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Precooling Rail
Shipments of

ILLINOIS PEACHES

with special reference
to the use
of ventilated packages

by
J. W. Lloyd

Bulletin 455

University of Illinois
Agricultural Experiment Station



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PRECOOLING RAIL SHIPMENTS OF ILLINOIS PEACHES

With Special Reference to Use of Ventilated Packages

J. W. LLOYD, Chief in Fruit and Vegetable Marketing

TESTS concerned with the refrigeration of eight carloads of Illinois peaches—four in 1935 and four in 1937—are reported in this bulletin. The rapid cooling of peaches in ventilated packages had been demonstrated by experiments in 1933 and 1934 under controlled laboratory conditions, but it seemed advisable to make further tests in refrigerator cars in order to determine how well this type of package was adapted to carlot shipments. Furthermore it was considered desirable to observe the combined effect of forced air circulation, salt, and ventilated packages on the rapidity with which peaches can be cooled after they are loaded into refrigerator cars.

Earlier experiments by this Station^{4*} had shown that in a refrigerator car handled under standard refrigeration the temperature of peaches packed in standard bushel baskets and having an initial temperature of about 72° F. was reduced about 24 degrees during the first 48 hours the car was in transit. In other tests, in which electric fans were used to increase the air circulation in refrigerator carloads of fruit, there was much greater uniformity of fruit temperatures thruout the load and more rapid cooling of the entire lading while the fans were in operation.^{6*} The addition of salt to the ice in the bunkers also hastened refrigeration.^{4*}

In the laboratory tests^{5*} referred to above, the most rapid cooling took place in ventilated bushel baskets with wide cracks between the staves. Peaches packed in this type of ventilated basket without any liner cooled down to 50° F. in less than 6 hours, or in less than half the time required for the contents of a standard lined tub bushel. Other workers^{2*} have shown that for safe carriage the temperature of peaches should be reduced to 50° F. as quickly as possible. It is reasonable to assume that with rapid cooling, peaches could be allowed to become more mature and of better flavor before picking.

The author acknowledges the assistance of S. W. DECKER, M. P. GEHLBACH, and V. A. EKSTROM in the procuring of data for this publication.

*These figures refer to literature citations on page 544.

PLAN OF THE TESTS

Plans for conducting the tests reported herein were started during the 1935 Illinois peach shipping season, and arrangements were made with one of the package manufacturers to make up a special order of ventilated packages for use in the tests, since baskets of this type were not carried in stock at that time.

Before fans for this work had been procured, it was learned that two different companies operating precooling equipment were seeking business at Illinois peach shipping points. Contacts were made with shippers considering the use of this service, and arrangements were finally made to conduct tests with a number of carloads. In each test, one half (one end) of the car was loaded with peaches packed in ventilated baskets and the other half with peaches packed in standard tub bushel baskets or standard round-bottom bushel baskets. Previous tests had shown that refrigeration is practically the same at similar points in opposite ends of refrigerator cars, provided lading, package types, and loading system are similar in the two ends of the car.^{4*}

Tests were undertaken in a number of cars in 1935, but various contingencies arose which rendered the results in several of the cars unreliable, such as failure of the fans to work properly, unloading part of car to fill truck orders, exhaustion of a large part of the ice supply in bunkers before the precooling period was completed, and unusual delay in completing loading of car. Therefore only four cars included in the tests made in 1935 are reported herein.

The Illinois peach crop in 1936 was too limited in volume to warrant undertaking any commercial precooling tests. In 1937 tests were resumed. These included only four cars, but in each test the car was followed thru to the terminal market. Temperature readings were made enroute and the fruit was inspected upon arrival. Results of the tests on the four cars in 1935 and the four cars in 1937 are included in the present report.

The Elberta variety was used in the 1935 tests. In 1937 three cars were loaded with Elberta and one with the Red Bird variety.

EQUIPMENT USED AND METHOD OF MAKING TESTS

Precooling Equipment.—The equipment of the two companies furnishing the precooling service used in these tests was entirely different. One type consisted of electric fans approximately 18 inches in diameter mounted on motors to be connected with the power-and-light circuit at the packing shed. One fan was placed at each end of the car directly

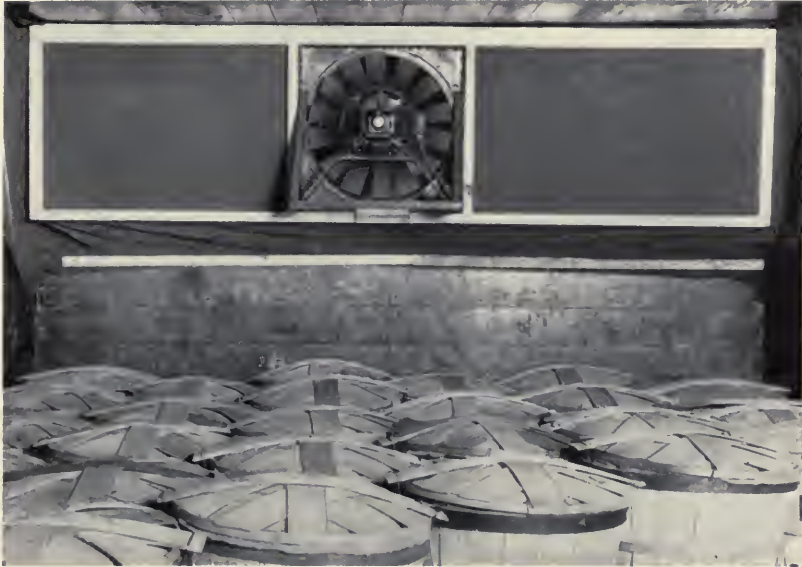


FIG. 1.—ELECTRIC FAN IN POSITION AT END OF CAR.

Precooling by means of this type of equipment involves the use of salt with the ice in the bunkers.

opposite the center of the opening between the body of the car and the top of the ice bunker (Fig. 1). A baffle of fabricated wood covered with canvas closed all the opening at the top of the bunker except the portion occupied by the fan.

The fans used in different tests with this first type of precooling equipment differed somewhat in type, some being multiple-bladed and others single-bladed. One of the most satisfactory was a single-bladed propeller fan with a half-horsepower motor, rated at 3450 r.p.m. This was operated on 220 volts, alternating current. Each fan was set so as to draw the cold air out of the top of the ice bunker and force it down upon the load and toward the center of the car. Thus air currents were set up which were directly opposite to those which normally occur in a refrigerator car loaded with fruit.^{6*} Of course the velocity of the air currents generated by the fans was very much greater than the ordinary rate of air movement in a refrigerator car.

When operating the above type of precooling equipment, salt was added to the ice in the bunkers after the loading of the car with fruit was completed and usually just before the fans were started. Sometimes more salt was added later.

The other type of precooling equipment employed was much more elaborate. Each precooling unit was self-contained and furnished its own power. It was mounted on a motor truck chassis and could be parked beside a refrigerator car on any team track and put into operation, all power required being furnished by the truck motor (Fig. 2). When this machine was used, the ice in the bunkers had no relation to the cooling of the fruit. The portable refrigeration plant itself fur-



FIG. 2.—PORTABLE PRECOOLING PLANT MOUNTED ON TRUCK CHASSIS

The truck motor furnishes the power for operating this refrigeration plant, which can be parked beside a refrigerator car on any team track.

nished the cold air which was forced into the car above the load thru the upper part of the doorway at one side of the car. After circulating thru the load it was drawn back into the machine thru an opening near the bottom of the false door that was fitted into the doorway of the car. A heavy canvas, perforated in certain areas, covered the center part of the load to aid in forcing the cold air toward the ends of the car.

Types of Packages and Liners.—The ventilated packages used in the 1935 tests were round-bottom bushel baskets each having 20 cracks approximately $\frac{3}{4}$ -inch wide at the top and gradually tapering until at the bottom the basket was solid (Fig. 3). These were compared with standard tub bushels or with standard round-bottom bushel baskets in the different tests. Paper liners were used with both ventilated and standard packages in all except one of the tests made in 1935. Each liner used in 1935 had 21 round holes ($\frac{3}{4}$ inch) arranged in two rows located at one-fourth the distance from the top and from the bottom.

In 1937 ventilated Leigh tubs (Fig. 4) were used as the ventilated



FIG. 3.—VENTILATED ROUND-BOTTOM BASKET (*left*) AND STANDARD TUB BUSHEL (*right*)

The three-hoop ventilated basket shown here is a more rigid package than the two-hoop ventilated basket, which was used in all but one of the tests in which round-bottom baskets were employed.



FIG. 4.—VENTILATED LEIGH TUB (*left*) AND VENTILATED TUB BUSHEL (*right*) USED IN TESTS

These two packages were quite extensively used for shipping Illinois peaches in 1938.



FIG. 5.—TWO TYPES OF LINERS USED IN 1937 TESTS

The new type of ventilated liner (*left*), with 80 holes, was used in all of the 1937 tests. It is a vast improvement over liners with 21 or 18 holes (*right*) which were in common use commercially in 1937 and were used in the 1935 tests.

package in two of the tests, ventilated tub bushels in the third, and ventilated round-bottom baskets in the fourth. In 1937 a new type of liner was used which provided more thoro ventilation than any available in 1935. The new liner contained 80 holes, each $1\frac{1}{2}$ inches long and $\frac{1}{2}$ inch wide (Fig. 5). Some of the standard liners in general use in 1937 contained only 18 holes, and these were not very well distributed (Fig. 5).

Equipment for Determining Temperatures.—Sixteen thermocouples were used in each car in 1935. Four were placed in the air and 12 were inserted in the fruit. Positions of the thermocouples in cars precooled with the fan type of equipment are indicated in Fig. 6. When the

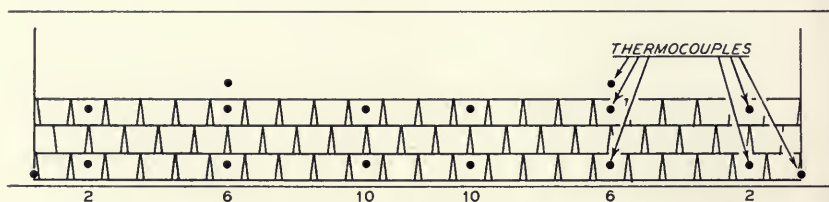


FIG. 6.—POSITIONS OF THERMOCOUPLES IN TEST CARS PRECOOLED WITH FAN TYPE OF EQUIPMENT IN 1935

Twelve thermocouples were inserted in the fruit, while 4 recorded air temperatures.

