			
Standard pack	12	none	none
Medium sugar-saving pack	6	5½	none
Medium sugar-saving pack	8	none	2½
Maximum sugar-saving pack	3	8	none
PEACHES			
Standard pack	17	none	none
Medium sugar-saving pack	8	8	none
Medium sugar-saving pack	9	none	5
Maximum sugar-saving pack	5	11	none
RASPBERRIES AND RHUBARB			
Standard pack	15	none	none
Medium sugar-saving pack	6	6½	none
Maximum sugar-saving pack	none	15	none
DRY SUGAR PACKS			
(No added water)			
CANTALOUP (10 lbs.)			
Standard pack	4	none	none
Medium sugar-saving pack	2	1⅔	none
Medium sugar-saving pack	none	none	2½
Maximum sugar-saving pack	1	2½	none
SOUR CHERRIES (pitted—3 lbs.)			
Standard pack	2	none	none
STRAWBERRIES (4 lbs.)			
Standard pack	2	none	none
Medium sugar-saving pack	1	1	none
Medium sugar-saving pack	1	none	⅔
Maximum sugar-saving pack	½	1⅓	none
Maximum sugar-saving pack	½	none	1

Note: When using dry sugar pack, sprinkle sugar on fruit and allow to stand for 3 to 4 minutes or until sugar is dissolved in fruit juice, add extra-sweet corn sirup or honey, and stir carefully until well mixed. Pack into containers for freezing.

FREEZING VEGETABLES

Five distinct operations in preparing vegetables for freezing are required. These are:

1. Wash and prepare the product for scalding.

2. Sort according to size and maturity.

3. Scald according to directions.

4. Cool immediately and drain.

5. Pack into containers (add no liquid). Certain types of containers require heat sealing with an electric flat iron or curling iron or with a heat sealer made especially for this purpose.

It is most important to select vegetables at the proper stage of maturity, and, if possible, they should be picked and frozen on the same day. If it is necessary to hold the product until the following day, most vegetables must be placed in a cool place and covered with cracked or crushed ice to prevent serious loss in quality. Some vegetables, such as sweet corn and peas, lose quality much more quickly than others. In general, delay of more than a few hours at summer temperatures will result in lower quality of the frozen product.

Proper scalding in boiling water is necessary for vegetables being prepared for freezing storage, except those to be packed in sugar or sugar sirup. The product should be carefully sorted so that vegetables of the same size and maturity may be scalded at one time. The recommended scalding periods are shown on page 24, beginning from the time the vegetable is first immersed. The water must return to a boil within 60 to 75 seconds; otherwise it indicates that too little water is being used in proportion to the amount of the product.

Usually, on the average kitchen stove, not more than one pound of the product can be scalded at one time for each 8 to 10 quarts of boiling water used. A clean, well-tinned wash boiler (not used for washing) or a 12-quart enamelware pail is useful for this purpose. The water used for scalding should be changed at frequent intervals if large quantities are being packed. As soon as scalding is finished, the vegetable should be quickly cooled in clean water, drained a few minutes, and then packed into suitable containers.

Recommendations for fruits as to varieties, containers, water supply, and cleanliness also apply to vegetables.

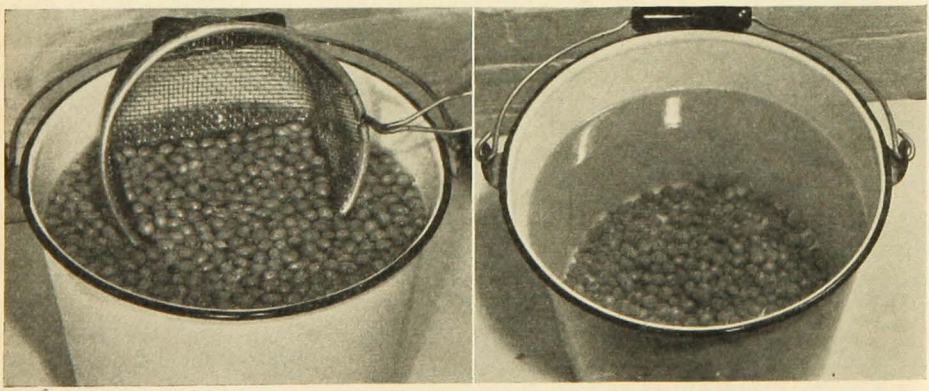

FIG. 3. GRADING PEAS FOR MATURITY IN BRINE

Left—The tender peas are skimmed from the surface
Right—The more mature peas sink to the bottom

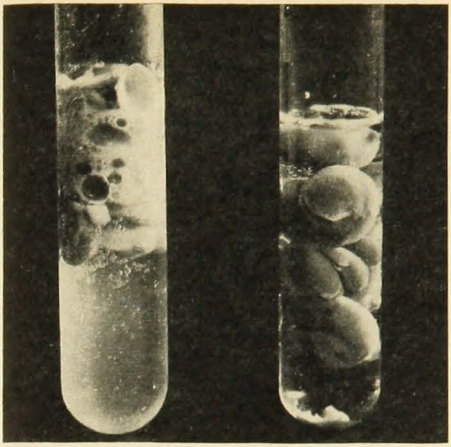

FIG. 4. TEST FOR ENZYME ACTIVITY WITH HYDROGEN PEROXIDE
Left—Unscalded vegetable showing evolution of gas bubbles
Right—No gas bubbles from properly scalded product

PREPARING VEGETABLES

Asparagus, Snap Beans—Prepare as you ordinarily would for cooking. Snap beans usually are cut into one-inch lengths, and asparagus often is cut into similar lengths to facilitate packing. Sort the asparagus into medium and large sizes. Avoid iron utensils because these vegetables may be discolored from them.

