AIR TRANSPORT OF CALIFORNIA STRAWBERRIES:

Factors Affecting Market Quality in Spring Shipments—1966

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AIR TRANSPORT OF CALIFORNIA STRAWBERRIES: FACTORS AFFECTING MARKET QUALITY IN SPRING SHIPMENTS—1966

By JOHN M. HARVEY, *investigations leader*; H. MELVIN COUEY and C. MAX HARRIS, *physiologists*; and FRANK M. PORTER, *plant pathologist*; *Market Quality Research Division, Agricultural Research Service*

SUMMARY

Transit times for strawberries shipped by air from growing areas in southern California to wholesale markets in the eastern United States averaged 17.4 hours. About 32 percent of this time was spent on the plane, almost 50 percent at airports, and 18 percent in trucks going to and from airports.

Ambient temperatures at airports averaged 55° to 59° F., the warmest temperature being at the origin airport in Los Angeles. Temperatures in the cargo compartments of the planes averaged 61° between Los Angeles and the midwest and 55° between the midwest and east coast.

Strawberry temperatures in transit averaged between 50° and 55° F. for fruit that had been partially precooled and shipped on the day of harvest. Fruit precooled overnight and shipped on the day following harvest averaged between 43° and 49° in transit. Fruit temperatures varied only slightly in relation to the type of pallet cover used, due to the relatively cool weather in the spring season.

A fiberboard sleeve coated with a polyethylene-wax mixture was effective in retaining the CO_2 gas given off by dry ice placed in the pallet load. The CO_2 reduced decay in lots shipped during warm weather late in the spring season, but was of no advantage early in the season when the weather was cooler.

The length of time (23 percent of total transit time) and the relatively high average temperature (59° F.) at the origin airport suggest the need for refrigerated holding rooms to retard warming of the fruit. Delaying the onset of warming until the berries were loaded on the plane would result in lower fruit temperatures through the entire transit period.

BACKGROUND

Strawberries from southern California are shipped mostly in the spring season to eastern and midwestern markets. Because of the relatively cool weather at this time of year, handling procedures for air shipment of berries are somewhat different from those for fruit shipped from the summer districts in northern California. The latter were studied in 1965 and a report was issued by the U.S. Department of Agriculture [1].

The spring tests were designed to relate various commercial shipping practices to spoilage and market quality, and also to study experimental protective pallet covers for strawberries. The variables studied were as follows:

1. Time, temperature, and handling procedures in each portion of the transit period;

2. Precooling the fruit for various times before shipment;

3. Use of dry ice to modify the atmospheres in transit; and

4. Use of various types of pallet covers to retain the modified atmospheres produced by dry ice and also to provide physical protection for the berries.

[1] HARVEY, JOHN M., COUEY, H. MELVIN, HARRIS, C. MAX, and PORTER, FRANK M. AIR TRANSPORT OF CALIFORNIA STRAWBERRIES: FACTORS AFFECTING MARKET QUALITY IN SUMMER SHIPMENTS—1965. U.S. Dept. Agr. Mktg. Res. Rpt. 751, 12 pp., illus. July 1966.

METHODS

Shipping tests made in the spring of 1966 are listed in table 1. All tests originated in Anaheim or Fullerton, Calif., where strawberries were received from the fields for palletizing and precooling.

Test flats of berries were selected at the precooling plant for uniformity in respect to origin, quality, size, and maturity. Test flats were placed in the top and middle layers of each pallet load of fruit in regular commercial shipments.

Transit Temperatures

Recording thermometers were fastened inside empty berry flats, and a flat with a thermometer in it was paired with each test package of fruit to provide temperature records. Temperatures in the top and middle layers of each pallet were recorded. Thermocouples also were placed at these and other locations in the pallet, and temperatures were read on a potentiometer at intervals during handling and transit. U. S. Department of Agriculture personnel accompanied the shipments to collect data in the various portions of the transit period.

Dry Ice

Dry ice (about 8 pounds) was wrapped in heavy paper and placed in an empty strawberry flat. An additional empty flat was always set below the one containing dry ice, and paper or fiberboard was used in the lower flat to help insulate the berries in surrounding flats from the dry ice. The paired flats (with dry ice and insulation) were set in the top two layers of certain pallet loads just before shipment.

Gas Sampling

When dry ice was used, a gas sampling tube was inserted into the pallet load to allow the measurement of carbon dioxide and oxygen concentrations at intervals in transit. Atmosphere composition was determined with an Orsat-type analyzer. Analyses were made at the airport before departure, in the plane, at transfer or stopover points, and on arrival at the destination airport.

Precooling

Precooling practices for strawberries in southern California are either to precool berries overnight and ship them the day after harvest or to partially precool them and ship them on the day harvested. These two practices were compared in replicated tests. In a few tests, berries were cooled rapidly in a "forced air" cooler,[2] which resulted in somewhat lower temperatures for fruit shipped on the day of harvest than otherwise would have been possible.