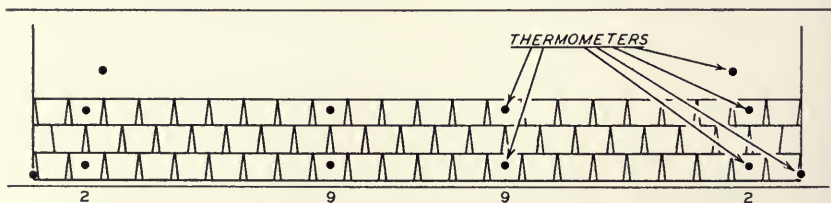


FIG. 7.—POSITIONS OF THERMOMETERS IN TEST CARS IN 1937

Eight thermometers indicated temperatures of the fruit in different parts of the car, while 4 indicated air temperatures.

truck type of precooler was used thermocouples were placed to record the temperature of the air as it entered the car and as it left, instead of recording the temperature at the bottom of the ice bunkers.

In placing a thermocouple in a fruit, the point was inserted in such a way that it grazed the side of the fruit pit and then passed a short distance into the flesh. Under this arrangement the temperature readings were those of the flesh in the immediate vicinity of the pit. In each instance the thermocouple was inserted in a fruit as near the center of

the package as was expedient; usually the fruit selected was in the third layer from the top, and in the third ring or center fruit of that layer.

For determining the temperatures in 1937, electrical resistance thermometers were employed except in one of the tests. Twelve thermometers were used in each car, 4 in the air and 8 in the fruit, at positions indicated in Fig. 7. The same method of inserting the thermometer points in the fruit was employed as with the thermocouples, and the position of the selected fruit in the package was essentially the same. The baskets of fruit in which temperatures were taken were always in the third row from one side of the car.

Arrangement of Packages in Car.—All cars of peaches were loaded 3 packages high, 6 wide, and 21 to 22 long, depending upon the length of the car.

RESULTS OF 1935 TESTS: LIMITED TO PRECOOLING PERIOD

Ventilated vs. Standard Packages, Both With Standard Liners

In Car A, loaded at Ozark, Illinois, August 10, 1935, a comparison was made between the rate of cooling of peaches packed in standard tub bushels and in ventilated round-bottom baskets, both equipped with standard liners and facing pads. The fan type of precooler was used. Two hundred pounds of salt was added to the ice just before the fans were started. After the fans had been operating $1\frac{1}{4}$ hours, 2,000 pounds of ice and 100 pounds more of salt were placed in the bunkers, which were not as well filled with ice as they should have been at the time precooling started. The fans were shut off for 15 minutes during this icing and salting. Operation was continued for $8\frac{1}{2}$ hours from the start, except for the 15 minute shut-off, mentioned above, and another shut-off of 30 minutes to allow a switch engine to move the car $6\frac{1}{2}$ hours after the start.

Rapidity of Cooling.—Temperature readings were taken ten times during the test. The readings for the fruit in each type of package are given in Table 1, together with the total drop in temperature during the $8\frac{1}{2}$ -hour period, and the air temperature at lower bunker openings and above the load.

The 15-minute shut-off of the fans and opening of the bunkers for reicing after the precooling equipment had been operating for $1\frac{1}{4}$ hours seriously interfered with the progress of the precooling. Every thermometer in the car registered higher at the end of the second hour than at the end of the first hour. Shutting off the fans toward the

TABLE 1.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN DIFFERENT PARTS OF CAR A:
FAN TYPE OF PRECOOLER, 1935
(Standard 21-hole liners were used in all packages)

Time elapsed (hours).....	Start	1/2	1	2	3	4	5	6 1/2	7 1/2	8 1/2	Drop in 8 1/2 hrs.	
Standard tub					<i>(Temperature of fruit, °F.)</i>							
Lower layer												
Basket 2.....	75.7	73.9	69.9	72.4	68.1	63.9	65.3	63.0	59.7	56.8	18.9	
Basket 6.....	77.2	76.0	72.1	74.8	69.9	70.6	70.6	64.8	65.0	63.0	14.2	
Basket 10.....	77.2	75.7	71.8	74.8	69.6	70.6	69.9	70.3	67.4	65.0	12.2	
Average.....	76.7	75.2	71.2	74.0	69.2	68.2	68.6	66.0	64.1	61.6	15.1	
Top layer												
Basket 2.....	80.8	79.6	75.4	76.6	67.7	66.5	63.9	61.8	58.5	55.3	25.5	
Basket 6.....	81.4	80.2	76.3	79.3	71.8	72.1	70.6	68.1	65.9	62.1	19.3	
Basket 10.....	81.1	79.6	75.4	79.6	75.1	73.3	71.5	67.7	65.9	60.9	20.2	
Average.....	81.1	79.8	75.7	78.5	71.5	70.6	68.6	65.8	63.4	59.4	21.7	
Average, both layers.....	78.9	77.5	73.4	76.2	70.3	69.4	68.6	65.9	63.7	60.5	18.4	
Ventilated basket					<i>(Temperature of fruit, °F.)</i>							
Lower layer												
Basket 2.....	82.1	78.7	72.7	74.2	70.3	69.6	67.1	57.8	58.8	53.8	28.3	
Basket 6.....	83.0	79.9	73.6	76.9	73.6	73.6	71.5	65.0	63.0	59.7	23.3	
Basket 10.....	79.9	76.6	71.5	75.4	73.3	73.3	72.7	65.3	63.0	63.0	16.9	
Average.....	81.6	78.4	72.6	75.5	72.4	72.2	70.4	63.3	62.4	58.8	22.8	
Top layer												
Basket 2.....	84.5	81.7	75.4	78.4	73.6	70.3	67.1	61.2	55.9	50.5	34.0	
Basket 6.....	82.4	79.3	73.9	76.0	72.7	71.2	67.8	57.1	59.4	56.2	26.2	
Basket 10.....	85.4	82.4	77.5	78.7	74.8	73.0	70.3	61.8	62.1	59.1	26.3	
Average.....	84.1	81.1	75.6	77.7	73.7	71.5	68.4	60.0	59.1	55.2	28.8	
Average, both layers.....	82.8	79.7	74.1	76.6	73.0	71.8	69.4	61.6	60.7	57.0	25.8	
					<i>(Temperature of air)</i>							
At bottom of bunker, standard.....	37.5	46.9	43.6	46.3	45.1	45.4	45.1	43.3	41.2	38.1	.....
At bottom of bunker, ventilated.....	29.3	47.2	41.8	43.6	40.7	42.1	43.0	36.6	40.3	37.8	.....
Above load, standard.....	37.2	37.2	32.6	35.9	33.0	34.7	36.9	38.1	37.2	35.6	.....
Above load, ventilated.....	76.9	37.2	32.6	35.9	33.8	35.9	37.8	36.3	37.2	35.6	.....

¹Six inches above load, at quarter length.

end of the precooling period, while the car was being switched, did not affect the temperature so much.

The cooling of the fruit was distinctly more rapid in the ventilated packages and in the top layer of packages of both types. The more rapid cooling of the top layer, compared with the bottom layer, was due to the reversal of the air currents in the car while the fans were

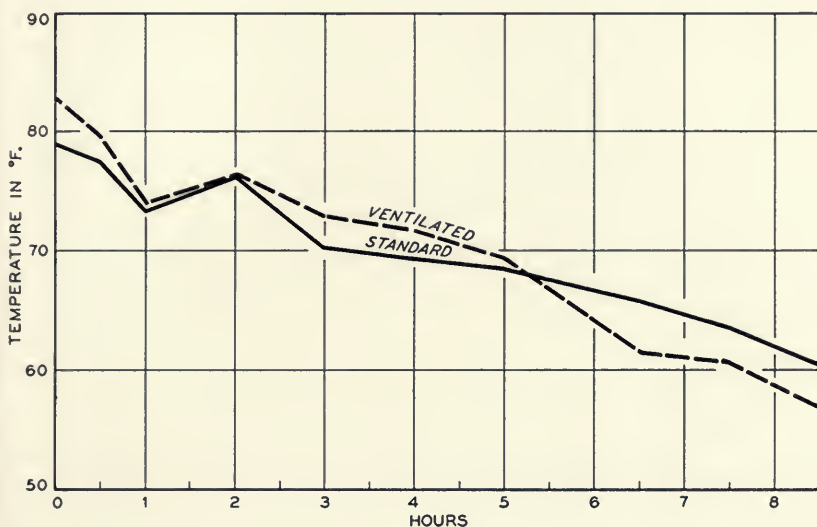


FIG. 8.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN CAR A

Cooling was distinctly more rapid in the ventilated packages. Standard liners and facing pads were used in both types of packages, and the fan type of precooler was used.

operating. If the temperature reductions in the baskets in both layers are averaged, the fruit in the ventilated packages shows a decline of 25.8 degrees and that in the standard packages only 18.4 degrees. The progress of the cooling in the two types of packages is shown in Fig. 8.

Ventilated Packages Without Liners vs. Standard Packages With Liners

In Car B, tested at Kinmundy, Illinois, August 29, 1935, a comparison was made between the rate of cooling of peaches packed in standard round-bottom baskets with standard liners and those packed in ventilated round-bottom baskets without any liners. The fan type of precooling equipment was used. Two hundred pounds of salt was

added to the ice in the bunkers just before the fans were started. No additional salt was used. The fans were operated without interruption for 6 hours.

