REDUCING TRANSPORT DAMAGE IN TOP-ICED SHIPMENTS OF FRESH VEGETABLES IN BUSHEL BASKETS

(A Study of Rail Shipments of Fresh Peas)

Marketing Research Report No. 772

Agricultural Research Service
U. S. DEPARTMENT OF AGRICULTURE

ACKNOWLEDGMENTS

The following organizations cooperated in the research on which this report is based: The American Veneer Package Association; the Freight Loading and Container Section, Association of American Railroads; the Pacific Fruit Express Co.; the Railroad Perishable Inspection Agency; Acme Steel Co.; and individual shippers and receivers. The following members of the Transportation and Facilities Research Division participated in the field work and the analysis of results: William F. Goddard, Jr., William R. Black, Boris P. Rosanoff, Thomas H. Camp, and Kenneth Myers. Mr. Rosanoff and Mr. Myers have retired. Mr. Camp has transferred to the Farmer Cooperative Service.

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Washington, D. C. Issued January 1967

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402—Price 15 cents

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(A Study of Rail Shipments of Fresh Peas)

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SUMMARY

Rail shipments of fresh peas and other green vegetables packed in bushel baskets and shipped under top ice have suffered high rates of loss and damage for many years. A study of rail shipments of fresh peas showed that the major causes of damage were the shifting of unstable loads, the failure of basket components, and the weight of large amounts of top ice on the loads.

Laboratory studies on different types of baskets and variations in basket design showed that a continuous-stave basket made primarily of gum wood suffered less breakage in compression tests than the conventional solid-bottom baskets used for shipments of peas from California to eastern markets. In shipping tests with the two types of baskets, the continuous-stave baskets had significantly less damage than the solid-bottom baskets when both types were shipped together in the same car in the conventional loading pattern with baskets alternately inverted. When the two types of baskets were shipped together in the crosswise-offset loading pattern, the continuous-stave baskets showed less damage than the solid-bottom baskets but the difference was not statistically significant.

In tests to compare the two loading patterns, the crosswise-offset pattern impaired cooling of peas, and damage to baskets was no less than that found in the conventional loading pattern. Peas in the conventional loading pattern cooled about three times as fast as those in the offset loads, and about twice as fast as those in another loading pattern tested.

Decreasing the amount of top ice on the loads and using half-stage bunker icing helped reduce damage in three out of four paired shipping tests, but differences were not statistically significant. Peas shipped in loads with modified icing cooled about as fast as those in the conventionally iced loads. Costs of the two types of icing service were about the same.

INTRODUCTION

Long distance shipments of fresh peas and other green vegetables usually are made with crushed ice on the loads to remove field heat and heat of respiration, and to prevent product dehydration. For many years rail refrigerator car shipments of a number of these products packed in tub-type bushel baskets and shipped under heavy applications of top-ice have incurred high rates of loss and damage. Losses have been especially high in shipments of fresh peas from western producing areas to eastern markets.

In 1960, the year this study began, loss and damage claims paid by U.S. Class I railroads for fresh peas reached $183 a car.[1] Claims

[1] ASSOCIATION OF AMERICAN RAILROADS, FREIGHT CLAIM DIVISION. FRESH FRUITS, MELONS AND VEGETABLES LOSS AND DAMAGE PER CAR—YEAR 1960. FCD Cir. 1817.

paid were 30.5 percent of the freight revenue received by the carriers for transporting the product. The high rate of loss and damage led the carriers to propose a container and loading tariff change that prohibited the use of top and body ice on rail shipments of all fresh vegetables packed in tub-type bushel baskets. This change would have seriously hampered marketing of these products.

The purpose of this research was to find ways of reducing refrigeration costs, and transit and handling damage of fresh peas and other green vegetables packed and shipped in bushel baskets.

The study was undertaken at the request of the basket manufacturers and the rail carriers. The objectives of the research were to identify the causes of the excessive damage, and to develop practical, inexpensive methods of reducing the losses. The work was carried out over a 3-year period and involved a study of basket design and construction, loading patterns, and methods of top-icing shipments of fresh peas.

An analysis of freight claim payments and railroad destination inspection records indicated loss and damage in rail shipments of fresh peas came from the same causes as damage to other fresh green vegetables packed in tub-type baskets and shipped under top ice.

IMPORTANCE OF TRANSPORT LOSSES

For more than 30 years container damage and product loss in rail shipments of fresh peas from California and other western producing areas to eastern markets have been higher than for almost all other fresh vegetables. By 1957, claims for peas were so high that the Freight Claim Division of the Association of American Railroads began to report loss and damage payments for peas as a separate category.

The data in table 1 show that during the 6-year period 1957-62, loss and damage claims ranged from one-fifth to almost one-third of the revenue received by rail carriers for transporting peas. During this period, the claim payment per car was never less than $100 and rose to $183 in 1960. Since that time, the trend of claim payments has been downward, but payments have remained about 20 percent of the freight revenue for fresh peas.

Loss and damage claims paid to shippers are part of transport costs and ultimately are reflected in freight charges. Transport charges are a large part of total marketing costs for fresh vegetables and usually influence consumer prices and producer returns. Therefore, reducing transport damage will help to hold down total marketing costs and thus bring higher returns to producers and lower prices to consumers. Products will also reach markets in better condition.

TABLE 1.—*Loss and damage claims payments, fresh peas, Class I U. S. railroads, 1957-62* [1]

Year	Carlot shipments	Gross freight revenue [2]	Loss and damage claim payments		Ratio L&D claims to freight revenue
			Total	Average per car	
	Number	*Dollars*	*Dollars*	*Dollars*	*Percent*
1957 [3]	874	524,400	118,673	135.78	22.6
1958	642	385,200	99,716	155.32	25.9
1959	705	423,000	89,920	127.55	21.3
1960	609	365,400	111,446	183.00	30.5
1961	597	358,200	91,305	152.94	25.5
1962	787	472,200	96,512	122.63	20.4

[1] Source: Circulars 18207, 94973, 85432, 74506, 63591, and 52198, 1958–63, Freight Claim Division, Association of American Railroads.

[2] Calculated on basis of an average per-car revenue of $600 reported for Class 89, "Vegetables, fresh NOS, not frozen," table 3, Freight Commodity Statistics, Statements 58,100; 59,100; 60,100; 61,100 and 62,100, Interstate Commerce Commission. Peas (green) are not reported separately.

[3] Peas were not segregated in reports before 1957—included in commodity group, berries, fruits, melons, and vegetables, NOS (Not Otherwise Specified).