Pallet Covers

Pallet covers were placed over the berries after they had been precooled and just before they were trucked from the precooling plant. Four types of pallet covers usually were compared in transit: (1) A "partial" cover, in

[2] GUILLOU, R., and PARKS, R. R. FRUIT COOLED BY FORCED AIR. Calif. Agr. 10(9): 7, illus. 1956.

TABLE 1.—*Air shipping tests with California strawberries, spring 1966*

Date	Carrier and flight No. [1]	Shipping origin in California [2]	Stops or transfers en route	Destination	Accompanied
Apr. 5	UAL 998	Anaheim	Chicago	Philadelphia	Yes
Apr. 5	UAL 986	Anaheim	Detroit	Philadelphia	Yes
Apr. 6	UAL 998	Anaheim	Chicago	Philadelphia	Yes
Apr. 6	UAL 986	Anaheim	Detroit	Philadelphia	Yes
Apr. 12	TWA 570	Anaheim	St. Louis	Philadelphia	Yes
Apr. 13	TWA 570	Anaheim	St. Louis	Philadelphia	Yes
Apr. 19	AAL 832	Fullerton	Chicago	New York	Yes
Apr. 20	AAL 834	Fullerton	Chicago	Newark	No
May 10	AAL 832	Anaheim	Chicago	New York	Yes
May 11	AAL 832	Anaheim	Chicago	New York	Yes

[1] TWA=Trans World Airlines, UAL=United Airlines, and AAL=American Airlines. These are regularly scheduled cargo flights.

[2] All flights originated at Los Angeles International Airport.

which the ends of the flats were exposed, but a lightweight corrugated fiberboard material covered the sides of the flats and the top of the pallet load; (2) a "regular" cover in which the top, bottom, and all sides of the load of berries were enclosed by a fiberboard sleeve and cap; (3) a cover similar to (2), but with the inner surface of the fiberboard "curtain coated" with a mixture of polyethylene and wax (all seams were taped), and (4) a cover similar to (2), but with a ½-inch sheet of expanded polystyrene insulation placed under the cap covering the top of the pallet load of berries.

Handling in Transit

After leaving shipping points, the strawberries were handled by conventional commercial procedures. They were hauled in refrigerated trucks to Los Angeles International Airport where the strawberry pallets were set on airline master pallets, each of which accommodated six strawberry pallets. The berries were held in place on the master pallets by a cargo net or were covered by an aluminum or fiberglass canopy, or "igloo". Once the master pallets were made up, they were set in a storage area to await loading on the plane.

On loading, test pallets usually were set in a forward position in the cargo compartment to be accessible for temperature and atmosphere readings in transit. Thermocouple wires and gas sampling tubes were passed through a safety net at the front of the cargo compartment into the vestibule between the cargo compartment and the pilots' cabin. This made it possible to obtain data in the vestibule by attaching instruments to the lines.

At terminal airports, the strawberry pallets were removed from master pallets and were transferred to refrigerated trucks that hauled them to the wholesale market. In most markets, the pallet loads of strawberries were moved directly from the trucks to the wholesaler's coldroom, but in the New York market, the pallet loads were disassembled in the truck and the paired flats were placed on a handcart and rolled to the coldroom.

Quality Evaluations

Test packages of strawberries usually were removed from the pallets at the wholesale market and taken by automobile to the U. S. Department of Agriculture's Market Pathology Laboratory for detailed examination. Berries were examined on arrival and at the end of 1 and 2 days' exposure to a temperature of 70° F. The berries were examined individually for decay, bruises, and other defects.

Analysis of Data

Data on temperature, atmosphere, and decay were averaged from readings taken on several similar flights. The combined data from several flights provided a more representative result on which to base conclusions than readings from an individual flight.

Values for the percentage of fruits that were decayed were converted to logarithms and treated statistically by analysis of variance. Precooling versus partial precooling was treated as whole plots, pallet covers as split plots, and positions within the pallet as split-split plots. The different examinations were analyzed separately. Duncan's Multiple Range test was used to test possible differences among means within a factor. Two tests were required to make one replication; therefore, four complete replications were obtained from eight tests.

RESULTS

Time in Transit

The average total transit time of strawberries from the shipping point in Southern California to their arrival at the wholesale market was 17.4 hours (fig. 1). Of this total time, berries spent 5.6 hours, or 32.2 percent, on the plane; 8.6 hours, or 49.4 percent, at airports; and 3.2 hours, or 18.4 percent, in trucks being hauled to and from airports.

The time spent at airports was divided as follows: 4.0 hours at Los Angeles International Airport; 2.5 hours at transfer points; and 2.1 hours at destination airports.

The transit time of berries on trucks (3.2 hours) was divided equally between that required to go from shipping point to the Los Angeles International Airport, a distance of about 40 miles, and that required to go from the destination airport to the wholesaler.