Marked Differences in Rapidity of Cooling.—Because of the cool weather prevailing when the peaches loaded in this car were harvested, the temperature of the fruit at the time precooling started was much lower than in Car A. Hence the rate of cooling was slower.^{5*} However,

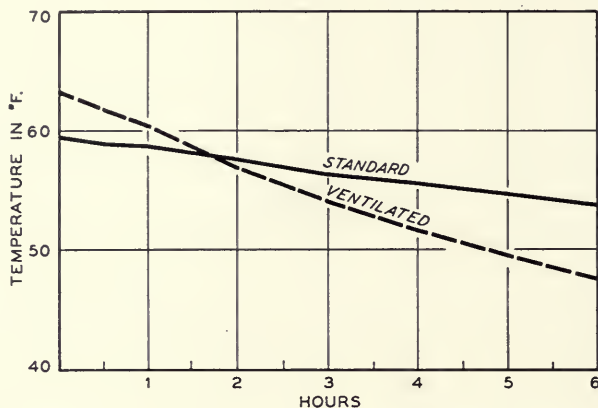


FIG. 9.—RAPIDITY OF COOLING OF PEACHES IN UNLINED VENTILATED BASKETS AND IN LINED STANDARD BASKETS IN CAR B

The difference in rate of cooling in the two types of packages was undoubtedly accentuated by the absence of liners in the ventilated baskets. The fan type of precooler was used.

the difference in rate of cooling in the standard baskets and the ventilated baskets was extremely marked, the average drop in temperature of the fruit in the ventilated baskets being nearly three times as great as that of the fruit in the standard baskets (15.7° F. against 5.7°). Here again the temperature of the fruit in the top layer of packages was reduced more rapidly than that of the fruit in the lower layer (Table 2).

The difference in temperature drop in the two kinds of packages was undoubtedly accentuated by the absence of any liners in the ventilated packages, the circulating cold air thus having freer access to the fruit in those packages.^{5*} The temperature of the fruit in both top and bottom layers of the ventilated packages was reduced to a safe carrying degree within the 6-hour precooling period. The relative rapidity of cooling of fruit in the two types of packages is indicated in Fig. 9.

TABLE 2.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED BASKETS IN DIFFERENT PARTS OF CAR B:
 FAN TYPE OF PRECOOLER, 1935
 (Standard baskets were lined with standard liners; ventilated baskets were unlined)

Time elapsed (hours).....	Start	½	1	2	3	4	5	6	Drop in 6 hrs.
Standard basket									
Lower layer									
Basket 2.....	57.5	57.1	56.8	55.9	55.3	55.0	54.1	52.9	4.6
Basket 6.....	60.0	59.4	59.4	58.8	57.5	57.2	56.8	56.2	3.8
Basket 10.....	57.5	57.5	57.5	56.5	56.2	55.9	55.6	54.7	2.8
Average.....	58.3	58.0	57.9	57.1	56.3	56.0	55.5	54.6	3.7
Top layer									
Basket 2.....	58.8	59.1	58.2	56.2	54.1	52.6	50.2	49.6	9.2
Basket 6.....	61.5	60.9	60.6	59.1	57.5	56.2	55.3	54.1	7.4
Basket 10.....	62.1	60.3	60.3	59.7	58.2	57.5	56.8	55.6	6.5
Average.....	60.8	60.1	59.7	58.3	56.6	55.4	54.1	53.1	7.7
Average, both layers.....	59.5	59.0	58.8	57.7	56.4	55.7	54.8	53.8	5.7
Ventilated basket									
Lower layer									
Basket 2.....	65.3	63.0	61.5	57.8	55.0	52.8	50.2	47.8	17.5
Basket 6.....	66.2	64.8	63.3	60.6	58.5	55.6	53.8	51.1	15.1
Basket 10.....	60.0	59.1	58.5	57.8	56.2	55.6	54.4	52.9	7.1
Average.....	63.8	62.3	61.1	58.7	56.5	54.6	52.8	50.6	13.2
Top layer									
Basket 2.....	62.1	62.1	60.3	55.0	50.8	47.8	44.8	42.7	19.4
Basket 6.....	59.1	57.8	56.8	54.7	52.9	51.1	49.6	48.4	10.7
Basket 10.....	67.1	64.8	62.4	56.2	51.4	47.8	44.8	42.7	24.4
Average.....	62.7	61.5	59.8	55.3	51.7	48.9	46.4	44.6	18.2
Average, both layers.....	63.2	61.9	60.4	57.0	54.1	51.7	49.6	47.6	15.7
(Temperature of air)									
At bottom of bunker, standard.....	42.4	43.3	40.9	39.7	37.2	36.3	36.0	35.6	....
At bottom of bunker, ventilated.....	43.0	49.0	47.5	44.8	42.4	40.6	40.3	39.4	....
Above load, ¹ standard.....	56.8	45.4	44.2	41.8	40.0	40.0	39.1	38.4	....
Above load, ¹ ventilated.....	60.9	42.4	40.3	38.7	36.6	35.6	35.3	35.0	....

¹Six inches above load, at quarter length.

TABLE 3.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN DIFFERENT PARTS OF CAR C:
 PORTABLE PRECOOLING PLANT, 1935
 (Standard liners were used in all packages)

Time elapsed (hours).....	Start	1/4	1/2	3/4	1	1 1/2	2	2 1/4	2 3/4	3 1/4	Drop in 3 1/4 hrs.
<i>(Temperature of fruit, °F.)</i>											
Standard tub											
Lower layer											
Basket 2.....	68.4	70.6	68.4	67.4	67.1	66.2	63.9	62.4	62.4	59.7	8.7
Basket 6.....	69.6	69.0	68.1	67.4	66.5	65.6	61.8	60.0	59.4	56.5	13.1
Basket 10.....	74.2	73.0	72.4	71.2	69.3	68.4	64.8	63.9	63.0	61.8	12.4
Average.....	70.7	70.8	69.6	68.6	67.6	66.7	63.5	62.1	61.6	59.3	11.4
Top layer											
Basket 2.....	75.1	74.8	74.5	73.9	72.7	71.8	69.3	67.4	65.3	63.6	11.5
Basket 6.....	78.1	77.5	77.5	77.8	77.2	76.3	75.4	72.7	72.7	71.2	6.9
Basket 10.....	75.7	74.2	72.7	71.5	69.0	66.5	64.5	61.8	58.2	56.5	19.2
Average.....	76.3	75.5	74.9	74.4	72.9	71.5	69.7	67.7	65.4	63.8	12.5
Average, both layers.....	73.5	73.1	72.2	71.5	70.2	69.1	66.6	64.9	63.5	61.5	11.9
<i>(Temperature of air)</i>											
Ventilated basket											
Lower layer											
Basket 2.....	66.2	65.9	65.7	65.0	63.9	63.0	60.6	60.3	55.3	51.1	15.5
Basket 6.....	68.4	68.4	67.1	67.1	65.6	64.5	62.1	61.2	56.2	53.8	14.6
Basket 10.....	69.9	68.3	66.8	66.8	65.3	62.4	59.4	57.4	53.5	51.7	18.2
Average.....	68.2	67.8	67.3	66.3	64.9	63.3	60.7	59.6	55.0	52.2	16.0
Top layer											
Basket 2.....	74.5	74.5	73.9	73.0	71.5	69.6	67.7	66.2	63.3	60.6	13.9
Basket 6.....	76.3	76.0	74.8	73.6	71.5	69.3	67.1	65.3	63.0	63.0	13.3
Basket 10.....	74.5	72.7	71.2	69.0	66.8	63.9	60.3	58.2	55.9	53.5	21.0
Average.....	75.0	74.4	73.3	71.8	69.9	67.6	65.0	63.2	60.7	59.0	16.1
Average, both layers.....	71.6	71.1	70.0	69.0	67.4	64.9	62.8	61.4	57.8	55.6	16.1
<i>(Temperature of air)</i>											
Entering car.....	.....	40.0	38.5	36.3	35.0	34.1	32.6	32.0	.....	.....	.....
Leaving car.....	.....	54.1	50.2	47.8	46.6	42.7	41.5	38.8	.....	.....	.....
Above load, standard.....	67.7	49.9	45.7	43.6	41.2	39.7	38.1	34.4	51.7	52.9	.....
Above load, ventilated.....	66.5	44.2	41.2	38.8	37.2	35.9	33.8	32.6	45.1	47.2	.....

¹Six inches above load, at quarter length.

Fruit Loaded on a Cool Day

The portable type of precooling plant mounted on a truck chassis was used for precooling Car C, loaded at Cobden, Illinois, August 13, 1935. The day the fruit was harvested and packed the weather was cloudy and fairly cool, so that the temperatures of the fruit at time of loading were not very high. The precooler was operated only 2¼ hours, in accordance with the commercial practice of the company. Temperature readings were continued for an hour after the precooler was disconnected from the car.

Portable Precooler Was Effective.—During the hour after the precooler was detached, the temperatures of the fruit near the center of the baskets continued to decrease rapidly on account of the transfer

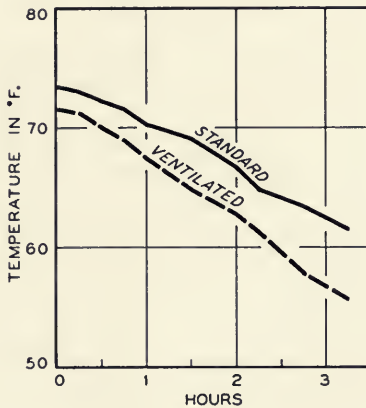


FIG. 10.—COOLING OF PEACHES LOADED ON A COOL DAY, CAR C

The portable type of precooling plant used on this load rapidly reduced the temperature of the fruit in both types of packages, tho the fruit in the ventilated baskets cooled considerably faster than in the standard baskets. Both types of baskets were equipped with standard liners.

of heat between the different rows of fruit in the package.^{5*} During the 3¼-hour cooling period the average drop in temperature of the fruit in the standard tub bushel baskets was 11.9 degrees, while in the ventilated round-bottom baskets it was 16.1 degrees (Table 3 and Fig. 10). Standard liners were used in both types of package.

