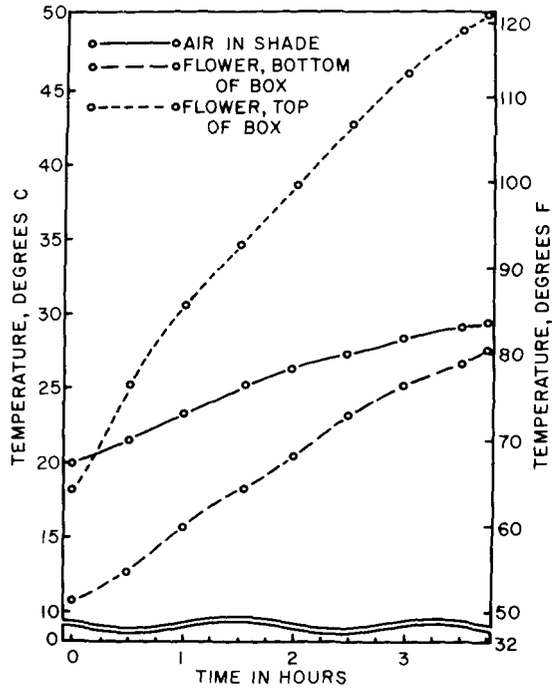
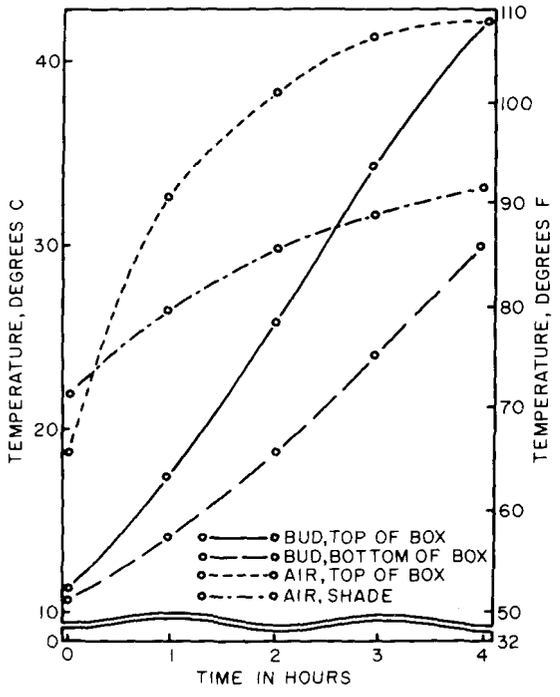
GRAPH 1. WARMING RATES OF 'IMPROVED WHITE SIM' CARNATIONS WHEN THE PACKAGE WAS EXPOSED TO DIRECT SUNLIGHT.



GRAPH 2. WARMING RATES OF 'FOREVER YOURS' ROSEBUDS WHEN THE PACKAGE WAS EXPOSED TO DIRECT SUNLIGHT.



Temperature managemen

CARNATION FLOWERS

E. C. MAXIE D. S. FARNHAM

Receivers in eastern markets occasionally complain that upon arrival, air-shipped California carnations appear "cooked" and 'Forever Yours' rosebuds have turned an unattractive blue. Neither species subsequently recover. Tests conducted during 1972 indicate that these problems are caused by poor packing practices, as well as handling procedures during transit.

CUT FLOWERS often are not cooled prior to shipment, even though roses are packed with shaved ice placed in the center of rose boxes. Both carnations and roses are packed in substantial amounts of paper or other insulating material. However, in air shipments, no refrigeration is provided, and once flowers are warmed they will remain warm until delivered to the receiver. High respiration rates create heat which speeds the warming of the flowers. Table 1 shows the measured respiratory rates and calculated respiratory heat evolution for 'Improved White Sim' open carnation flowers, and buds of 'Forever Yours' roses. From these data, one would predict severe adverse effects resulting from elevated temperatures. Respiratory heat production at 68°F (20°C) and 122°F (50°C) was approximately 25 and 165 times as great, respectively, as at 32°F (0°C).