Temperatures in Transit

Ambient temperatures.—Ambient temperatures to which spring shipments of berries were exposed (fig. 2) were cooler than temperatures measured in the summer season for shipments out of northern California. Refrigerated trucks

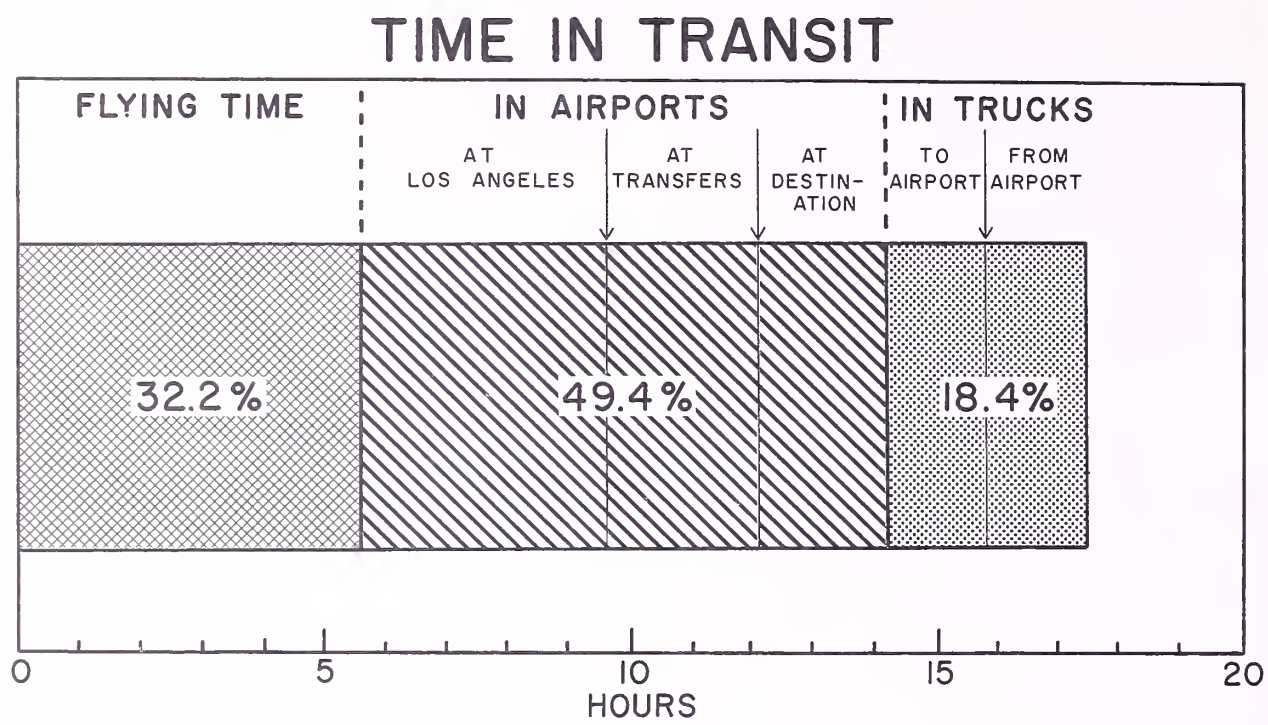

FIGURE 1.—Proportion of time for stated phases of transit for air shipments of California strawberries—spring 1966.

with thermostats set below 40° F. were used to haul the berries to the airport. Temperatures at the Los Angeles Airport averaged about 59° during the time test lots were there. Most of the test shipments were in the airport during the late evening hours. Ambient temperatures at the stopover or transfer airports averaged about 55° and those at destination airports averaged 58°. Temperatures in the cargo compartments of the plane averaged 61° between Los Angeles and the midwest and 55° between the midwest and east coast. The average temperature for the second portion of the plane trip was lower than the first, because several tests involved transfers to propeller driven aircraft at Chicago. Temperatures in the load compartment were somewhat lower in these planes than in the jet freighters.

Fruit temperatures in precooled and partially precooled lots.—Partially precooled berries shipped on the day of harvest remained between 50° and 55° F. during transit (fig. 2). Berries precooled overnight and shipped the day after harvest averaged between 43° and 49° in transit. The precooled berries averaged about 6° cooler than the partially precooled fruit during most of the transit period.

Fruit temperatures in relation to type of pallet cover.—The type of pallet cover had only a slight effect on transit temperatures of berries shipped during the cool spring season. Average temperatures of precooled fruit shipped in the four types of covers differed by less than 4° F. (fig. 3). Similarly, pallet covers had little effect on average temperatures of the partially precooled fruit (fig. 4).

Fruit temperatures in relation to position on pallet.—Top-layer berry temperatures averaged 5° to 6° F. warmer in transit than middle-layer temperatures when the fruit had been precooled overnight before shipment (fig. 5). Top-layer temperatures were above 50° for a major portion of the time in transit. In partially precooled fruit, the difference between average temperatures of berries in the top and middle layers was slight, except at the beginning of the transit period (fig. 6). At this point, temperatures were higher in the middle layer than at the top, which would be expected with fruit only partially precooled. Top-layer berries shipped in pallet covers with insulation under the cap were slightly lower in average temperature than those shipped in covers without insulation—about 3° F. cooler than top berries in the partial sleeve and 2° cooler than those in the regular sleeve. Greater differences would be expected in warm weather.