Fruit Loaded on a Hot Day

Car D, tested at Cobden, Illinois, August 16, 1935, was loaded with fruit packed during a day when the temperature was high, the

TABLE 4.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN DIFFERENT PARTS OF CAR D:
PORTABLE PRECOOLING PLANT, 1935
(Standard liners were used in all packages)

Time elapsed (hours).....	1	1½	2	2¼	2¾	3	3¼	4¼	4¾	Drop in 4¾ hrs.
Standard tub										
Lower layer										
Basket 2.....	85.7	83.0	81.1	80.2	80.2	79.6	77.2	74.5	71.2	14.5
Basket 6.....	88.4	86.3	85.1	84.8	84.2	83.6	81.7	79.0	76.0	12.4
Basket 10.....	84.5	83.9	83.3	80.5	79.3	78.4	76.3	73.0	70.9	13.6
Average.....	86.2	84.2	82.6	81.8	81.2	80.5	78.4	75.5	72.7	13.5
Top layer										
Basket 2.....	85.4	86.3	85.4	84.5	83.3	83.9	81.4	78.7	78.1	7.3
Basket 6.....	87.8	87.5	86.9	86.0	85.4	85.4	82.4	80.2	78.4	8.5
Basket 10.....	87.2	85.4	82.4	80.8	78.7	77.5	73.9	69.9	67.4	19.8
Average.....	86.5	86.4	84.9	83.8	82.3	82.2	79.2	76.2	74.6	11.9
Average, both layers.....	86.3	85.3	83.7	82.8	81.7	81.3	78.8	75.8	73.6	12.7
Ventilated basket										
Lower layer										
Basket 2.....	80.5	73.6	71.8	71.8	69.6	68.4	67.1	63.6	61.5	19.0
Basket 6.....	84.5	78.4	76.9	76.0	75.4	73.6	71.8	68.4	65.0	19.5
Basket 10.....	83.9	79.6	74.8	74.5	73.3	71.2	68.7	63.9	60.9	23.0
Average.....	82.9	76.3	74.5	74.1	72.7	71.1	69.2	65.3	62.4	20.5
Top layer										
Basket 2.....	88.1	86.6	83.6	83.0	81.4	79.9	76.9	71.8	69.0	19.1
Basket 6.....	90.5	88.1	82.7	81.7	79.9	78.4	74.8	70.3	67.4	23.1
Basket 10.....	87.2	85.4	77.8	76.6	73.9	71.5	68.7	65.3	64.2	23.0
Average.....	88.6	86.7	81.3	80.4	78.4	76.6	73.4	69.1	66.8	21.8
Average, both layers.....	85.7	79.9	71.9	71.2	73.5	73.8	71.3	67.2	64.6	21.1
					(Temperature of air)					
Entering car.....	50.5	43.9	42.4	41.8	40.0	38.8	.....	.....	.....	.....
Leaving car.....	64.2	58.5	55.6	53.8	52.6	50.8	.....	.....	.....	.....
Above load ¹ , standard.....	80.8	54.4	47.8	44.5	42.7	41.8	60.0	63.9	63.6	.....
Above load ¹ , ventilated.....	53.8	46.9	45.1	44.2	43.0	42.1	58.2	61.5	61.8	.....

¹Six inches above load, at quarter length.

outside thermometer registering 94° F. at 4 p. m., the time at which the loading was completed. A temperature reading was made at this time, but the precooling machine, which was of the same type as that used for Car C, did not start operating until 4:45. The next reading was made at 5 p. m., after the machine had been operating for 15 minutes. No reading was made just before the machine started.

After the loading had been completed and the car closed, and previous to the starting of the machine, the refrigerative effect of the ice in the bunkers was operative for $\frac{3}{4}$ hour. The precooler was operated for $2\frac{1}{4}$ hours. Thus a total of 3 hours elapsed from the time the first reading was made until just before the precooler was stopped. Temperature readings were continued for $1\frac{3}{4}$ hours after the precooling machine was detached from the car, making a total period of $4\frac{3}{4}$ hours during which temperature records were taken.

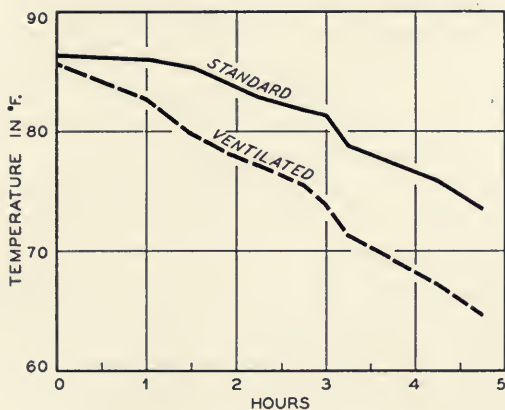


FIG. 11.—COOLING OF PEACHES LOADED ON A HOT DAY, CAR D

Fruit at high initial temperature was cooled very rapidly by the portable type of precooling plant, but this was especially true of the fruit in the ventilated packages. Standard liners were used in both types of packages.

Marked Differences Between Packages.—Again, the fruit in the ventilated packages cooled much more rapidly than that in the standard packages, the difference in rate of cooling being somewhat more marked than in Car C. This greater difference may have been due to the higher initial temperature of the fruit in Car D. The average drop in the temperature of the fruit in the standard tub bushel baskets during the $4\frac{3}{4}$ hours was 12.7 degrees, while that of the fruit in the ventilated round-bottom bushel baskets was 21.1 degrees (Table 4 and Fig. 11). Both types of packages were equipped with standard liners.

RESULTS OF 1937 TESTS: CARS FOLLOWED TO TERMINAL MARKETS

In the tests conducted in 1935 there was no opportunity for determining the ultimate effect of the precooling, either by temperature readings while the fruit was in transit or by inspection of the fruit upon arrival at destination. Plans for the tests in 1937 therefore provided for following each car, taking temperature readings at transfer and reicing stations, and inspecting the condition of the fruit when the car was opened in the terminal market to which it was shipped. Cars were purposely selected that were to be billed to points at considerable distance, so that the real effect of differences in temperature of fruit at the end of the precooling period might have a chance to manifest itself.

In the 1937 tests fruit temperatures were determined at eight points in each car (Fig. 7).

Since practically a week's time is required to prepare a test car, conduct the precooling operations, follow the car thru to market, await the unloading of the car so the temperature-recording equipment could be taken out, and drive back to the producing region, it was decided to make one test on Red Bird peaches before the opening of the Elberta shipping season, so as to run at least four tests while Illinois peaches were available.

As a result of the favorable outcome of the tests of ventilated packages in 1935 (a preliminary report of which was presented at the meeting of the Illinois State Horticultural Society in December of that year^{3*}), several peach growers in the state had provided themselves with ventilated packages for part of their shipments in 1937. Arrangements were made with certain of these growers for conducting tests on some of their cars. The orchardist with whom arrangements were made for testing the car of Red Bird peaches and one car of Elbertas had provided himself with a supply of ventilated Leigh tubs (Fig. 4), which he expected to use for shipping most of his fruit. Accordingly these Leigh tubs were used as the ventilated package for comparison with standard tub bushel baskets. A new type of ventilated liner, commercially available in 1937 (Fig. 5), was used in both types of package in the test with Red Bird peaches.

Ventilated vs. Standard Packages Under Standard Refrigeration

Car E, loaded with Red Bird peaches at Cobden, Illinois, on July 5, 1937, was followed thru to Detroit, Michigan. Since no precooling

TABLE 5.—PROGRESS OF COOLING OF RED BIRD PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN DIFFERENT LOCATIONS IN CAR E, 1937
(Car was shipped from Cobden, Illinois, to Detroit, Michigan, under standard refrigeration without precooling. Eighty-hole liners were used in all packages)

Time elapsed (hours).....	Start	2½	Chicago 22	Detroit 44½	Drop in 2½ hrs.	Drop in 22 hrs.
Standard tub						
(Temperature of fruit, °F.)						
Lower layer						
Basket 2.....	66.0	65.4	59.9	54.0	.6	6.1
Basket 8.....	75.4	71.6	61.8	....	3.8	13.6
Average.....	70.7	68.5	60.8	....	2.2	9.8
Top layer						
Basket 2.....	65.7	64.2	57.1	53.4	1.5	8.6
Basket 8.....	72.9	72.6	59.9	57.1	.3	13.0
Average.....	69.3	68.4	58.5	55.2	.9	10.8
Average, both layers.....	70.0	68.4	59.7	54.8	1.5	10.3
Ventilated (Leigh) tub						
Lower layer						
Basket 2.....	76.0	58.3	42.0	40.1	17.7	34.0
Basket 8.....	89.8	77.8	57.4	....	12.0	32.4
Average.....	82.9	68.0	49.7	....	14.9	33.2
Top layer						
Basket 2.....	83.4	81.6	52.1	49.7	1.8	31.3
Basket 8.....	84.6	81.6	59.9	56.5	3.0	24.7
Average.....	84.0	81.6	56.0	53.1	2.4	28.0
Average, both layers.....	83.4	74.8	52.8	48.8	8.6	30.6
(Temperature of air)						
At bottom of bunker, standard.....	52.8	43.8	35.7	35.7	....	....
At bottom of bunker, ventilated.....	51.5	42.0	35.7	36.0	....	....
Above load, ¹ standard.....	71.9	68.0	56.5	55.6	....	....
Above load, ¹ ventilated.....	71.3	60.8	51.2	50.6	....	....

¹Fifteen inches above load, 3 feet from bunker.

equipment was available at Cobden before the beginning of the Elberta season, the car was shipped under standard refrigeration without precooling. Both standard and ventilated packages were used.

Temperature readings were made soon after the car was closed following the completion of the loading. Another reading was made 2½ hours later, shortly before the car left the shipping point. The next reading was made in Chicago 22 hours after the original reading; and the final reading was made in Detroit 44½ hours after the first reading (Table 5).

Temperature Reductions Previous to Shipment.—Owing to difference in time of loading, the temperature of the fruit in the standard packages was much lower than of that in the ventilated packages at the time the first reading was made. During the first 2½ hours of refrigeration the drop in the temperature of the fruit in the standard packages was slightly more than 2 degrees in the lower layer of baskets and slightly less than 1 degree in the top layer. The drop in temperature of the fruit in the ventilated packages during this 2½-hour period was 14.9 degrees in the lower layer and 2.4 degrees in the top layer. This shows the rapidity with which refrigeration may start in the ventilated

packages in the lower layer directly accessible to the cold air emerging from the bottom of the bunker and drifting toward the center of the car.