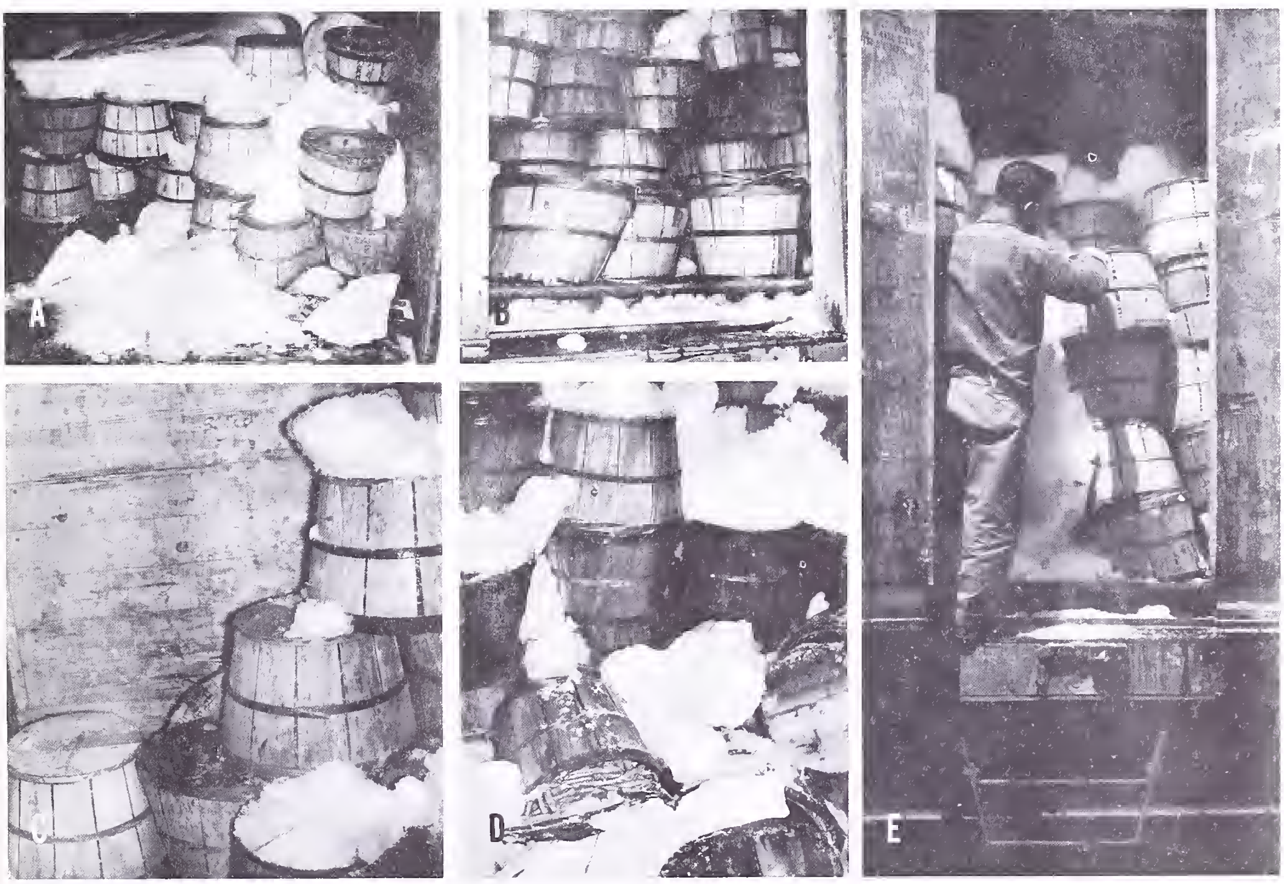
TYPES AND PROBABLE CAUSES OF TRANSPORT DAMAGE

An exploratory study was made in 1960 to attempt to identify the type and probable causes of damage in rail shipments of fresh peas. The packing, loading, and icing of seven carloads of peas were observed in California producing areas and the baskets were inspected during unloading at destination.

Of 4,253 baskets inspected, 1,037, or 24.4 percent, were damaged when they were unloaded at destination. The most prevalent type of damage was badly squeezed baskets (fig. 1A), which accounted for 34.1 percent of the damaged baskets. Baskets with broken hoops (fig. 1C) accounted for 25.1 percent of the damage; those with broken and loose covers (fig. 1D), 16.4 percent; badly wracked baskets (fig. 1E), 12.9 percent; baskets with broken and cut side staves (fig. 1B), 9.2 percent; and baskets with broken and split bottoms, 2.3 percent.

The major causes of damage were an unstable loading pattern, failure of basket components, and too heavy a layer of top ice.

Most of the damage was associated with shifting of loose, unstable loads from which most of the crushed ice in the spaces between the baskets had melted (fig. 2B). Observations showed the baskets were made of brittle shook material and the covers were too small to fit the tops of many baskets. Some baskets were poorly assembled. The weight of the large amount of top ice on some loads also contributed to damage, especially to baskets in the lower layers of the load (fig. 2A). Some damage also resulted from upsetting the vertical columns of baskets during switching of partly unloaded cars on team tracks (fig. 2C).



(A) BN–27912; (B) BN–27903; (C) BN–27908; (D) BN–27911; (E) BN–27910

FIGURE 1—Five of the most common types of transport damage encountered during shipment of fresh peas by rail refrigerator car. *A*, Badly squeezed baskets; *B*, cut staves and broken bottom hoop; *C*, broken middle hoops; *D*, spilled contents caused by loose cover; and *E*, badly wracked basket.

(A) BN–27909 (B) BN–27902 (C) BN–27905

FIGURE 2.—Three of the most common causes of transport damage encountered during shipment of fresh peas by rail refrigerator car. (*a*) Heavy cover of top ice remaining at destination; (*b*) shifted vertical columns and lack of recess ice between baskets; and (*c*) vertical columns upset during switching of cars on team tracks.

TEST PROCEDURES

Laboratory tests were made to compare the compressive resistance of baskets of various design and construction, and three types of field tests were made. The first set of field tests compared basket damage in rail shipments of peas loaded in the conventional pattern and in an experimental pattern, and the ease of loading and unloading baskets in the two patterns. The initial cooling times of fresh peas shipped in these patterns, plus a third loading pattern, were also measured. The second set of field tests compared the performance of conventional solid-bottom baskets and continuous-stave baskets. The third set of field tests compared conventional icing of shipments with a modified method of icing.

Laboratory Tests

The laboratory tests were made at the Forest Products Laboratory in 1961. Compressive forces were applied to empty baskets to simulate the forces imposed on containers during rail shipment. Baskets were tested under four methods of compressive loading: (1) Two baskets with covers on placed top to top, with load forces applied to the basket bottoms; (2) two baskets with covers on placed bottom to bottom, with load forces applied to the basket tops; (3) single baskets with covers on, with load forces applied to the sides; and (4) single baskets without covers, with the load force applied so that it tended to push the outside top hoop or the bottom from the basket. (The basket was supported only at the outside top hoop while force was applied to the inside of the basket bottom.)

All tests were conducted in a compression testing machine operated at a head speed of 0.25 inch per minute.

Before testing, each basket was submerged in water for 24 hours to simulate shipment under top ice. Each test was repeated five times.

Field Tests

Load Patterns.—Shipping tests were conducted during the 1961 and 1962 shipping seasons to compare basket damage and ease of loading and unloading of the conventional pattern and a pattern previous research had shown to give a tight, stable load for peaches shipped in bushel baskets but without top ice.[2] In the conventional pattern, baskets were stacked alternately bottom-to-bottom and top-to-top (fig. 3A). The bottom-to-bottom and top-to-top stacking also was used in the experimental pattern, but the baskets were offset crosswise (fig. 3B). Transport researchers gathered data by inspecting 10,377 baskets in 11 shipments with the new loading pattern and 15 control shipments using the conventional one.

Studies were made to measure the initial half-cooling time for three loading patterns.[3]

[2] SHADBURNE, R. A. IMPROVED LOADING OF BASKETS OF PEACHES AND FRESH PRUNES IN RAILROAD CARS. U.S. Dept. Agr. Mktg. Res. Rpt. 275, 76 pp., illus. Sept. 1958.