Temperature profiles for precooled and partially precooled pallets with insulated caps and fiberboard covers are shown in figure 7. The

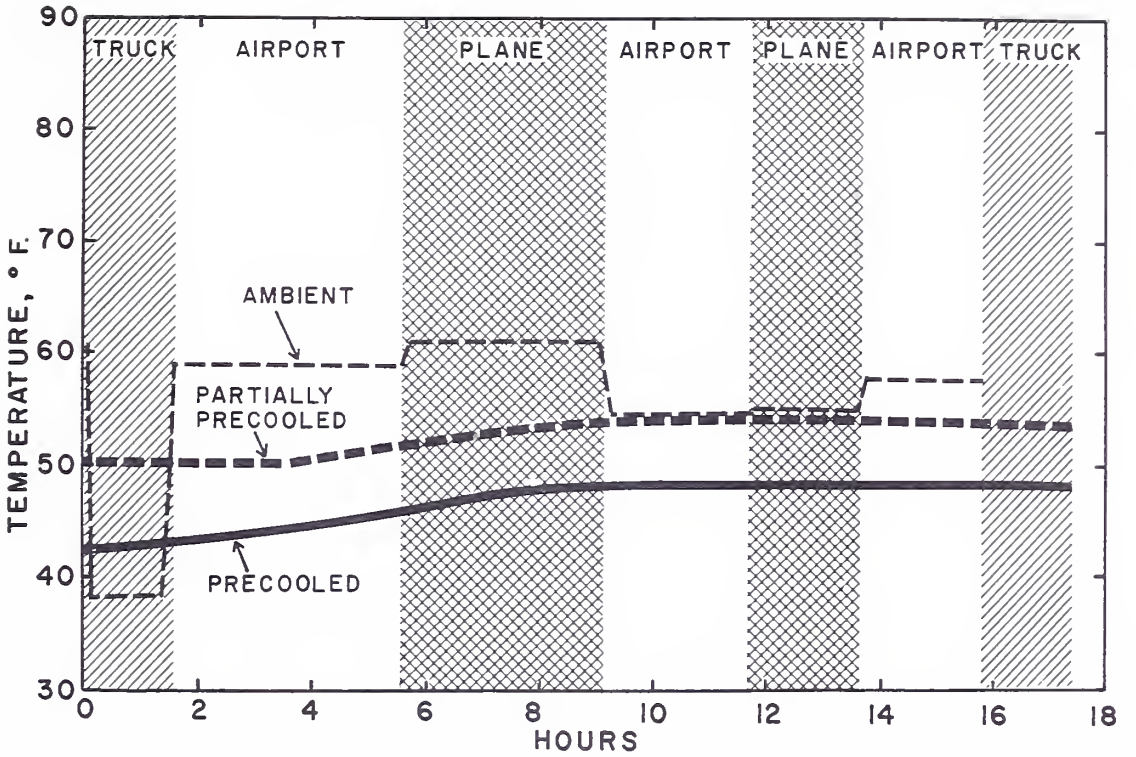

FIGURE 2.—Average temperatures of precooled and partially precooled California strawberries shipped by air to eastern markets—spring 1966.