Temperature Reductions in Transit.—The further influence of the two types of packages upon rate of refrigeration is well indicated by the reduction in temperature during the 22-hour period which elapsed by the time the car reached Chicago. The average drop in temperature of the fruit in the lower layer of standard packages during the period was 9.8 degrees, while that in the top layer was 10.8 degrees, or an average of 10.3 degrees for both layers. The drop in temperature of the fruit in the lower layer of ventilated packages during the same period was 33.2 degrees, while that in the top layer was 28.0 degrees, or an average of 30.6 degrees for both layers. Altho the average temperature of the fruit in the ventilated packages at the start was 13.4 degrees higher than that of the fruit in the standard packages, it was 6.9 degrees lower at the end of the 22-hour period (Fig. 12). Even tho allowance is made for the differences in temperature at the start, there is a wide margin in favor of the ventilated packages in reference to rapidity of refrigeration of the fruit contained.

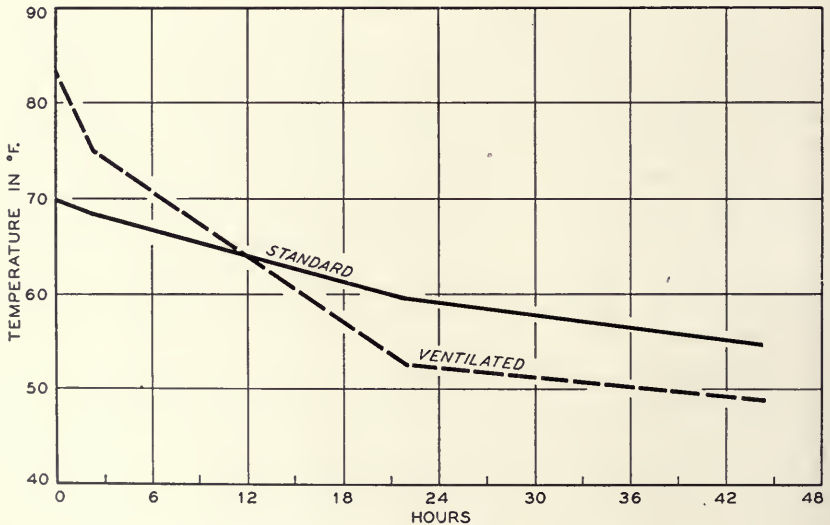


FIG. 12.—COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES UNDER STANDARD REFRIGERATION, CAR E

This car was shipped from Cobden, Illinois, to Detroit, Michigan, without precooling. Refrigeration was much more rapid in the ventilated packages. Eighty-hole liners were used in both types of packages.

Temperature and Condition of Fruit at Destination.—By the time the car reached Detroit one thermometer had become displaced. Leaving out of consideration the corresponding thermometer in the other end of the car, the average temperature of the three baskets of fruit in the standard packages was 54.8° F., while that in the ventilated packages was 48.8° F., a difference of 6 degrees.

Inspection in Detroit 44½ hours after the car was loaded at Cobden showed the U. S. No. 1 peaches to be in good firm condition except for a trace (about 1 percent) of brown rot in the fruit in the standard packages. There was no decay apparent in the No. 1 peaches in the ventilated packages. A few baskets of Utility grade peaches in ventilated packages, that had been put in to fill out the car, showed 7 percent brown rot.

Ventilated Leigh Tubs vs. Standard Tub Bushels

Car F, loaded with Elberta peaches at Cobden, Illinois, on August 13, 1937, was precooled and billed thru to Bay City, Michigan. The precooling was done with the portable truck type of precooler. The peaches in one half of the car were packed in ventilated Leigh tubs while those in the other end were packed in standard bushel tubs. The new type of ventilated liner, with 80 holes, was used in both types of packages. The condition of the fruit in both types of containers was "hard" to "firm" at the time of loading. Loading was completed and the car closed at 11:40 a. m. The bunkers were practically full of ice at this time. A temperature reading was made at 1 p. m., and the car was opened for attaching the precooling equipment at 1:10. Actual precooling was started a few minutes later, and the machine was continued in operation for 3 hours.

Temperatures During Precooling.—During the 3-hour precooling period the temperature of the peaches in the standard packages near the center of the car dropped very rapidly (18 degrees in the lower layer and 25 degrees in the top layer). The drop in temperature of the fruit in the same type of packages near the end of the car was very much less (7.8 degrees and 9.2 degrees in lower and top layers respectively). On the other hand there was much less variation in the amount of drop in temperature of the fruit in ventilated packages in different positions in the car. In the lower layer the difference in temperature of the fruit in the package near the end of the car and near the center was only 2½ degrees. In the top layer the difference was greater, the drop being 20 degrees in the basket near the center of the car and 12.2 degrees in the basket near the end of the car.

There was thus much better distribution of the refrigeration in the ventilated packages, even tho the average drop in temperature was only slightly greater (Table 6).

Temperatures in Transit.—Half an hour after the above readings were made, the car was “pulled” by a switch engine and attached to the fast fruit train. The bunkers were seven-eighths full of ice at this time. The car was billed for Bay City, Michigan, with instructions not to reice.

The next temperature reading was made in Chicago 22 hours after the initial reading. By this time the temperature of the fruit in the standard containers in different parts of the car was much more nearly equalized.

Temperature readings were made at Grand Rapids, at Saginaw (two readings), and finally at Bay City 68 hours after the original reading at Cobden. The drop in the temperature of the fruit in the two types of packages during the first 48 hours is shown graphically in Fig. 13.

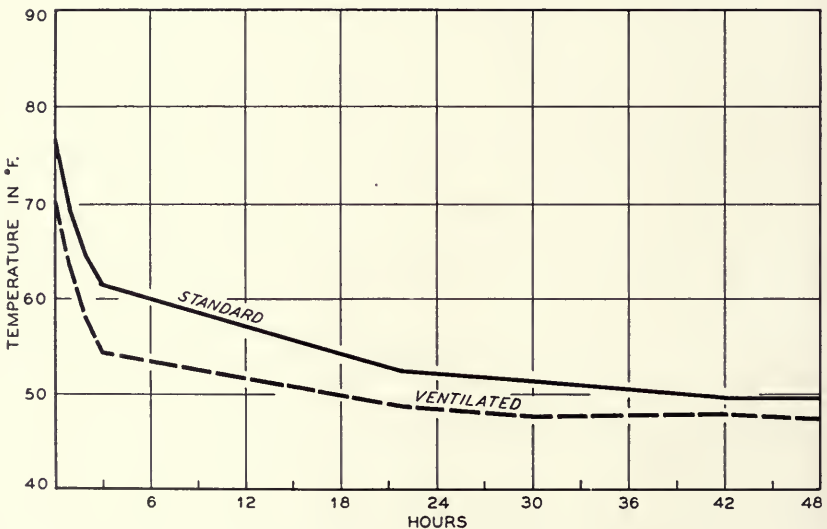


FIG. 13.—COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN CAR F, PRECOOLED BUT NOT REICED

This car was precooled and billed thru to Bay City, Michigan, without reicing. It was in transit for 68 hours. The temperatures during the first 48 hours of the 68 in which the car was in transit are shown here. Temperatures of fruit in different parts of the car and in the two types of packages tended to become equalized as the end of the journey approached. Eighty-hole liners were used in both types of packages.

TABLE 6.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN DIFFERENT LOCATIONS IN CAR F, 1937
(Car was precooled at Cobden, Illinois, with portable precooling plant, and shipped to Bay City, Michigan, without reicing.
Eighty-hole liners were used in all packages)

Time elapsed (hours).....	Start	1	2	3	Chicago 22	Grand Rapids 30	Saginaw Yards		Bay City 08	Drop in 3 hrs.	Drop in 22 hrs.
							42	54			
Standard tub											
Lower layer											
Basket 3.....	74.0	71.5	69.0	66.2	52.2	49.8	47.0	45.0	44.2	7.8	21.8
Basket 9.....	75.0	67.0	61.0	57.0	49.8	48.0	47.5	46.2	45.0	18.0	25.2
Average.....	74.5	69.2	65.0	61.6	51.0	48.9	47.2	45.6	44.6	12.9	23.5
Top layer											
Basket 2.....	79.0	76.8	73.5	69.8	53.5	53.8	52.0	53.5	52.0	9.2	25.5
Basket 9.....	78.5	62.5	54.8	53.5	54.1	54.0	53.2	53.5	53.0	25.0	24.6
Average.....	78.7	69.6	64.1	61.6	53.8	53.9	52.6	53.5	52.5	17.1	24.9
Average, both layers.....	76.6	69.4	64.6	61.6	52.4	51.4	49.9	49.7	48.5	15.0	24.2
Ventilated (Leigh) tub											
Lower layer											
Basket 2.....	66.0	61.0	56.0	52.0	42.8	41.2	40.2	39.8	39.8	14.0	23.2
Basket 9.....	66.0	58.0	53.0	49.5	46.2	45.8	46.8	45.5	45.0	16.5	19.8
Average.....	66.0	59.5	54.5	50.7	44.5	43.5	43.5	42.6	42.4	15.3	21.5
Top layer											
Basket 2.....	75.0	70.5	66.5	62.8	54.0	52.5	52.0	51.8	52.2	12.2	21.0
Basket 9.....	73.5	63.5	57.0	53.5	52.2	52.0	53.2	51.2	51.2	20.0	21.3
Average.....	74.2	67.0	61.7	58.1	53.1	52.2	52.6	51.5	51.7	16.1	21.1
Average, both layers.....	70.1	63.2	58.1	54.4	48.8	47.9	48.0	47.1	47.0	15.7	21.3
<i>(Temperature of fruit, °F.)</i>											
<i>(Temperature of air)</i>											
At bottom of bunker, standard.....	41.0	36.0	34.2	34.5	36.5	36.2	35.5	35.0	35.0	.....	.....
At bottom of bunker, ventilated.....	40.0	35.8	33.2	33.0	36.0	35.5	35.0	35.0	35.0	.....	.....
Above load, ¹ standard.....	67.5	38.0	34.5	41.2	55.2	55.2	52.5	58.0	55.0	.....	.....
Above load, ¹ ventilated.....	67.5	37.8	34.0	38.8	53.8	55.5	52.8	58.2	55.0	.....	.....

¹Fifteen inches above load, 3 feet from bunker.

Temperatures at Destination.—When the car arrived at its destination, the bunkers were nearly half full of ice, and there was no apparent difference in the amount of ice in the two bunkers. The temperature of the fruit in the top layer of packages was nearly uniform thruout the length of the car, including both types of packages. The temperature of the fruit in the lower layer of packages was, for each type of package distinctly lower than that in the top layer. The average temperature of the fruit in the ventilated packages was only slightly lower ($1\frac{1}{2}$ degrees) than that of the fruit in the standard containers.