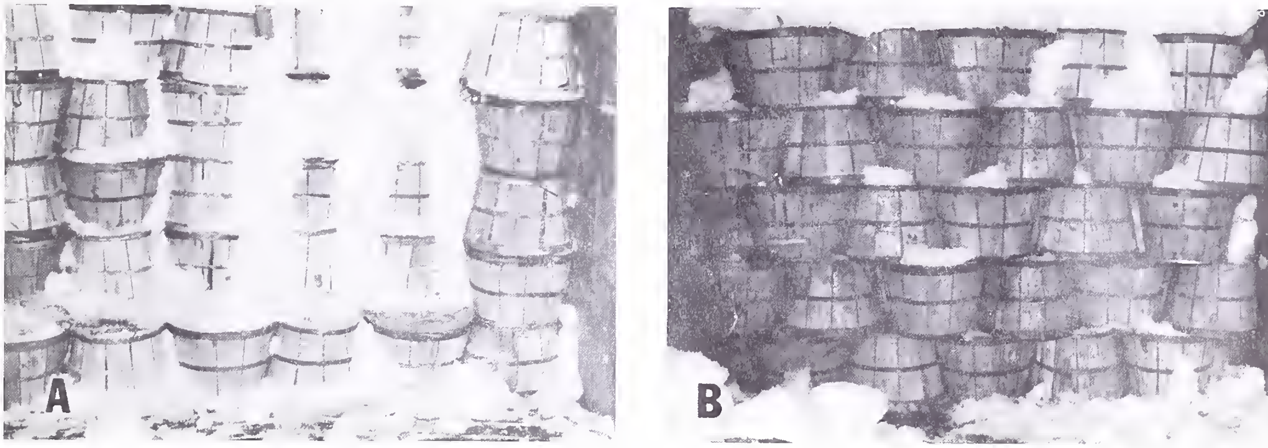
[3] Half-cooling time is the time required to reduce the initial difference between the temperature of the commodity and the temperature of the top ice by one-half. GUILLOU, R. COOLERS FOR FRUITS AND VEGETABLES. Univ. of Calif. Agr. Expt. Sta. Bul. 773, 65 pp., illus. 1960.

In addition to the conventional and offset patterns described above, the studies also included the 5–4 loading pattern, in which stacks of baskets were alternately five and four baskets wide.

Product temperatures during initial cooling before shipment were obtained with thermocouples inserted in the pea pods in baskets midway between the sidewalls, at the middle- and quarter-length positions of the car. Portable electric motors were used to drive the air circulating fans in the car.

Data to compare transit temperatures were obtained with recording thermometers placed in baskets of peas in the middle row, at the bottom, middle, and top layers of the quarter-length position.

Basket Design.—Performances of conventional solid-bottom and continuous-stave baskets made primarily of gum wood (fig. 4) were compared in two controlled shipping tests using the conventional and offset loading patterns. An equal number of each type of basket



(A) BN–27906 (B) BN–27913

FIGURE 3.—Two methods of loading baskets of fresh peas inside refrigerator cars. *A*, Conventional, nonoffset, bottom-to-bottom and top-to-top, alternately inverted loading pattern; and *B*, crosswise-offset, alternately inverted pattern.

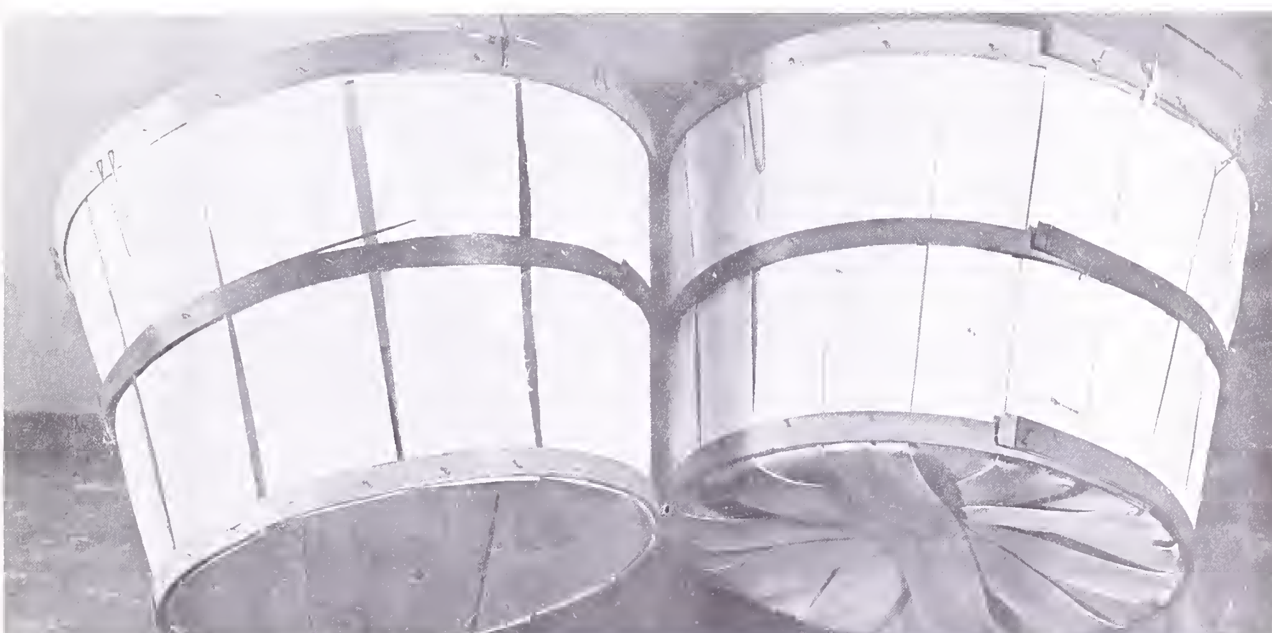


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FIGURE 4.—Solid bottom basket (left) and continuous-stave basket (right).

was packed in the same fields and loaded into the same refrigerator car, with the continuous-stave baskets on one side of the car and the solid-bottom baskets on the other side (fig. 5). The baskets were inspected at destination and the type and amount of damage were recorded for each basket. Refrigeration data were not gathered because exploratory tests indicated that the change in basket design would not materially affect product cooling.

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FIGURE 5.—Partly unloaded, longitudinally split load of solid bottom baskets (left background) and continuous-stave baskets (right foreground).

Icing Methods.—Four paired shipping tests of baskets in the conventional loading pattern were made during the 1962 season to see whether the amount of top ice could be reduced without seriously impairing refrigeration of the peas. Each paired shipment had one conventionally iced load and one load with modified icing. Under conventional icing, the loads of baskets were top iced at origin with an average of 24,750 pounds of crushed ice, and an average of 5,225 pounds of crushed ice was added at one point in transit. The modified method used an average of 14,400 pounds of crushed top ice at origin, with 5,800 pounds of block ice in the ice bunkers of each car. In the modified icing tests, an average of 6,500 pounds of crushed ice was applied to each load at a transit icing point.

The peas in each pair of cars were packed in the same type of baskets by the same shipper and the cars moved together in the same train. Transit temperatures were registered by recording thermometers, and data on load shifting, basket damage, and product condition were obtained by inspection at destination.

RESULTS

Laboratory Tests

The baskets tested are described in table 2; they are referred to in this discussion by the lot numbers shown in the table.