Since boxes of flowers are frequently observed in open sunlight, or being held in warm rooms at air terminals or in markets, and considering the respiratory heat data, it was believed desirable to assess the potential effects of these practices on flower temperature. Thermocouples were placed in the center of open carnation flowers and buds of roses packaged in small, commercial boxes, in order to record temperatures continuously.

Graph 1 shows the warming rate of carnations from an initial 41°F (5°C) when the container was placed for four hours in direct sunlight. During the period of the test (10:00 a.m.–2:00 p.m.) the temperature of the ambient air increased from 68°F (20°C) to 84°F (29°C), while flowers in the top layer of the box reached 121°F (49.5°C), and those in the bottom of the box reached 88°F (31°C).

Graph 2 shows data for buds of 'Forever Yours' roses handled in an identical

TABLE 1. MEASURED RESPIRATORY RATES AND CALCULATED RATES OF RESPIRATORY HEAT PRODUCTION BY 'IMPROVED WHITE SIM' CARNATION FLOWERS AND 'FOREVER YOURS' ROSEBUDS

Temperature °F	Carnations		Roses	
	Respiratory Rate Mg. CO_2/Kg./Hr	B.T.U./Ton/Hr Respiratory Heat*	Respiratory Rate Mg. CO_2/Kg./Hr	B.T.U./Ton/Hr Respiratory Heat
32	9.7	89	11	95
68	239.0	2,191	293	2,685
86	516.0	4,730	530	4,858
104	1,053.0	9,653	872	7,990
122	1,606.0	14,718	1,445	13,245

* Calculated by the method of Lutz and Hardenburg, U.S.D.A. Handbook 66; $\frac{220 \times \text{Mg. } CO_2/\text{Kg./Hr}}{24}$

TABLE 2. AIR TEMPERATURES WITHIN CONTAINERS DURING AIR-TRANSIT OF CUT CARNATIONS FROM SAN FRANCISCO, 1972*

Date	Destination	Box Temperatures Initial	Box Temperatures Final	Air Temp. on Arrival
		°F	°F	°F
8/26	Binghampton, N.Y.	53	95	72
8/29	Knoxville, Tenn.	67	80	85
8/30	Newark, N.J.	65	75	70
9/6	Baltimore, Md.	56	85	?
9/6	Zelienople, Pa.	60	68	80
9/6	Rockford, Ill.	59	75	66
9/7	Dallas, Texas	66	85	86
9/7	Atlanta, Ga.	65	78	78
9/7	Savannah, Ga.	64	75	80
9/7	Savannah, Ga.	64	75	80

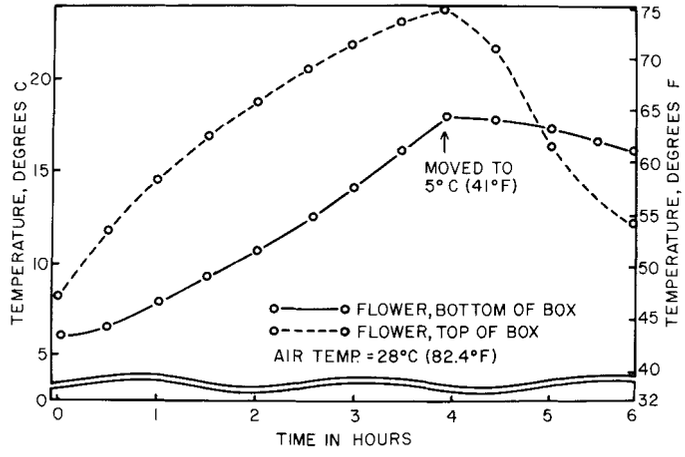
* Temperatures measured by Ryan recording thermographs packed within flower containers.

effects on quality of

AND ROSEBUDS

F. G. MITCHELL N. F. SOMMER

GRAPH 3. WARMING RATES OF 'IMPROVED WHITE SIM' CARNATIONS EXPOSED TO 82.4°F IN THE SHADE, AND COOLING RATES WHEN SUBSEQUENTLY PLACED AT 41°F.



manner. The ambient air warmed from 72°F (22°C) to 91.5°F (33°C) during the four hours of the test. Buds at the top of the box reached 109°F (43°C) and those at the bottom of the box reached 87°F (30.5°C).