Condition of Fruit at Destination.—Within a few minutes after the temperature reading in Bay City, the car was opened and about one-third of the peaches were unloaded. The peaches were firm and in good market condition at this time with the exception of a very small percentage that showed rot. The fruits from one package of each type of container taken from corresponding positions in the car were

TABLE 7.—DEFECTIVE PEACHES IN STANDARD AND IN VENTILATED CONTAINERS ON ARRIVAL IN MARKET AT BAY CITY, MICHIGAN: CAR F

Kind of package	Number of fruit in package	Brown rot		Bruised peaches	
		No.	perct.	No.	perct.
Standard tub bushel.....	178	3	1.68	6	3.37
Ventilated (Leigh) tub.....	198	1	.50	4	2.02

counted out and very carefully examined. Of the 178 peaches in the standard container 3 showed brown rot and 6 showed shipping bruises. Of the 198 peaches in the ventilated package only 1 showed brown rot while 4 showed shipping bruises (Table 7). Altho the percentage of damaged peaches was small, there appeared to be some advantage in favor of the fruit shipped in the ventilated packages.

Ventilated Packages and Liners vs. Standard Packages and Liners

Car G was loaded with Elberta peaches at Ozark, Illinois, on August 20, 1937, and precooled with the fan type of precooling equipment. One half of the car was loaded with peaches packed in ventilated tub bushels and the other half with peaches packed in standard tub bushels. The new type of ventilated liner was used in the ventilated containers, and the old type of liner (with much less ventilation) was used in the standard containers.

Loading was started at 12 m. and was completed at 2:45 p. m. The

car had been fully iced before it was received at the siding, but more ice was added at 12:30 p. m. to completely fill the bunkers. The car was closed at 2:50 p. m. and the precooling equipment was put into operation at 2:52. At 3:30 p. m. the ice bunkers were opened and 200 pounds of salt was placed over the ice and chopped in. Precooling was continued until 7:50, a total period of 5 hours. The equipment was removed and the car sealed at 8 p. m.

This car was billed out under standard refrigeration for Buffalo, New York. Temperature readings were made at Bluford and Neoga, Illinois; at Frankfort, Indiana; Bellevue, Ohio; and finally at the Food Terminal in Buffalo, New York.

Reicing took place at Bluford, Frankfort, and Bellevue. The elapsed time from the start of precooling until delivery of the car at its destination was 63 hours.

Drop in Temperatures During Precooling.—At the time precooling started, the average temperature of the fruit in the ventilated tubs was 3.3 degrees higher than that of the fruit in the standard tubs. At the end of the 5-hour precooling period the average temperature of the fruit in the ventilated tubs was 12.3 degrees lower than that of the fruit in the standard tubs. In the bottom layer cooling was more rapid in the package near the bunker than in that toward the center of the car in both types of package. In the top layer cooling was about equally rapid in the standard containers in both positions, but was more rapid in the ventilated package toward the center of the car (Table 8).

Temperatures in Transit and at Destination.—When the reading was made at Bluford 21½ hours after the loading had been completed, the difference in temperature of the fruit in the two types of packages was less marked than at the close of the precooling period. At this time the average temperature of the fruit in the ventilated packages was 52.5° F., while that of the fruit in the standard packages was 56.7° F. The temperature of the fruit in both types of packages continued to decline until the car was delivered at its destination, when the average temperature of the fruit in the ventilated packages was 44.0° F. and that of the fruit in the standard packages was 46.0° F.

The progress of cooling of the fruit in each type of package during the first 48 hours is graphically presented in Fig. 14.

Condition of Fruit at Destination.—The peaches were inspected upon arrival by two inspectors, one a representative of the consignee and the other a representative of the railway company. Fifty peaches were taken out of each basket inspected. All inspected baskets were from the top layer in the car. Results of the inspection are shown in

TABLE 8.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED CONTAINERS IN DIFFERENT LOCATIONS IN CAR G, 1937
(Car was precooled at Ozark, Illinois, with fan type of precooler and shipped under standard refrigeration to Buffalo, New York.
Eighteen-hole liners were used in standard containers, and 80-hole liners in ventilated containers)

Time elapsed (hours).....	Start	1	2	3	4	5	Blufford 21½	Frankfort 38½	Buffalo 63	Drop in 5 hrs.	Drop in 21½ hrs.
<i>(Temperature of fruit, °F.)</i>											
Standard tub											
Lower layer											
Basket 2.....	80.8	78.5	75.0	72.2	69.2	66.8	49.8	43.2	39.0	14.0	31.0
Basket 9.....	83.5	83.0	81.2	79.2	77.2	75.8	56.0	49.5	44.2	7.7	27.5
Average.....	82.1	80.7	78.1	75.7	73.2	71.3	52.9	46.3	41.6	10.8	29.2
Top layer											
Basket 2.....	81.0	79.5	77.5	75.8	73.0	70.5	60.0	56.0	49.8	10.5	21.0
Basket 9.....	80.0	80.0	77.8	75.5	72.5	70.0	61.2	57.0	51.0	10.0	18.8
Average.....	80.5	79.7	77.6	75.6	72.7	70.2	60.6	56.5	50.4	10.3	19.9
Average, both layers.....	81.3	80.2	77.9	75.7	72.9	70.8	56.7	51.4	46.0	10.5	24.6
Ventilated tub											
Lower layer											
Basket 2.....	82.8	74.5	66.5	61.8	57.2	54.5	46.0	41.0	38.0	28.3	36.8
Basket 9.....	82.0	77.2	72.0	68.2	64.2	62.5	53.0	45.8	43.0	19.5	29.0
Average.....	82.4	75.8	69.2	65.0	60.7	58.5	49.5	43.4	40.5	23.9	32.9
Top layer											
Basket 2.....	86.5	83.8	79.0	75.0	69.5	66.2	56.0	50.5	46.5	20.3	30.5
Basket 9.....	87.2	73.5	65.2	59.2	54.0	51.0	35.2	33.8	48.5	36.2	32.0
Average.....	86.8	79.6	72.1	67.1	61.7	58.6	35.6	32.1	47.5	28.2	31.2
Average, both layers.....	84.6	77.7	70.7	66.0	61.2	58.5	52.5	47.7	44.0	26.1	32.1
<i>(Temperature of air)</i>											
At bottom of bunker, standard.....	43.8	50.5	47.2	46.0	44.5	44.0	36.0	36.0	35.0	.....	.....
At bottom of bunker, ventilated.....	40.5	54.5	51.0	48.2	46.5	45.5	35.2	35.5	34.8	.....	.....
Above load, ¹ standard.....	80.5	46.2	43.8	43.0	42.0	42.0	42.0	59.5	52.2	.....	.....
Above load, ¹ ventilated.....	80.8	47.2	45.0	43.5	42.2	42.2	58.5	52.5	52.0	.....	.....

¹Fifteen inches above load, 3 feet from bunker.

Table 9. Both inspectors stated that the fruit seemed to be in a little better condition in the ventilated packages. The amount of brown rot or of "decay" was too small to warrant any definite comparisons on these points. Likewise, there was little difference in the percentage of "soft" peaches in the two types of packages.

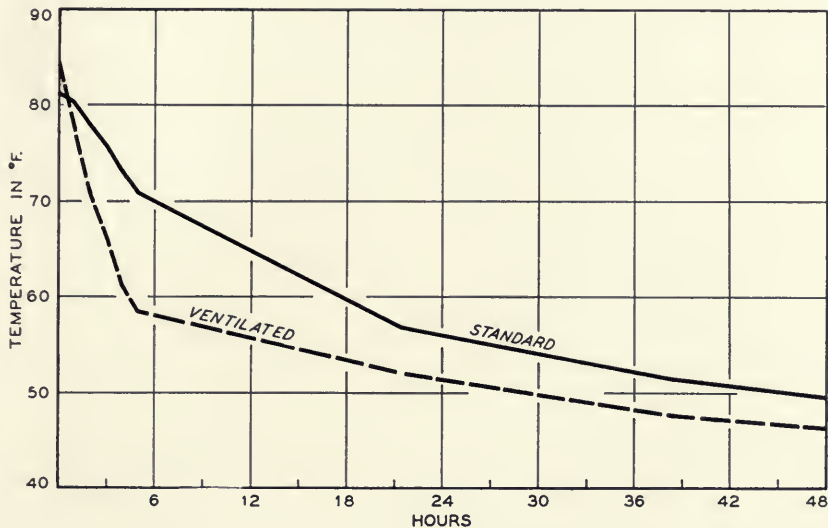


FIG. 14.—COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN CAR G DURING FIRST 48 HOURS

This car was followed thru to Buffalo, New York, which was reached in 63 hours. Undoubtedly the new type of liner was an important factor in the extremely rapid refrigeration of the fruit which took place in the ventilated packages during the precooling period. An 18-hole liner was used with the standard packages.

TABLE 9.—DEFECTIVE PEACHES IN STANDARD AND IN VENTILATED CONTAINERS ON ARRIVAL IN MARKET AT BUFFALO, NEW YORK: CAR G

Kind of package and position	Brown rot		"Decay"		Soft peaches	
	No.	perct.	No.	perct.	No.	perct.
Standard tub						
4th from end.....	1		None		2	
At quarter-length.....	None		None		None	
Near middle of car.....	None		None		2	
All 3 baskets.....	1	.66	None	None	4	2.66
Ventilated tub						
3d from end.....	None		None		1	
At quarter-length.....	None		None		5	
Near bunker.....	None		2		None	
Near middle of car.....	None		None		None	
All 4 baskets.....	None	None	2	1.00	6	3.00

Standard vs. Ventilated Round-Bottom Baskets With Ventilated Liners

Car H, loaded with Elberta peaches at a siding near Irvington, Illinois, on August 27, 1937, was followed thru to its destination in Burlington, Vermont. Half the car was loaded with peaches packed in standard round-bottom bushel baskets and half with peaches packed in ventilated round-bottom baskets. The new type of ventilated liner was used in both types of packages. The bunkers were completely full of ice when loading of the car started at 2:30 p. m. The first reading was made at 5 p. m. after the thermometers had been in place about half an hour. The car was switched from the loading track to the Centralia ice yard, and arrived at the ice track at 9:45 p. m. A temperature reading was made just before the car was opened at 10 p. m. to install the precooling equipment, which was of the fan type. Ice was added at 10:15 p. m., in the amount of 3,200 pounds, to fill the bunkers; and 200 pounds of salt was placed on top of the ice.