Compressive resistance of baskets was measured in terms of "maximum load" and "work to maximum load." Maximum load is the largest load in pounds resisted by the basket when subjected to a continuously applied force. Failure of one or more basket parts occurred at maximum load and the ability of the basket to further resist the force was greatly reduced. Work to maximum load is a measure of the work done on the basket during application of the crushing force up to the point of maximum load. This measure gives an indication of the energy expended in deforming the baskets and may be used as a guide in determining the shock resistance of the baskets.

The results of the compression tests are given in table 3. The continuous-stave baskets (lot 5), made primarily of gum wood, outperformed all other baskets in the side-to-side compression tests, and ranked second in the hoop removal tests. However, this lot performed poorly in the other two tests. Because of their resiliency, the continuous-stave baskets resisted breakage and regained their original shape after the compressive load was removed.

The kinds of woods used may have influenced the performance of the continuous-stave basket more than the type of construction, but the laboratory tests did not measure the effect of each factor separately. The types of woods used for the staves, hoops, and covers of the continuous-stave baskets were harder and more shock-resistant than most of the woods used in the other test lots. The results of the compression tests indicated that the continuous-stave baskets would be highly resistant to damage from squeezing, wracking, and broken hoops, the types of basket failure which accounted for more than 70 percent of all damage found during exploratory work in the 1960 season.

Lot 3 baskets gave good performance in all tests in which both maximum load and work to maximum load were measured. Lot 3 baskets never ranked lower than third in performance when compared with the other lots of baskets.

TABLE 2.—*Description of lots of baskets used in laboratory compression tests*

Lot No.	U. S. region of shook manufacture	Area of basket assembly	Special features	Species of wood used in basket parts: Bottoms [1]	Covers [2]	Staves [2]	Hoops [2]
1	Western	California	Solid bottoms	Ponderosa pine	Ponderosa pine	Ponderosa pine, some Douglas-fir	Sweetgum, American elm
2	Western	New Jersey	Solid bottoms	Ponderosa pine	Ponderosa pine	Ponderosa pine	Sweetgum
3	Southern	Texas	Solid bottoms	Cottonwood, American elm, sycamore, willow	Cottonwood	Hackberry	Cottonwood, willow
4	Western	North Carolina	⅜- by 0.010-inch flat metal bottom hoop and recessed covers, solid bottoms	Willow, ponderosa pine	Ponderosa pine	Ponderosa pine	Sweetgum [3]
5	South Central	Arkansas	Continuous stave	Blackgum [4]	Redgum, blackgum, hackberry, sycamore	Blackgum	Blackgum, sweetgum
6	Eastern	New Jersey	Thick top hoops, solid bottom	Red maple, yellow-poplar, ponderosa pine	Ponderosa pine	Yellow-poplar	Yellow-poplar
7	Western	California Illinois	L-shaped metal bottom hoop, solid bottoms	Ponderosa pine	Ponderosa pine	Ponderosa pine	Elm [3]

[1] Bottoms generally resawn lumber.
[2] Covers, staves, and hoops rotary-cut veneer.
[3] Bottom hoop metal.
[4] Bottom of rotary-cut veneer since basket is continuous-stave type.

TABLE 3.—*Rank of bushel baskets in compression tests* [1]

Rank	Basket top to basket top: Lot No.	Maximum load	Lot No.	Work to maximum load	Basket bottom to basket bottom: Lot No.	Maximum load	Lot No.	Work to maximum load	Side-to-side: Lot No.	Maximum load	Hoop removal: Lot No.	Maximum load	Lot No.	Work to maximum load
		Pounds		*Inch-pounds*		*Pounds*		*Inch-pounds*		*Pounds*		*Pounds*		*Inch-pounds*
1	4	1,700	7	625	4	1,780	6	500	5	160	3	1,430	3	595
2	3	1,550	3	520	3	1,400	7	495	7	145	5	1,380	5	([2])
3	7	1,400	6	455	7	1,320	3	490	3	130	6	1,370	6	560
4	2	1,300	1	415	1	1,200	2	420	6	115	4	1,290	4	380
5	1	1,230	2	360	2	1,180	1	410	4	110	7	[3] 840	7	[3] 255
6	6	1,110	4	310	6	1,050	5	355	1	105	2	830	2	240
7	5	780	5	310	5	770	4	350	2	95	1	660	1	170

[1] Values are averages of five replications.
[2] Information not available because of nature of basket.
[3] Values are averages for only four replications.

Furthermore, in the two tests in which lot 3 baskets ranked third, their performance was not significantly lower than that of the higher ranking lots.

The test results suggested that the kind of wood used for the staves accounted for most of the good performance of lot 3 baskets. The staves used in the baskets were of hackberry wood, which is considerably more shock resistant and harder than either yellow-poplar or ponderosa pine. Hackberry also is more resilient than the other two woods and is as good as yellow-poplar and better than ponderosa pine in such properties as bending strength and compressive strength.

The performance of the baskets in lot 6 (yellow-poplar staves, thick top hoops) was fairly consistent except in resisting top-to-top compression similar to that caused by overhead weight of the load and top ice. In the hoop removal test, lot 6 baskets were significantly better than other baskets with ponderosa pine staves. This could hardly be attributed to the thicker top hoops since the failure was generally characterized by the bottom being pushed out as staves were sheared from the bottom staples.

No significant difference was found between the performance of the lots of baskets with ponderosa pine staves assembled in western United States and the baskets assembled in eastern United States. The use of metal bottom hoops did affect the performance of the baskets with ponderosa pine staves, particularly under the maximum compression to simulate superimposed loading of basket tops or bottoms. The baskets with the 3/8- by 0.010-inch metal bottom hoop (lot 4) gave significantly better results than all other baskets except lot 3 baskets when subjected to top-to-top or bottom-to-bottom compression. In resistance to hoop removal, lot 4 baskets performed significantly better than the other baskets with ponderosa pine staves (lots 1, 2, and 7) and almost as well as those with hackberry or yellow-poplar staves or the continuous-stave baskets.

As the use of a narrow metal bottom hoop improved the performance of baskets with ponderosa pine staves, particularly under top- or bottom-crushing loads, the question arises of why lot 7 baskets with L-shaped metal bottom hoops did not perform better. This probably was because lot 7 baskets had only one staple driven through the metal hoop and stave and clinched just above the top surface of the bottom. Lot 4 baskets had two staples per stave driven through the bottom hoop. The use of at least one more staple in the metal hoop at each stave probably would help improve the performance of the baskets in lot 7. One basket in lot 7 had three staples driven through the metal hoop at each stave with at least one of the three staples driven into the basket bottom. This particular basket was subjected to the hoop removal test and withstood almost twice as much load as the other four baskets in the same lot with only one staple per stave. This basket also withstood twice as much work to maximum load as the other baskets in this lot.

The types of basket failure for many of the lots in the tests were similar and did not appear to be altered by slight modifications in basket design. In the top-to-top and bottom-to-bottom compression tests, the type of failure and condition of all baskets at maximum load were the same for all lots except lots 3 and 5. The most usual types of failure were buckling and breaking of the staves across the grain of the wood, and occasionally, some staples pulling at the center hoop. In lots 3 and 5 the staves buckled inward or outward, but usually did not break across the grain. Therefore, when the load was removed, the baskets regained their original shape. All lots tested showed the same type of failure in the side-to-side compression tests. This was buckling, breaking, or splitting of the cover slats. In the hoop removal tests of lots 3 and 5, the top hoops split and some staples pulled through the top hoops (fig. 6). In all

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FIGURE 6.—Basket subjected to hoop removal test, showing typical failure of outside top hoop because of splitting at the staples.

other lots, the bottoms were pushed out because the staves were sheared from the staples at the bottom (fig. 7).