Carrots, Cauliflower, Spinach—Prepare as you ordinarily would for cooking. Dice or slice carrots. Cut cauliflower into medium-sized pieces weighing about 14 to the half pound.

Cantaloup—Cut into small cubes measuring about one half to three quarters of an inch and use a 5+1 sugar or honey pack. The product must be firm but well ripened. If slightly immature, the quality is very inferior.

Ground Cherries (Husk Tomato)—Husk and scald in water for two minutes, then pack in sirup at the concentration recommended for peaches.

Lima Beans, Peas—It is most important to pick these at the right stage of maturity. Discard all hard, overmature specimens at the time of shelling. Small, poorly formed peas will not freeze well. Overmature peas may be separated before scalding by brine flotation (see page 11), using about one-half cup of salt per gallon of water.

Rhubarb—Cut stalks into one-inch lengths and pack in sirup. Rhubarb may be frozen without sugar with good results although the quality will not be equal to that frozen in sirup.

Soybeans (Vegetable type)—Soybeans are difficult to shell unless first scalded in the pod for five minutes, then chilled. Scald the shelled beans for an additional minute, then cool and pack into containers.

Sweet Corn—Selection at the right stage of maturity is very important. It may take a little practice and experience to learn the proper stage, which is slightly more mature than usually would be selected for table use. Remove the husks and silk; trim ends.

In most instances, it will be best to cut the corn from the cob because it is difficult to scald the center of the cob properly without overscalding the corn itself. Off flavors are apt to develop if the corn is packed on the cob and the whole ear is not thoroughly scalded. Do not cut corn from the cob until after scalding. Cut corn requires one third the space occupied by the same quantity of corn on the cob. When packing corn on the cob, use only small- and medium-sized ears weighing less than 7 ounces to facilitate proper scalding.

Other Vegetables—Among the vegetables that may be frozen satisfactorily, but which are not commonly used in Minnesota for freezing storage, are Brussels sprouts, beets, beet greens, cabbage, kale, mushrooms, squash, Swiss chard, and turnips.

Vegetables Not Suitable for Freezing—Whole tomatoes and vegetables used uncooked in salads such as celery, cucumbers, endive, and lettuce are not suitable for freezing.

SCALDING TIME REQUIRED

On the basis of tests for enzyme activity and organoleptic ratings made during the course of these experiments, the following scalding periods are recommended for products immersed in water having a temperature range of approximately 198°-210° F.

Product	Size or Weight of Pieces	Scalding Time (minutes)
Asparagus	Not over ½ inch in diameter	3
Asparagus	½ to ¾ inch in diameter	4
Broccoli	Not thicker than 1 inch	4
Brussels sprouts	Medium to large	4
Carrots	Small (diced)	3
Cauliflower	Approximately ½ oz.	4
Corn (to be cut)	All sizes	3½
Corn (on cob)	Small (3 to 5 oz.)	6
Corn (on cob)	Medium (5 to 7 oz.)	8
Lima beans	Small (25 to 35 per oz.)	3½
Lima beans	Medium (20 to 25 per oz.)	4
Lima beans	Large (15 to 20 per oz.)	4½
Peas	Small	2
Peas	Medium to large	2½
Peas	Edible pod type	3½
Snap beans, very tender	Cut pieces	2½
Snap beans, slightly mature	Cut pieces	3½
Soybeans (vegetable type)	Scald in pod	6
Spinach, very tender		2
Spinach, more mature	Discard thick stems	3

THAWING THE FROZEN PRODUCT

Commence cooking frozen vegetables, if practicable, before the product is completely thawed. Do not start cooking corn on the cob until the cob is thawed. Most frozen fruits are at their best if served about the time that thawing is completed. Thaw fruit in the original container which should be placed bottom side up if leak-proof. Do not remove cover during thawing or until ready to serve. Rapid thawing in lukewarm water is preferred for peaches and apricots to minimize discoloration. Unsugared fruit, not to be used for cooking, is best thawed in sirup. When frozen foods have been thawed they should not be refrozen.

FRUIT AND VEGETABLE JUICES

Most fruit juices, and tomato and rhubarb juice, are well adapted for freezing. They may be sweetened to the taste before freezing or frozen without added sugar. Blends of certain juices may be made by freezing one fruit and later thawing and pressing out the juice at the time when another fruit is ready for harvesting.

Glass, earthenware, stainless steel, or aluminum containers should be used in preparing fruit juices. Avoid iron, tin, copper, gray and blue enamelware.

Juices for freezing should not be placed in containers larger than one gallon, or in glass containers that taper sharply at the top.