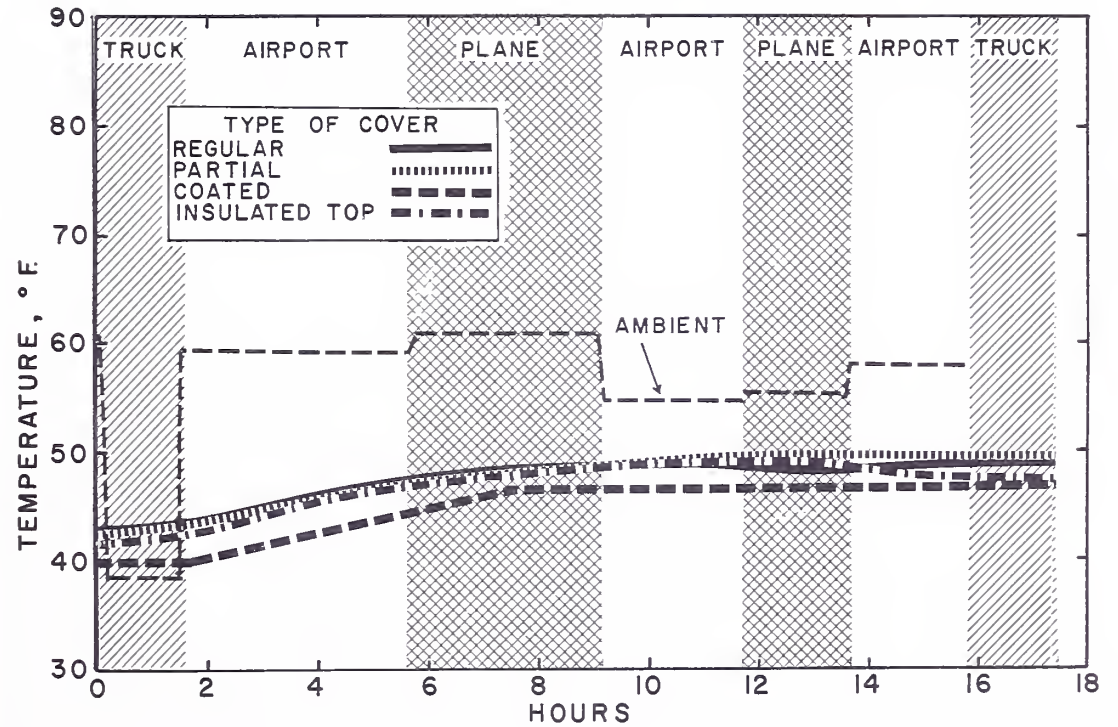

FIGURE 3.—Average temperatures of precooled California strawberries shipped in various types of pallet covers to eastern markets—spring 1966.

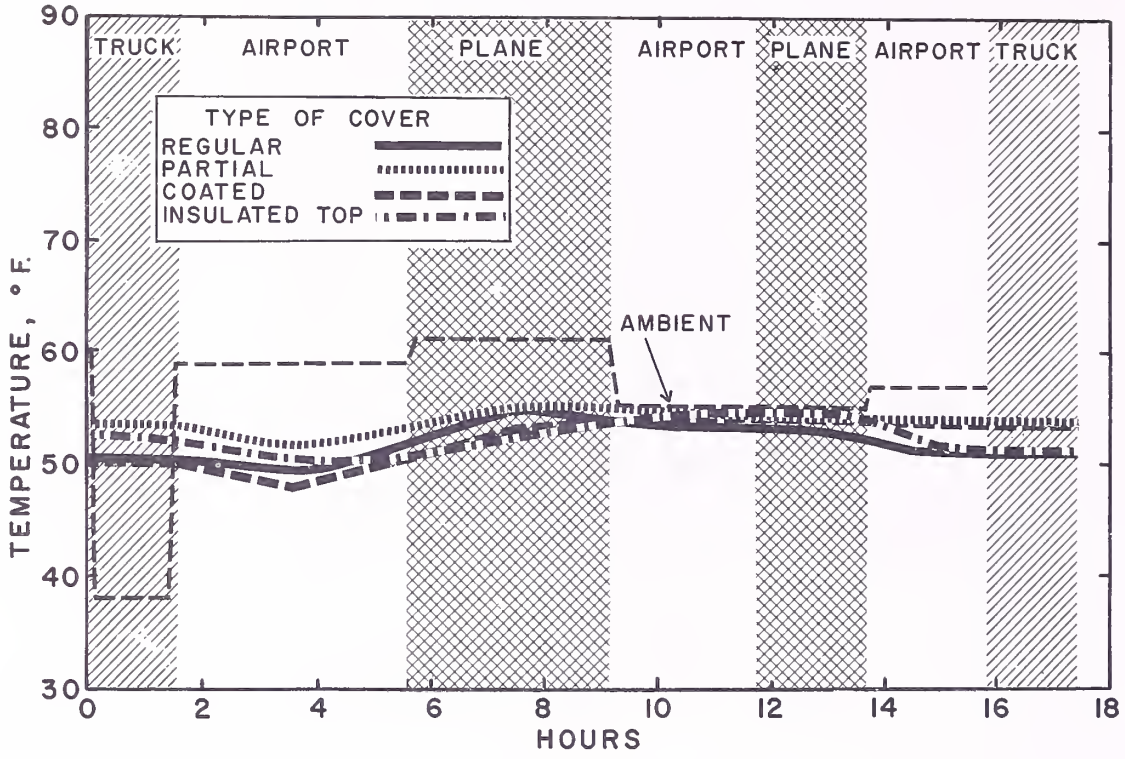

FIGURE 4.—Average temperatures of partially precooled California strawberries shipped in various types of pallet covers to eastern markets—spring 1966.