The metal bottom hoops increased the weight of the baskets by about 1/4 pound per basket. The average weight of the baskets varied from lot to lot, but the difference between the minimum and maximum average weight for all lots was only about 3/4 pound.

The amount of water pickup varied somewhat between lots, but the average maximum and minimum weight of moisture pickup varied by less than 1 pound.

In nesting or shipping the empty baskets from the basket-making plants to the laboratory, the baskets with the L-shaped metal bottom hoops (lot 7) suffered the most damage. This damage was cutting and breaking of the staves across the grain near the top of the metal hoop from the shearing action of the metal hoops when the baskets were nested.

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FIGURE 7.—Basket with 3/8- by 0.010-inch metal bottom hoop showing typical failure of staves shearing from bottom staples in hoop removal evaluation.

Field Tests

Load Patterns.—Use of the crosswise-offset loading pattern for the conventional solid-bottom baskets did not reduce total basket damage significantly. In 11 shipments of the offset load, 12.2 percent of the baskets inspected were damaged, whereas in 15 cars of the conventional loading pattern, 12.5 percent of the baskets were damaged. The data given in table 4 show that the baskets shipped in each type of load pattern sustained about the same types of damage. Squeezing was the most prevalent damage in both load patterns, followed by broken hoops, and broken and loose covers.

Previous research on the use of the crosswise-offset pattern for baskets of peaches showed that overall labor requirements for loading bushel baskets in this pattern were no greater than for conventional load patterns.[4] Observations made during loading confirmed the findings of the previous research. As soon as the loading crews became familiar with the basket arrangement in the offset pattern, loading proceeded smoothly with no greater effort or time requirements than for the conventional

[4] See footnote 2.

TABLE 4.—*Basket damage in rail shipments of fresh peas, by type of load pattern and type of damage, 1961 and 1962* [1]

Type of damage	Conventional load		Crosswise-offset load	
	Number of damaged baskets	Percent of total damaged baskets	Number of damaged baskets	Percent of total damaged baskets
Broken and loose covers	144	18	94	19
Cut staves	77	10	33	7
Wracking	78	10	79	16
Broken hoops	163	20	92	19
Broken or split bottoms	43	5	28	6
Squeezing	293	37	160	33
Total	798	100	486	100

[1] Solid-bottom baskets; total baskets inspected were 6,383 in the conventional loads, 3,994 in crosswise-offset loads.

pattern. Destination observations revealed that the offset loads were unloaded with no more difficulty than the conventional loads.

Initial cooling of the peas was faster in conventional loads than in offset loads during both pretransit and transit cooling (fig. 8). Table 5 lists the half-cooling times of peas in conventional, offset, and 5–4 loading patterns in five tests. Half-cooling time of peas in conventional loads was about one-third of that of peas in offset loads and half that of peas in 5–4 loads.

The differences in the half-cooling times (table 5) and trip temperatures (table 9, Appendix) show that car precooling and transit refrigeration of the product are impaired by the crosswise-offset pattern. Offsetting the baskets crosswise of the car prevents the crushed ice from shifting down into the spaces between the baskets in the lower layers (fig. 9). The smaller amount of ice that sifted down into the spaces of the body of the offset loads was demonstrated by the differences in the depth of top ice at shipping point. The four offset loads, for example, had an average of 17 inches and the four companion, conventional loads had 12 inches, even though nearly equal amounts of ice were applied to all eight cars.

Basket design.—Shipping experiments comparing the performance of the continuous-stave baskets, made primarily of gum wood, with con-

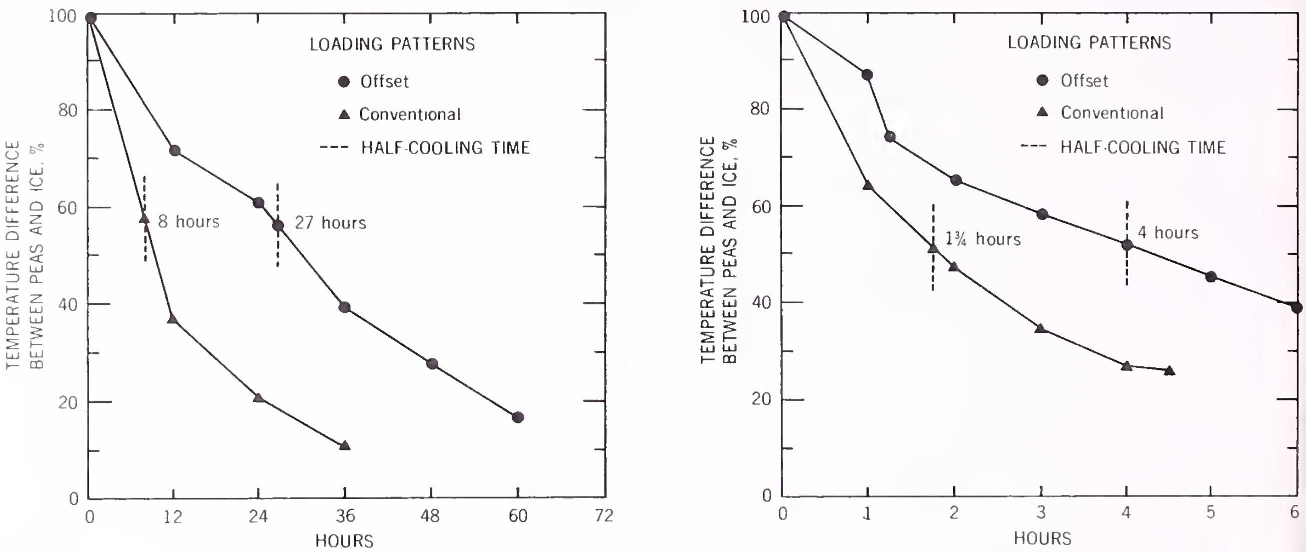

FIGURE 8.—Cooling rates of top-iced fresh peas packed in bushel baskets and positioned in rail cars in two different loading patterns. Cooling rates (*left*) before transit, test No. 6, and (*right*) during transit, test No. 7.

TABLE 5.—*Half-cooling times of top-iced fresh peas in bushel baskets in rail cars before transit and during transit, by type of loading pattern*

Test number and time of initial cooling	Conventional		Offset		5–4	
	Initial temperature of peas	Half-cooling time	Initial temperature of peas	Half-cooling time	Initial temperature of peas	Half-cooling time
	° *F.*	*Hours*	° *F.*	*Hours*	° *F.*	*Hours*
4, pretransit	63	2¾	70	7¼	--	--
7, pretransit	54	1¾	55	4	--	--
6, transit	51	8	49	27	--	--
1, transit	53	11	--	--	53	20
3, transit	60	18	--	--	49	34

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FIGURE 9.—Cross section of a partly unloaded, crosswise offset load of fresh peas showing lack of recess ice in body of load.

ventional solid-bottom baskets showed the continuous-stave baskets were more resistant to serious damage under comparable conditions of loading and handling.[5] Results of four shipping tests, each containing an equal number of each type of basket loaded in the same pattern are given in tables 6 and 7. In the conventional loading pattern, 14.5 percent of the solid-bottom baskets and 10.4 percent of the continuous-stave baskets inspected were damaged.[6] In the crosswise-offset pattern (table 7), 6.7 percent of the solid-bottom baskets and 5.3 percent of the continuous-stave baskets were damaged.[7]

In addition to the total damage being less for the continuous-stave baskets than for the solid-bottom baskets, the continuous-stave baskets had less serious damage. Table 6 shows that 39 percent of the total damage to the continuous-stave baskets resulted from squeezing and wracking. These two types of damage usually do not impair the ability of this type of basket to carry the product through subsequent handling without spillage or loss of contents as do other types of damage such as broken bottoms, broken covers, and cut side staves. The normal resiliency of the continuous-stave baskets, first revealed in the container laboratory tests, helped them resist serious damage from the forces imposed on them during transport and related handling.