The precooler was started into operation at 10:30 p. m. and was continued in operation until 4:30 a. m., a period of 6 hours, during which readings were made once an hour.

Average Temperature Reduction Previous to Shipment.—During the 5 hours after the first temperature reading was made and before the salt was put in or the fans were started, the average drop in temperature of the fruit in the standard baskets was 6.3 degrees while that of the fruit in the ventilated baskets was 9.3 degrees even tho the temperature in the ventilated baskets at the start was 5.9 degrees lower than in the standard baskets. During the 6 hours the precooler was in operation the average temperature of the fruit in the standard baskets was reduced 13.7 degrees and that of the fruit in the ventilated baskets 16.1 degrees.

During the 11 hours after loading and previous to shipping, the average temperature of the fruit in the standard baskets was reduced 20 degrees and that of the fruit in the ventilated baskets 25.5 degrees, thus increasing the difference in temperature between the two lots to 11.4 degrees, and leaving the average temperature of the fruit in the standard baskets at 65.2° F. and that of the fruit in the ventilated packages at 53.8° F. at the close of the precooling period (Table 10).

Temperature Reductions in Different Layers.—During the first 5 hours, while the normal cooling effect of the ice in the bunkers without forced air circulation or salt was operative, the fruit in the lower layer of packages cooled more rapidly than that in the top layer of the same type of package. As soon as the precooling equipment was put into

TABLE 10.—PROGRESS OF COOLING OF PEACHES IN STANDARD AND IN VENTILATED BASKETS IN DIFFERENT LOCATIONS IN CAR H, 1937
(Car was loaded near Irvington, Illinois, and shipped to Burlington, Vermont, under standard refrigeration after precooling at Centralia, Illinois, with fan type of precooler. Eighty-hole liners were used in both types of baskets)

Time elapsed (hours).....	Start	5	6	7	8	9	10	11	Cham- paign 28	Port Huron 48	Burling- ton 91½	Drop in 5 hrs.	Drop in 11 hrs.	Drop in 28 hrs.
<i>(Temperature of fruit, °F.)</i>														
Standard basket														
Lower layer														
Basket 2.....	80.8	70.8	68.5	67.0	65.0	63.0	61.0	59.2	47.5	41.0	36.5	10.0	21.6	33.3
Basket 9.....	85.5	77.5	74.2	72.5	70.0	69.0	67.0	66.0	53.0	45.5	43.5	8.0	19.5	32.5
Average.....	83.1	74.1	71.3	69.7	67.5	66.0	64.0	62.6	50.2	43.2	40.0	9.0	20.5	32.9
Top layer														
Basket 2.....	87.0	82.8	80.0	78.0	76.0	73.5	71.0	70.0	56.2	49.2	44.2	4.2	17.0	30.8
Basket 9.....	87.5	84.5	81.0	78.5	75.0	70.5	67.5	65.5	56.8	54.0	50.5	3.0	22.0	30.7
Average.....	87.2	83.6	80.5	78.2	75.5	72.0	69.2	67.5	56.5	51.6	47.3	3.6	19.5	30.7
Average, both layers.....	85.2	78.9	75.9	74.0	71.5	69.0	66.6	65.2	53.4	47.4	43.7	6.3	20.0	31.8
Ventilated basket														
Lower layer														
Basket 2.....	76.5	62.0	59.5	57.8	55.5	53.2	52.0	50.0	41.8	39.8	38.2	14.5	26.5	34.7
Basket 9.....	76.5	67.0	62.0	61.0	57.5	55.0	53.5	52.0	46.8	43.0	55.0	9.5	24.5	29.7
Average.....	76.5	64.5	60.7	59.4	56.5	54.1	52.7	51.0	44.3	41.4	46.6	12.0	25.5	32.2
Top layer														
Basket 2.....	83.2	74.0	68.5	65.0	62.0	59.0	56.0	54.2	50.0	45.2	43.2	9.2	29.0	33.2
Basket 9.....	81.0	76.8	73.2	70.5	66.8	64.0	63.0	59.0	53.5	51.0	55.2	4.2	22.0	27.5
Average.....	82.1	75.4	70.8	67.7	64.4	61.5	59.5	56.6	51.7	48.1	49.2	6.7	25.5	30.3
Average, both layers.....	79.3	69.9	65.8	63.6	60.4	57.8	56.1	53.8	48.0	44.7	47.9	9.3	25.5	31.3
<i>(Temperature of air)</i>														
At bottom of bunker, standard.....	42.2	41.5	53.0	50.2	49.0	47.2	46.2	45.5	34.0	34.5	33.8	.....	.....	.....
At bottom of bunker, ventilated.....	45.0	43.8	53.0	51.0	49.0	47.0	46.5	45.2	34.8	34.5	33.8	.....	.....	.....
Above load, ¹ standard.....	77.8	73.5	48.8	43.5	42.5	41.8	41.5	41.0	53.0	51.2	46.5	.....	.....	.....
Above load, ¹ ventilated.....	77.0	73.0	46.0	44.0	42.2	41.5	41.0	40.5	53.0	51.0	46.0	.....	.....	.....

¹Fifteen inches above load, 3 feet from bunker.

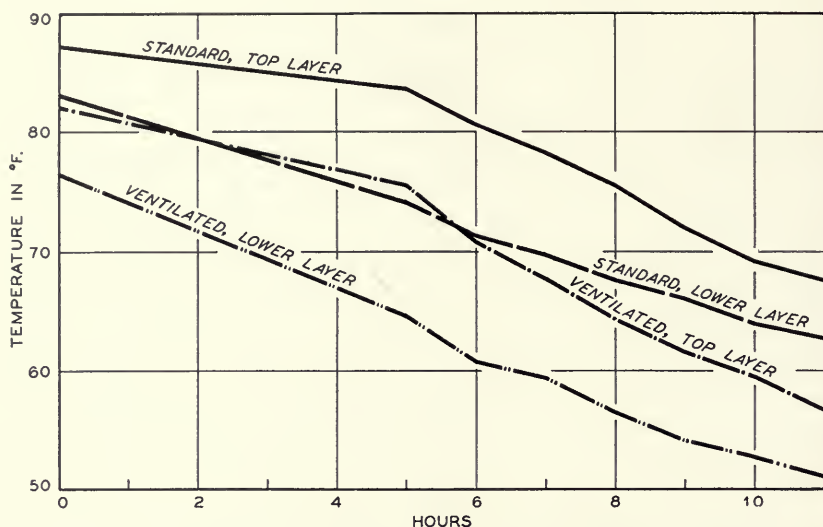


FIG. 15.—COOLING OF PEACHES IN TOP AND BOTTOM LAYERS OF PACKAGES IN CAR H DURING FIRST 11 HOURS

Cooling was much accelerated when the precooling equipment started operation 5 hours after loading. Immediate change in rate of cooling of fruit in the top layer of packages was apparent. The new type of 80-hole liner was used in both types of packages.

operation, the temperature of the fruit in the top layer began to drop more rapidly than that of the fruit in the lower layer, and the more rapid cooling of the top layer was maintained to the end of the precooling period (Fig. 15). This illustrates the point that precooling by forcing a blast of cold air over the top of the load of fruit reduces the temperature of the fruit which is normally the hottest and least affected by the normal flow of cold air from the bottom of the ice bunkers. Thus more uniform refrigeration thruout the load of fruit is eventually effected.

Treatment of Car in Transit.—The precooling equipment was removed and the car sealed at 4:45 a. m., August 28. At 5:30 a. m. the bunkers were again filled with ice, 2,800 pounds being used. The car was billed out under standard refrigeration to Burlington, Vermont. It was reiced at Harvey, Illinois; Port Huron, Michigan; and St. Albans, Vermont. Temperature readings were made at Champaign and Harvey, Illinois; at Port Huron, Michigan; Mimico, Ontario; and upon arrival at Burlington, Vermont.

Temperature Reductions in Transit.—The reading in Champaign was made 28 hours after the initial reading at the loading point. At

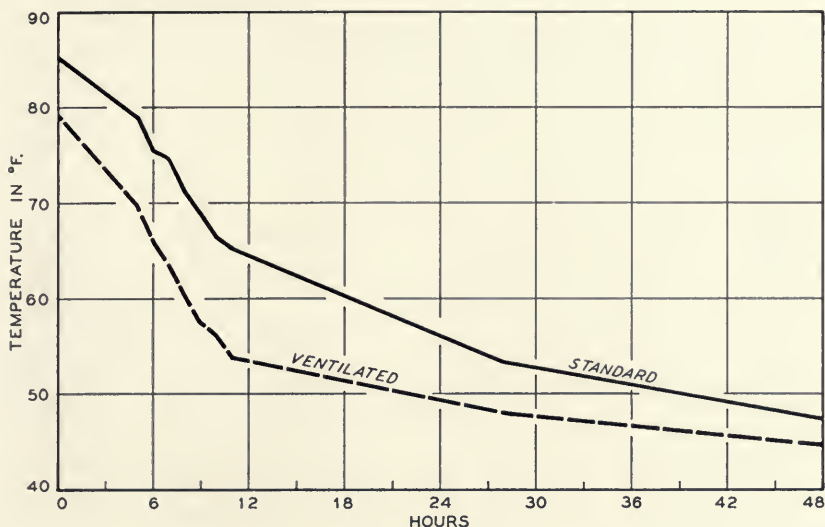


FIG. 16.—COOLING OF PEACHES IN STANDARD AND IN VENTILATED PACKAGES IN CAR H DURING FIRST 48 HOURS

Precooled and shipped under standard refrigeration to Burlington, Vermont, this car reached its destination 91½ hours after the initial temperature reading. The fruit arrived in firm condition. The 80-hole ventilated type of liner was used in both types of packages.

this time the average temperature of the fruit in the standard baskets had been reduced to 53.4° F. and that of the fruit in the ventilated baskets to 48.0° F. In the reading at Port Huron 48 hours after the original reading, the average temperature of the fruit in the standard baskets was found to be 47.4° F. and that of the fruit in the ventilated baskets 44.7° F. The progress of cooling of the fruit during the 48-hour period is graphically presented in Fig. 16.