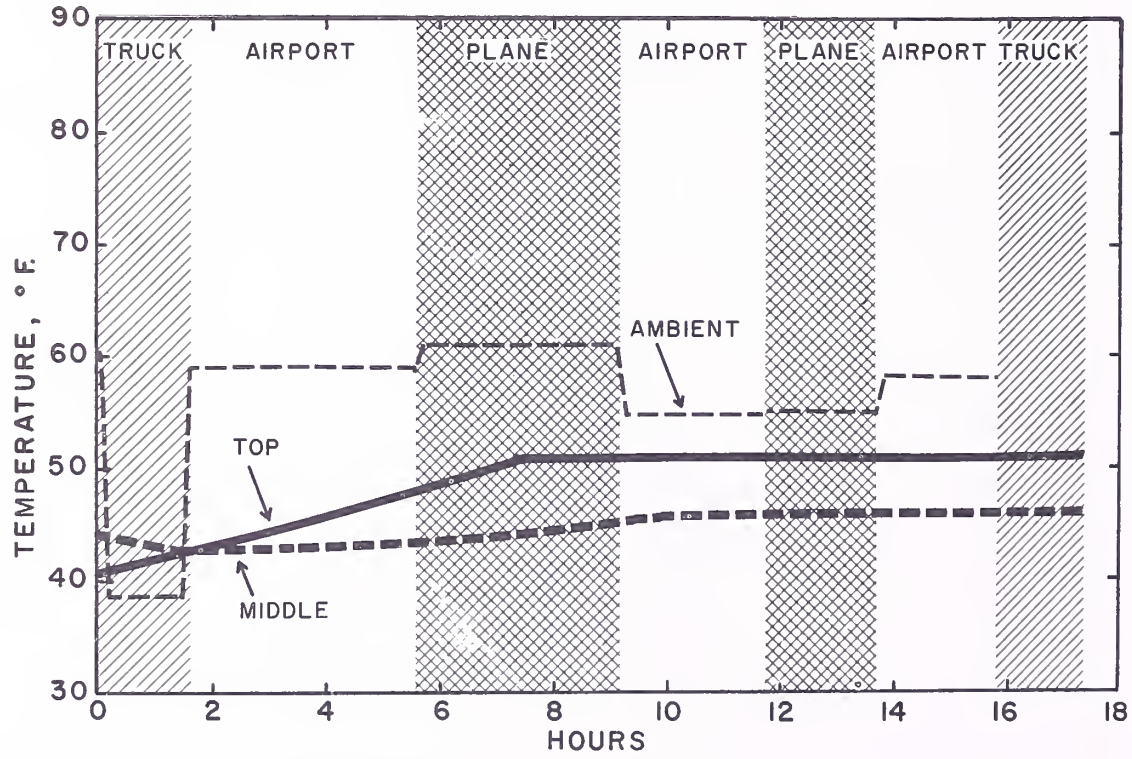

FIGURE 5.—Average temperatures in top and middle layers of pallet loads of precooled California strawberries shipped by air to eastern markets—spring 1966.