Icing methods.—Basket damage was less under modified icing service in three out of four paired shipping tests. An average of 3.1 percent of the baskets shipped under the modified icing service were damaged, compared with 6.9 per-

[5] Baskets with hackberry staves (lot 3 in the laboratory tests) were not available for the shipping experiments.

[6] Difference statistically significant at the 5-percent level by the chi-square test.

[7] Difference not statistically significant at the 5-percent level by the chi-square test.

TABLE 6.—*Basket damage in rail shipment of fresh peas, by type of basket, conventional loading pattern*

Condition of baskets and type of damage	Solid-bottom baskets			Continuous-stave baskets		
	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected
Damaged:						
Broken and loose covers	17	21	3.1	11	19	2.0
Cut staves	8	10	1.4	0	0	0
Wracking	4	5	.7	3	5	.5
Broken hoops	35	43	6.3	12	21	2.2
Broken or split bottoms	9	11	1.6	12	21	2.2
Squeezing	8	10	1.4	20	34	3.6
Total damaged	81	100	14.5	58	100	10.5
Undamaged	474	--	85.5	497	--	89.5
Total inspected	555	--	100.0	555	--	100.0

cent in the conventionally iced loads (table 8).[8] The influence of large amounts of top ice on container damage during transport has been noted by other researchers.[9]

Table 8 shows the distribution of total basket damage by type of damage. These data reveal that the most prevalent types of damage in the conventionally iced loads were squeezed and wracked baskets. In the loads with modified icing, wracked baskets, and broken and loose covers were the most common types of damage. Total damage in loads with the modified icing was more evenly distributed among all types of damage than the total damage in loads with conventional icing.

[8] Difference not statistically significant by analysis of variance.

[9] WINTER, J. C., and MASTERS, B. M. CONTAINER BREAKAGE IN TOP-ICED SHIPMENTS OF VEGETABLES. U.S. Dept. Agr. 25 pp., illus. 1953.

TABLE 7.—*Basket damage in rail shipments of fresh peas, by type of basket, crosswise-offset loading pattern*

Condition of baskets and type of damage	Solid-bottom baskets			Continuous-stave baskets		
	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected
Damaged:						
Broken and loose covers	7	12.5	0.8	5	16.7	0.9
Cut staves	0	0	0	1	3.3	.2
Wracking	9	16.1	1.1	11	36.7	1.9
Broken hoops	7	12.5	.8	5	16.7	.9
Broken or split bottoms	8	14.3	1.0	0	0	0
Squeezing	25	44.6	3.0	8	26.6	1.4
Total damaged	56	100.0	6.7	30	100.0	5.3
Undamaged	776	--	93.3	538	--	94.7
Total inspected	832	--	100.0	568	--	100.0

TABLE 8.—*Basket damage in rail shipments of fresh peas, by type of damage and method of icing* [1]

Condition of baskets and type of damage	Conventional icing			Modified icing		
	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected	Number of baskets	Percent of damaged baskets	Percent of total baskets inspected
Damaged:						
Broken and loose covers	16	11.2	0.8	10	19.6	0.6
Cut staves	17	11.9	.8	6	11.8	.4
Wracking	25	17.5	1.2	14	27.4	.8
Broken hoops	8	5.6	.4	8	15.7	.5
Broken or split bottoms	20	13.9	1.0	5	9.8	.3
Squeezing	57	39.9	2.7	8	15.7	.5
Total damaged	143	100.0	6.9	51	100.0	3.1
Undamaged	1,927	--	93.1	1,604	--	96.9
Total inspected	2,070	--	100.0	1,655	--	100.0

[1] Four paired cars, conventional loading pattern.

In one paired shipment, initial cooling of peas in loads with conventional icing and with modified icing was the same (half-cooling time was 15 hours), and transit temperatures were about the same (fig. 10). In another shipment, half-cooling time of peas was 14 hours in the load with conventional icing and 25 hours in the load with modified icing. After the fourth day, temperatures in the middle of both loads were about the same (fig. 11). Temperature records for the other two pairs of cars were incomplete because of failure of several of the recording thermometers. However, average trip temperatures, determined from the thermometers which did not fail, differed for loads with conventional icing and with modified icing by only one or two degrees for both pairs of cars (table 10, appendix).

The lightly top-iced loads arrived at the transit icing point, Council Bluffs, Iowa, with about one-fourth to three-fourths of the load bare of ice, but still wet. Except at the doorway, much of the remaining ice was only 1 or 2 inches deep. In half these cars, the ice in the spaces between the baskets in the body of the load had melted down to the second layer from the top of the load. An average of about three-fourths of the original bunker ice remained in the cars at Council Bluffs.

Figure 12 shows that the greatest meltage occurred in the ends of the cars and the least in the middle of the loads. In the cars with modified icing the circulating air discharged onto the load from the fans to the top of the bunker bulkheads was cooled from its passage through the bunker ice. The smaller amount of top ice placed on the loads at the shipping point did not block the circulating air as much as the larger amounts of ice on the conventionally iced loads. When the crushed ice was applied at the re-icing point, the light cover of ice remaining on the loads permitted much of the crushed ice to sift down into the spaces between the columns of baskets. The ice in the load recesses increased the number of baskets in direct contact with the ice and helped to stabilize the loads during the remainder of the transit period.

The costs of the conventional icing and the modified icing were about the same.