Graph 3 shows the effect on carnation flower temperature of storage in a warm, dark room for four hours followed by transfer to 41°F (5°C). Flowers at the top of the box reached 75°F (24°C) and those at the bottom 63°F (17°C). The flowers cooled slowly once the box was placed at 41°F (5°C), but it should be emphasized that only a single, small box (12 bunches) was used. A large box (25 bunches) or stacks of boxes would be expected to cool very slowly. Under current methods of shipment the flowers would have remained at the elevated temperatures until delivered.

Graphs 4 and 5 show the results of holding 'Forever Yours' rosebuds at 83°F (28.5°C) with and without ice in the package. With ice, flowers at the top and bottom of the box both warmed to 60°F (15.5°C). Without ice, the flower temperatures in the two positions were (respectively) 74°F (23.5°C) and 71°F (21.5°C).

To evaluate carnation temperatures in transit, ten test shipments of Watsonville-grown carnations were shipped by air from San Francisco to eastern markets. Ryan recording thermographs were packed along with the flowers and the boxes were subsequently handled in typical commercial fashion. Table 2 shows the minimum and maximum temperatures recorded by the thermographs. In every case, the lowest temperature was recorded at the time of packing. Thereafter, temperatures rose until the flowers were unpacked. However, the most rapid rise occurred while the flowers were on the plane, or immediately thereafter. In five of the ten lots, air temperatures in the packages were 80–95°F. Considering respiratory heat production, the pulp temperatures of the flowers may have been as high as 90–105°F when the package was opened.

High temperatures within shipping containers may be a major factor adversely affecting quality of these two species of California cut flowers. Recent evidence indicates that temperatures in luggage compartments in commercial jet aircraft occasionally reach 115–130°F (46–54.5°C). Under such conditions, packaged cut flowers would likely suffer irreparable damage if the time of elevated temperatures exceeded two hours.

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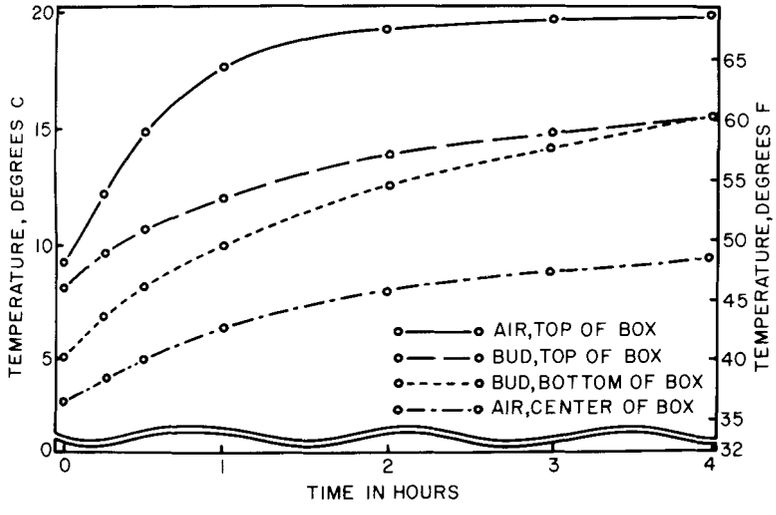
GRAPH 4. WARMING RATES OF 'FOREVER YOURS' ROSEBUDS HELD AT 82.4°F IN SHADE WHEN PACKAGE CONTAINED SHAVED ICE.



GRAPH 5. WARMING RATES OF 'FOREVER YOURS' ROSEBUDS WHEN HELD AT 82.4°F IN SHADE. PACKAGE CONTAINED NO ICE.