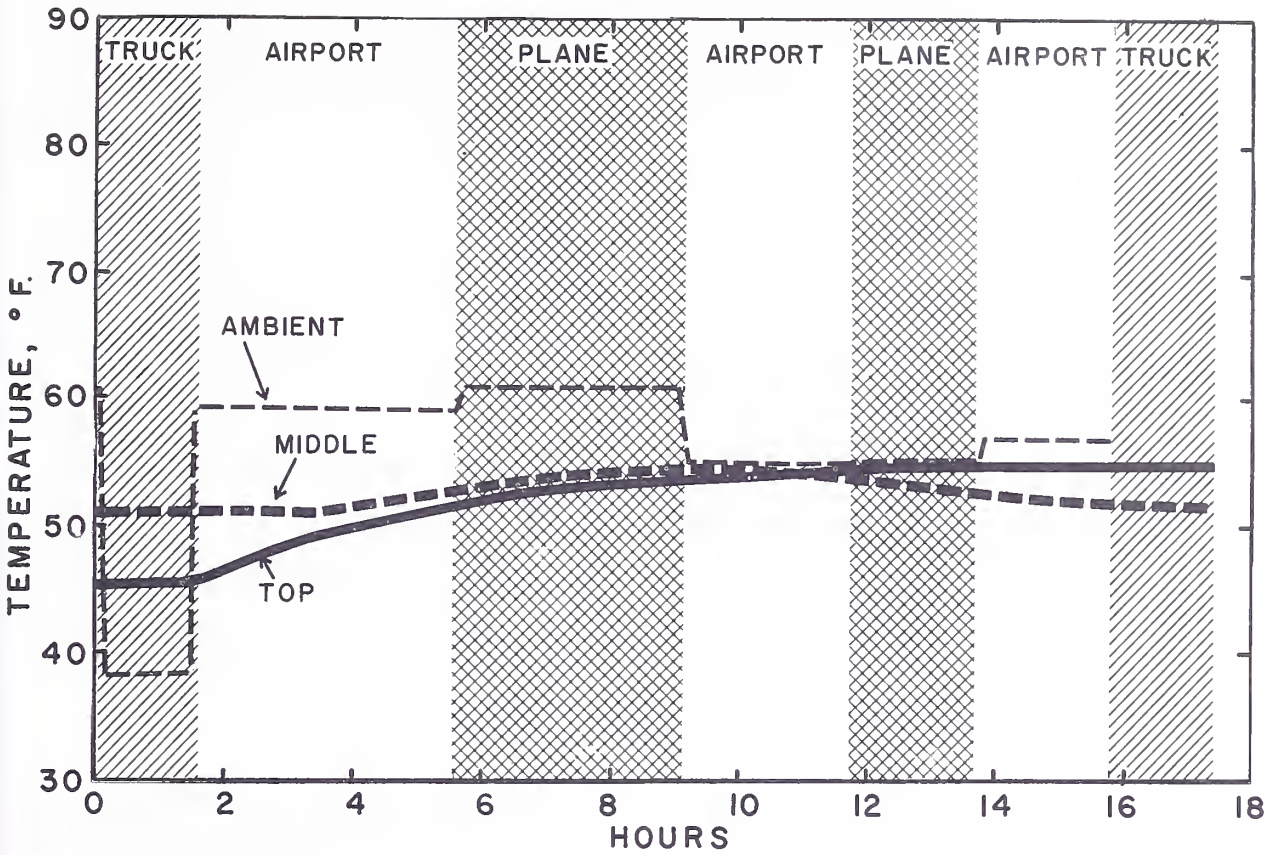

FIGURE 6.—Average temperatures in top and middle layers of pallet loads of partially precooled California strawberries shipped by air to eastern markets—spring 1966.

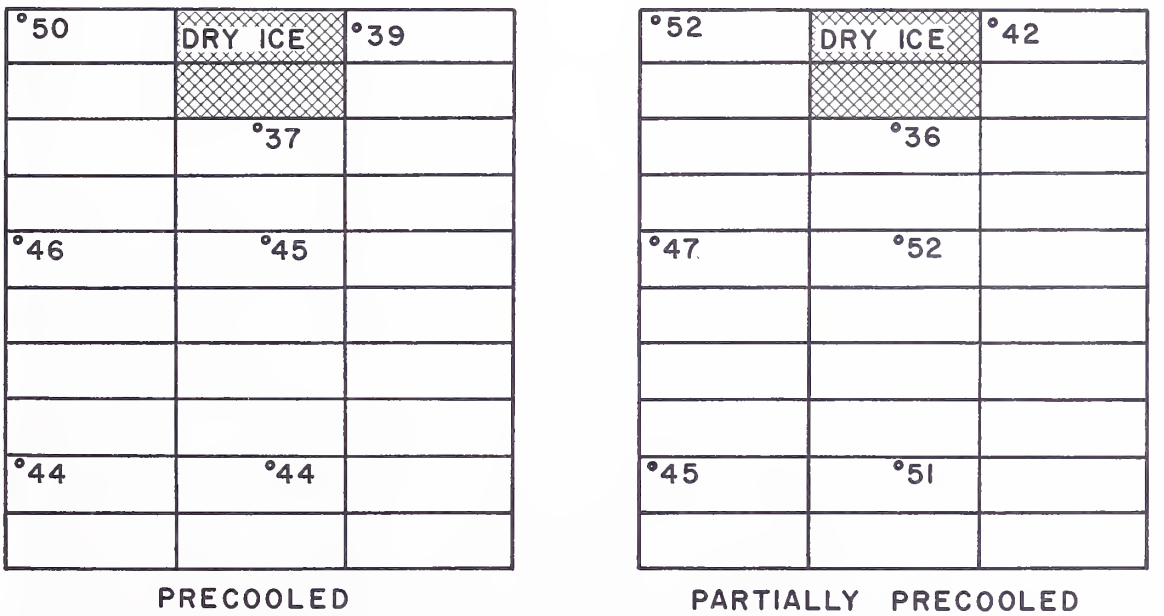

FIGURE 7. Average transit temperatures of precooled and partially precooled California strawberries at various positions on pallets—spring 1966 (average of 3 tests, using regular pallet covers and covers with insulated caps).

temperatures shown are averages for the entire time in transit. Average temperatures near the dry ice and at the periphery of the pallet did not differ greatly in the precooled and partially precooled fruit. However, average temperatures were about 7° F. lower toward the center of precooled pallets than at comparable positions in the partially precooled ones shipped in the spring season.

Atmospheres in Transit

Atmosphere modification resulting from the use of dry ice and the coated pallet covers are shown in table 2. Carbon dioxide levels were not as high as those obtained in the summer study with polyethylene film plus the sleeve. However the use of higher density coatings and improved taping of the seams to provide a better barrier to the escape of CO_2 should improve the performance of this cover. There was no significant buildup of carbon dioxide with the regular fiberboard cover, even though dry ice was used.

TABLE 2.—*Atmosphere composition in pallet loads of California strawberries, using coated pallet covers and dry ice, spring 1966* [1]

Cooling method and place	CO_2	O_2
	Percent	*Percent*
Precooled berries:		
Los Angeles International Airport	12.5	17.0
In transit	15.5	14.5
Chicago	12.5	17.0
In transit	13.5	15.5
Destination	11.5	16.5
Partially precooled berries:		
Los Angeles International Airport	9.5	16.5
In transit	12.0	16.5
Chicago	10.5	17.0
In transit	10.5	17.0
Destination	10.0	16.5

[1] Averages from three tests.