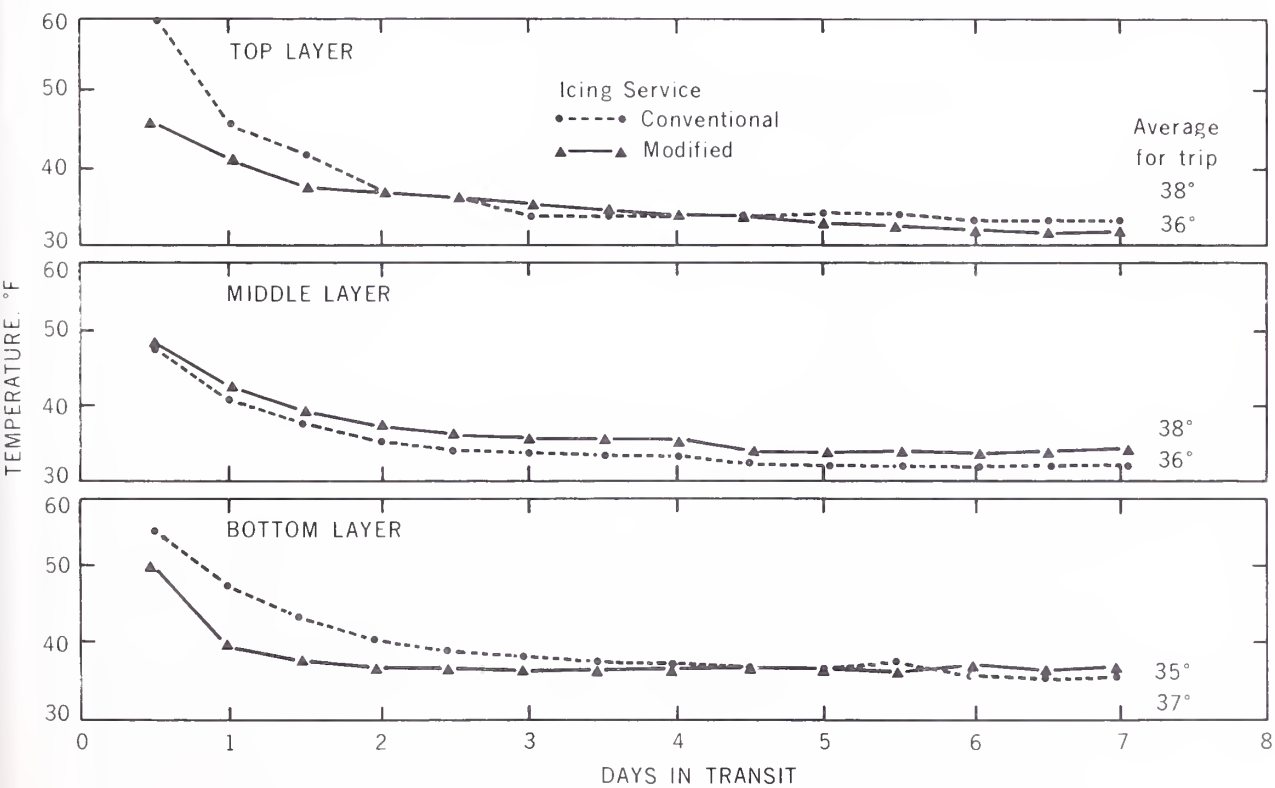

FIGURE 10.—Transit temperatures of fresh peas in bushel baskets in rail cars during transit, as influenced by type of icing service, test No. 8.

The heavily top-iced loads arrived at Council Bluffs with an adequate amount of ice over the load, but the ice was not of uniform depth. As in the companion cars, the greatest meltage occurred at the ends of the cars and the least at the center of the loads. The stack of baskets adjacent to the bunker was bare of ice in some cars, but so much ice remained at the doorway that re-top-icing was difficult. Moreover, the heavy cover of ice remaining on most of the top surface of the load prevented the newly applied ice from sifting down into the recesses of the load.

Under both types of icing, the greatest amount of top ice remained at the doorway and the least near the bunkers. The depth of top ice after icing at the shipping point and in transit was about the same for the entire length of the load. The lack of uniformity in depth before the re-top-icing and at destination was caused by uneven meltage during transit and has been observed in other research.[10] Little or no top ice remained on many of the loads near the bunkers at destination, but frequently an excessive amount remained near the doorway.

[10] BARGER, W. R. REPORT OF TRANSPORTATION TEST WITH LETTUCE AND CARROTS FROM SALINAS, CALIF., TO CHICAGO, ILL., PHILADELPHIA, PA., BALTIMORE, MD., AND NEW YORK CITY, AUGUST 18 TO 30, 1939. U.S. Dept. Agr., H.T. & S. Off. Rpt. 37, 79 pp. March 1940.

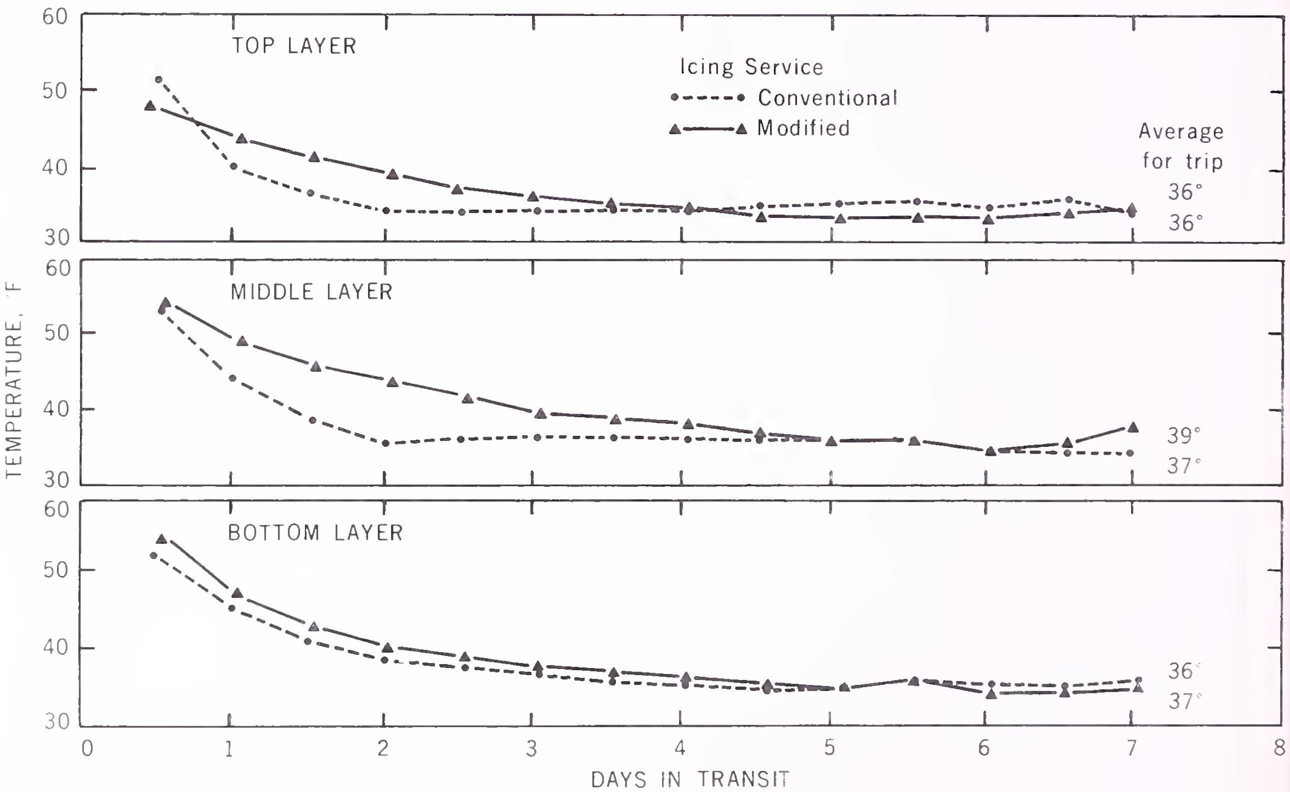

FIGURE 11.—Transit temperatures of fresh peas in bushel baskets in rail cars during transit, as influenced by type of icing service, test No. 9.