The difference in temperature between the two lots of fruit became less and less as time went on until the final reading at its destination, when the fruit in the standard baskets had attained a temperature lower than that in the ventilated baskets. This was 91½ hours after the initial reading.

Condition of Fruit at Destination.—One hour after the last reading was made, the car was opened and the condition of the peaches noted. Fifty peaches were taken from each of four packages examined. Inspection of these samples resulted in the data given in Table 11. The amount of brown rot and number of soft peaches were too small in both types of packages to warrant any comparison. In one of the

TABLE 11.—DEFECTIVE PEACHES IN STANDARD AND IN VENTILATED CONTAINERS ON ARRIVAL IN MARKET AT BURLINGTON, VERMONT: CAR H

Kind of package	Brown rot		Bruised peaches		Soft peaches	
	<i>No.</i>	<i>perct.</i>	<i>No.</i>	<i>perct.</i>	<i>No.</i>	<i>perct.</i>
Standard basket						
Basket 1.....	None		2		2	
Basket 2.....	None		2			
Both baskets.....	None	None	4	4.00	2	2.00
Ventilated basket						
Basket 3.....	None		6			
Basket 4.....	1		1			
Both baskets.....	1	1.00	7	7.00	None	None

ventilated baskets there were more and in the other less bruised peaches than in either of the standard baskets. The peaches in general were firmer and greener in the ventilated packages than in the standard packages.

GENERAL DISCUSSION OF RESULTS

The outstanding feature in nearly all the tests just reported was the much more rapid reduction in the temperature of the fruit in the ventilated packages than in the standard packages. As was to be expected, the initial temperature of the fruit in the different cars and in different parts of the same car had a decided influence upon the rate of cooling, which varied considerably in the different tests and in different parts of a load.

When the fan type of precooler was used, there was usually a greater drop in the temperature of the fruit in the top layer of packages than in that of the lower layer, during the time the precooler was in operation. This was due to the forcing of the cold air directly upon the top layer, where, under normal conditions in a refrigerator car temperatures are likely to be highest. When the portable precooling plant was used, there usually was not much difference in the average drop in the temperature of the fruit in the top and bottom layers, but there was a tendency toward a greater drop near the center of the car, especially in the top layer.

Vagaries in rates of cooling in the same parts of different cars were doubtless due to differences in the adjustment of the precooling equipment and in details of operation.^{1*}

In general, more thoro precooling could have been attained if the equipment had been operated for a longer time on each car, and if a lower air temperature had been maintained during the cooling period than was maintained in most of the cars included in the tests.

After the close of the precooling period the temperature of the fruit continued to decline, but the differences between the temperatures in the different types of packages tended to diminish. However, the favorable effect of the more rapid early cooling of the fruit in the ventilated packages was shown in the firmer condition of the fruit upon arrival in the terminal markets.

COMMERCIAL PRACTICES IN 1938

No test shipments in the precooling of peaches were made by the Illinois Experiment Station in 1938; but an effort was made to ascertain to what extent precooling of peaches was practiced by Illinois shippers that season, and also the extent to which ventilated packages were used in marketing the peach crop.

Precooling.—Personal contacts with peach growers during the 1938 crop movement and consultation with operators of commercial precooling equipment revealed that a number of Illinois growers handling large volumes of peaches had nearly all their rail shipments precooled. The charge for precooling was \$12.50 to \$25 a car.

Equipment for precooling had been further improved for the 1938 season; and this, together with the experience of previous years, made more efficient precooling possible. Some operators of precooling equipment tried to get the temperature of the fruit down to 40° F., as recorded by a thermometer inserted into a fruit near the center of a basket in the top layer of baskets near the car door. To attain this temperature, precooling practices were varied to meet specific conditions. For example, the quantity of salt was varied from 200 to 400 pounds to the car, the amount depending upon: (1) the initial temperature of the fruit, (2) the outside air temperature, (3) the amount of ice in the bunkers, and (4) the time available for precooling before the fruit train would arrive to pick up the car.

One of the companies operating the fan type of precooler preferred to have at least 8 hours in which to precool a car, but because of late loading of the car or early movement of the train on which shipment was desired, they were sometimes obliged to do the work in 4 hours. When this occurred, more salt had to be used, and even then the desired temperature was not always attained. In fact, unless all conditions were favorable, the temperature of the fruit at the end of the precooling period was more likely to be in the neighborhood of 50° F. than 40° F. In the report to the shipper the precooling company recorded the initial and final temperature of the fruit, the amount of salt used, and the length of time the precooler was operated.

Ventilated Baskets.—The use of ventilated baskets for shipping peaches had become an even more common practice in Illinois in 1938 than the precooling of rail shipments of this product. An incomplete survey made in southern Illinois during and shortly after the peach movement showed that 22 shippers used 128,201 ventilated bushel containers in the marketing of their peaches. The survey covered the operations of 126 growers, who marketed 460,002 bushels of peaches in 1938. Thus the ventilated packages used represented 28 percent of the total packages used by the growers included in the survey. Three years previous the only Illinois peaches shipped in ventilated packages were those included in the tests by the Experiment Station. The cost of ventilated packages and the new type of liners was practically the same as that of standard packages and the old type of liners.

SUMMARY

Refrigeration tests with eight carloads of Illinois peaches in 1935 and 1937 are reported herein. The effects of two different types of packages—ventilated and standard—on the rapidity with which the fruit cooled were studied, half of each car being loaded with ventilated packages of fruit and half with standard containers. A special type of ventilated liner, not available in 1935, was used in the 1937 tests.

Four of these cars were observed only during the precooling period, and four were followed thru to their destinations. In the latter tests the condition of the fruit was observed when the cars were unloaded.

The precooling equipment was of two types. One consisted of electric fans (with accessories) which forced cold air from the ice bunkers thru the load of fruit. With this type of cooler, salt was added to the ice in the bunkers to reduce the air temperature. The other type of cooler consisted of a portable refrigeration plant mounted on an auto-truck chassis.

The results of the 1935 tests, which covered only the precooling period, may be summarized as follows:

1. The temperature of the fruit in the ventilated packages equipped with standard liners was reduced 25.8 degrees in 8½ hours, while that of the fruit in the standard packages with standard liners was reduced only 18.4 degrees. (*Car A*)
2. The temperature of the fruit in ventilated baskets without any liners was reduced approximately three times as much during a 6-hour precooling period as that of the fruit in the standard baskets equipped with standard liners. (*Car B*)

3. In a car precooled with a portable refrigeration plant, the temperature of the fruit in the ventilated packages dropped 16.1 degrees in $3\frac{1}{4}$ hours, while that in the standard packages dropped only 11.9 degrees. The day was fairly cool and the temperature of the fruit not very high at the start. Standard liners were used in both types of package. (*Car C*)

4. In a car loaded on a hot day, when the outside temperature was 94° F., the drop in the temperature of the fruit in the ventilated packages during a $4\frac{3}{4}$ -hour refrigeration period was 21.1 degrees, while in the standard containers it was only 12.7 degrees. The pre-cooling equipment was of the same type as that used for Car C just mentioned. (*Car D*)

The results of the 1937 tests, in which each car was followed thru to the terminal market and temperature readings were made enroute, were briefly as follows:

1. In a car loaded with Red Bird peaches, and shipped under standard refrigeration without precooling, the temperature of the fruit in the ventilated packages was reduced 30.6 degrees in 22 hours; while that of the fruit in the standard packages was reduced only 10.3 degrees. The new type of 80-hole liner was used in both types of packages. (*Car E*)

2. In a car precooled with the portable truck type of cooler, the average reduction in fruit temperatures in 3 hours was nearly the same in both the ventilated and the standard containers, both of which were equipped with the new type of ventilated liner. However, the amount of temperature drop in the fruit in the ventilated packages in different parts of the car was much less varied than it was in the standard packages. (*Car F*)

3. In a car precooled with the fan type of precooling equipment, the temperature of the fruit in ventilated tub bushels equipped with the new type of ventilated liner dropped 26.1 degrees in a 5-hour pre-cooling period, while in the standard tub bushels equipped with the standard type of liner the drop was only 10.5 degrees. (*Car G*)

4. In a car in which precooling equipment was not installed until 5 hours after loading was completed, the temperature of the fruit in ventilated baskets equipped with the new type of ventilated liner was reduced 9.3 degrees by the effect of the ice in the bunkers; while in the standard baskets with the same type of liners the temperature dropped only 6.3 degrees. During the next 6 hours, while the pre-cooler (fan type) was in operation, the fruit in the ventilated packages showed

a further temperature drop of 16.1 degrees and the fruit in the standard packages a drop of 13.7 degrees. (*Car H*)

5. Variations in the rate at which the peaches in the different tests cooled (both in 1935 and in 1937) were attributable partly to differences in the initial temperature of the fruit and partly to differences in the operation of the precooling equipment.

6. The peaches in both types of containers in the 1937 tests carried thru to their destinations in excellent market condition, tho the fruit in the ventilated packages was usually slightly firmer. The amount of brown rot and other decay was too small to warrant comparison.

That precooling of rail shipments of peaches and the use of ventilated containers are coming into favor among Illinois growers was indicated in contacts made with 126 growers in 1938. A number of those handling large volumes of peaches were precooling nearly all their rail shipments; and ventilated packages were used for marketing approximately 28 percent of the Illinois peach crop, according to an estimate based on interviews with these 126 growers, who marketed nearly half a million bushels of peaches in 1938.

CONCLUSIONS

1. Precooling is worthy of adoption as a general practice for rail shipments of Illinois peaches.

2. For rapid precooling, the fruit should be packed in ventilated containers equipped with the new type of ventilated liners.

3. Even for rail shipments of peaches that are not precooled, the use of ventilated packages is warranted because of the more rapid refrigeration which these packages permit.

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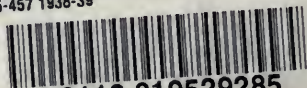
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445-457 1938-39

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