Decay in Relation to Precooling and Type of Pallet Cover

Decay (table 3) was much less affected by the type of pallet cover used in the spring shipments than it was in previous tests made in the summer. Averaging the data from all spring tests showed that type of pallet cover had no significant effect on decay. However, in the last pair of tests made in the spring, when average transit temperatures were somewhat warmer than in tests made earlier in the season, decay development (after 1 and 2 days from arrival) was considerably less in the coated sleeves than in any of the other types of pallet covers. This result agrees with previous findings,[3] which showed that "high" carbon dioxide levels reduced decay at the higher transit temperatures, but had little effect when transit temperatures were desirably low.

In the spring tests, overnight precooling showed no advantage over partial precooling in reducing decay (table 4). Temperature

[3] See footnote 1, page 1.

TABLE 4.—*Decay in California strawberries in relation to precooling, spring 1966* [1]

Examination time	Percentage of berries decayed when pallet loads were precooled as indicated: Partial precooling	Overnight precooling
	Percent	*Percent*
On arrival	3.6a	3.7a
Plus 1 day at 70° F.	6.9a	7.9a
Plus 2 days at 70° F.	25.1a	35.4b

[1] Decay was mostly gray mold rot.

Geometric means of 4 replications (8 tests): Means at each examination not followed by the same letter are significantly different at the 5-percent level.

TABLE 3.—*Decay in California strawberries in relation to type of pallet cover, spring 1966* [1]

Examination time	Percentage of berries decayed when pallet loads covered by—: Partial sleeve	Fiberboard sleeve and cap plus dry ice	Fiberboard sleeve plus insulated cap and dry ice	Coated fiberboard sleeve and cap plus dry ice
	Percent	*Percent*	*Percent*	*Percent*
On arrival	3.3a	3.6a	4.6a	3.3a
Plus 1 day at 70° F.	7.6a	7.6a	8.2a	6.2a
Plus 2 days at 70° F.	27.7a	32.7a	35.5a	24.6a

[1] Decay was mostly gray mold rot.

Geometric means of 4 replications (8 tests): Means at each examination are not significantly different at the 5-percent level.

differences between the two commercial precooling practices were not great, 43° F. vs. 50°, respectively, when all lots were averaged. The slightly lower temperature in the berries held overnight than in those partially cooled and shipped the day of harvest apparently did not compensate for the longer time between harvest and reaching market required for overnight precooling. Had the berries precooled overnight been cooled to a more desirably low temperature, that is 35° F., a greater reduction of decay probably would have been obtained. The advantages of good precooling of summer shipments has been well demonstrated.[4 5 6]

[4] See footnote 1, page 1.

[5] HARVEY, JOHN M. TIME AND TEMPERATURE EFFECTS ON PERISHABLES SHIPPED BY AIR. Fifth Conf. Transportation of Perishables Proc.: 56–64, illus. Univ. of Calif., Davis. Mar. 28–29, 1961.

[6] MITCHELL, F. G., MAXIE, E. C., and MAYER, GENE. LOW HOLDING TEMPERATURES STILL VITAL WITH RAPID MARKETING OF STRAWBERRIES. Calif. Agr. 20(3): 13–14, 1966.

Decay was slightly higher in fruit shipped in the top layers of the pallets than in that shipped in the middle layers (table 5), but the difference was not statistically significant.

TABLE 5.—*Decay in California strawberries in relation to position on pallet, spring 1966* [1]

Examination time	Percentage of berries decayed when berries were placed at indicated position on pallet	
	Top layer	Middle layer
	Percent	*Percent*
On arrival	4.2a	3.2a
Plus 1 day at 70° F.	8.3a	6.5a
Plus 2 days at 70° F.	30.6a	29.1a

[1] Decay was mostly gray mold rot.

Geometric means of 4 replications (8 tests): Means at each examination are not significantly different at the 5-percent level.

DISCUSSION AND CONCLUSIONS

Cool ambient temperatures during the early spring tests reduced differences in fruit temperature and decay development resulting from the use of various types of pallet covers. In previous shipping tests made in warm weather, the pallet covers helped to retain low berry temperatures and, when used in combination with dry ice, to retard decay development. Later in the spring, when relatively high ambients prevailed, the coated fiberboard covers, with the seams taped and dry ice enclosed, also reduced decay. Improved coatings should result in higher CO_2 atmospheres and better decay control than in current tests.

Pallet covers should also be considered in respect to the mechanical protection they afford and their role in maintaining the vertical alinement of flats, preventing pilferage, and protecting the berries from rainfall. During handling in various phases of transit, pallet loads of berries are subject to a considerable amount of tugging, pushing, and compression. A fiberboard sleeve and cap tends to reduce damage from these forces.

Precooling temperatures were not as low as desirable. Berries precooled overnight should be at temperatures near 35° F., rather than the 43° average recorded. Strawberries keep best at 32° and the nearer berries are to this temperature in all phases of handling and transportation, the smaller will be the loss of quality.

Strawberries from southern California spent an average of 4 hours at the origin airport at temperatures near 59° F. Placing the fruit in a coldroom during this period would help retain the refrigeration achieved during precooling and would delay a temperature rise until later in the transit period. The number of degree-hours above temperatures favorable for quality maintenance would thereby be reduced.

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