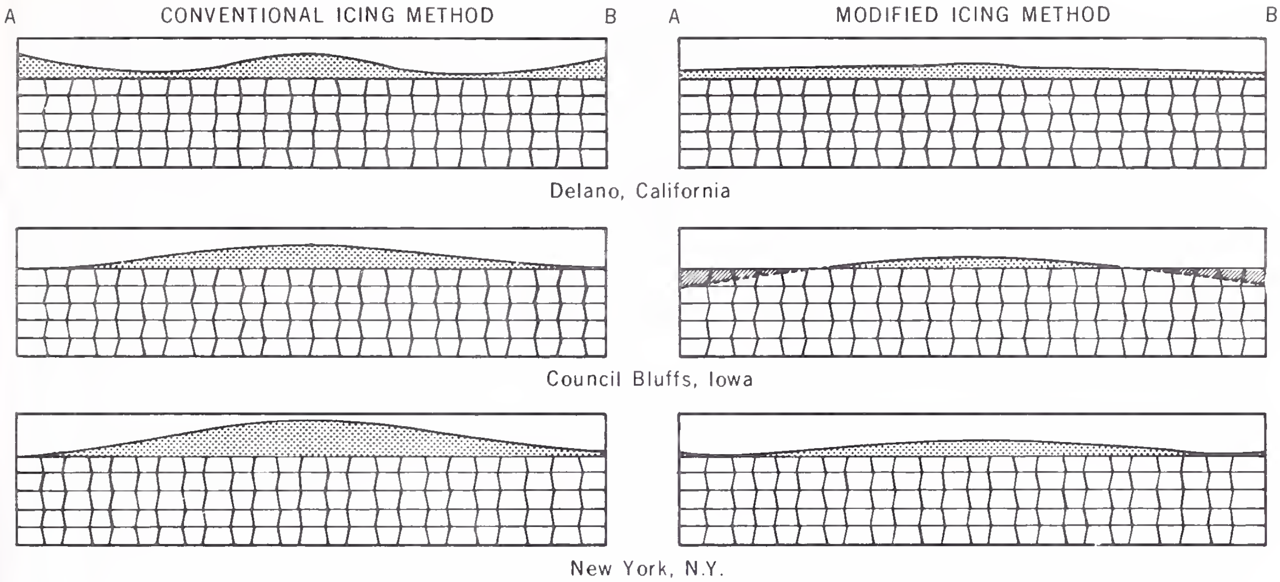

FIGURE 12.—Top-ice distribution profiles for paired loads of bushel baskets of fresh peas in rail cars with conventional and modified icing, showing average amounts of ice on loads at shipping point (Delano), re-icing station (Council Bluffs) before re-icing, and destination (New York). (A and B indicate the ends of the cars; B is the brake end.)

CONCLUSIONS AND RECOMMENDATIONS

Better baskets and better icing methods studied in this research on rail shipments of fresh peas from California to eastern markets can be used to materially reduce loss and damage in top-iced shipments of all green vegetables packed in bushel baskets.

Use of continuous-stave baskets, made primarily of gum wood, instead of the conventional solid-bottom baskets is recommended to reduce transport damage. The baskets should not be overpacked, and the covers should fit the baskets and be firmly secured at all four points.

Reducing the amount of top ice put on the loads at the shipping point and using half-stage bunker icing may also help cut the amount of transit damage. More frequent top icing in transit with less ice in each application should help to insure adequate cooling and reduce the weight of the ice on the load at any one time. Adequate hydrocooling to remove most of the field heat from the product before loading also will help maintain desirable product temperatures during transit. Better distribution of ice during the last part of the trip might be achieved by applying more at the ends of the car and less at the doorway. This method should be used at both the shipping point and in-transit icing points.

The conventional loading pattern with baskets alternately inverted should be used for all shipments. The baskets should be handled carefully and stowed tightly in the car to produce a stable, shift-resistant load. Top ice should be applied so that it will fill all spaces between the baskets in the loads. The top ice applied at shipping point and in transit should be deeper on the ends of the loads than in the middle, but not deep enough to block the flow of air from the fans at the top of the bunker bulkheads.

APPENDIX

TABLE 9.—*Loading, icing and trip temperature data for test shipments of fresh peas, by type of load pattern, Kern County, Calif., to New York, N. Y., 1960 and 1961*

Date shipped, test No., car, and load pattern	Top ice supplied [1]			Trip temperature [2]			
	At shipping point		In transit	BQ	MQ	TQ	Load average
	Amount	Depth on load					
1960	*Pounds*	*Inches*	*Pounds*	*° F.*	*° F.*	*° F.*	*° F.*
Test 1, Apr. 6:							
Car A, 5–4	27,600	15	4,100	38	37	36	37
Car B, conventional	27,600	17	4,100	37	37	37	37
Test 2, Apr. 13:							
Car C, 5–4	24,000	12	6,800	37	37	[3]	--
Car D, conventional	24,000	12	3,200	35	[3]	[3]	--
Test 3, Apr. 20:							
Car E, 5–4	24,000	14	6,800	37	38	39	38
Car F, conventional	24,000	13	5,000	38	37	36	37
1961							
Test 4, Apr. 12:							
Car G, crosswise-offset	24,000	22	5,000	41	41	41	41
Car H, conventional	24,000	13	5,000	34	36	35	35
Test 5, Apr. 18:							
Car I, crosswise-offset	19,500	16	4,500	41	38	[3]	[3]
Car J, conventional	21,000	11	3,900	33	33	33	33
Test 6, Apr. 19:							
Car K, crosswise-offset	21,000	17	3,800	39	39	35	38
Car L, conventional	21,000	12	6,000	36	36	34	35
Test 7, Apr. 25:							
Car M, crosswise-offset	18,600	14	6,000	42	40	34	39
Car N, conventional	21,000	11	5,600	34	34	33	34

[1] Top ice applied to the loads in crushed form was measured in 300-lb. blocks.
[2] Average of temperatures at 12-hour intervals during transit. BQ=bottom quarter-length, MQ=middle quarter-length, and TQ=top quarter-length.
[3] Recording thermometer failed to operate.

TABLE 10.—*Loading, icing and trip temperature data for test shipments of fresh peas, by type of icing method, Kern County, Calif., to New York, N. Y., 1962* [1]

Test No., date shipped and car	Ice supplied [2]			Depth of ice on load		Trip temperature [3]			
	At shipping point		In transit	At shipping point	At destination	BQ	MQ	TQ	Load average
	Bunker ice	Top ice							
	Pounds	*Pounds*	*Pounds*	*Inches*	*Inches*	*° F.*	*° F.*	*° F.*	*° F.*
Test 8, April 25:									
Car O	5,800	12,600	8,000	6	4	35	38	36	36
Car P	0	24,000	5,000	13	11	37	36	38	37
Test 9, April 26:									
Car Q	5,800	12,000	8,000	5	6	37	39	36	37
Car R	0	24,000	5,000	13	14	36	37	36	36
Test 10, May 1: [4]									
Car S	5,800	16,500	5,000	6	6	38	([5])	39	--
Car T	0	25,500	5,000	13	12	([5])	39	([5])	--
Test 11, May 2: [4]									
Car U	5,800	16,500	5,000	6	6	([5])	([5])	40	--
Car V	0	25,500	5,900	16	8	36	37	([5])	--

[1] Cars loaded with 720 baskets using conventional, alternately inverted pattern.
[2] Top ice applied to the loads in crushed form was measured in 300-lb. blocks.
[3] Average of temperatures at 12-hour intervals during transit. BQ=bottom quarter-length, MQ=middle quarter-length, and TQ=top quarter-length.
[4] Test cars loaded the day before being shipped.
[5] Recording thermometer failed to operate.

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