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Bulk bin Cooling of Oranges in storage rooms

Four variations in design of bulk bins were compared in test runs in three cold storage rooms with different cooling capacities. A comparison with field boxes on pallets was made in one of the rooms.

Each bin measured 48″ × 48″ at the bottom. All had 7/16″–9/16″ wide slots in the bottoms, 7½″ apart. Bins 30″ deep, holding 22 field boxes of fruit, were of three designs: with vertical slots in four sides approximately 7½″ apart; with sides closed except for a 1¼″ slot at the base of four sides; and with completely closed sides. Bins 24″ deep had closed sides.

Fruit coming off the trees in the morning was allowed to remain in the sun until the four bulk bins were full. Some fruit had a rise in pulp temperature as much as 25°F, which shows the advisability of shading fruit as much as possible from the direct sun and moving it to the shed without delay.

Six thermocouples—each inside an average-sized orange—were placed in each bin in the field, as the fruit was picked. There were three thermocouples in one corner at different depths—positioned one layer up from the bottom, at the middle, and one layer down from the top—and there were three in the center, at the same depths. The test bins were placed in the middle of a filled cooling room. Each was raised 6″ from the floor as a result of the built-in pallet for the fork lift, and was the bottom bin in a two-high arrangement. The air in the room was circulated by drawing it across cooling coils and blowing it out over the top of the fruit.

The records of the tests were plotted, and half-cooling times were calculated for air supply at a constant temperature. Half-cooling time is the time required to reduce the temperature of the fruit one-half the way from the initial temperature to cold storage air temperature.

At the end of each test run the coolest fruit was that at the bottom corner and the warmest fruit was at the top center. Open sides gave a slight increase in cooling rate over closed sides—around 10%–15%—showing that 85%–90% of the cooling, even in bins with slotted sides, was accomplished by convection of cool air up through the bin and fruit.

Cooling in the center of a bulk bin apparently takes about twice as long as in the center of a pallet load of field boxes. The 30″ deep bin required about 20% more time for cooling than the 24″ bin.

Uniformity of cooling may sometimes be as important as speed. In these tests, cooling was not consistently more uniform in one kind of bin than in another. However, the number of hours required for fruits to reach a given temperature—in either the warmest or the coolest location—was more than twice as great for closed-sided bins as for field boxes on pallets. Whether such differences would be of commercial importance was not determined.

As room cooling appears to be best adapted to oranges, apples, and pears, which are less highly perishable and which are commonly stored after cooling, the more rapid cooling in bins with open sides could be considered negligible. Open sides might offer greater advantages in other methods of cooling.

In selecting the bin best suited for a given use, consideration must be given to the kind of fruit and its respiration rate; the effect of slow cooling on fruit ripening or coloring; effect of air slots in damaging the fruit; and the importance of rapid cooling.

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Bulk bins similar to those tested. Front set of four bins awaits removal to shed as second set is being filled.

Half-Cooling Times of Oranges in Bulk Bins

Test room No.	Bin design: Bottom	Sides	Depth	Test fruit: Center top Hours	Corner bottom Hours
8	Slotted	Slot at base	30″	17.0	3.0
8	Slotted	Slotted	30″	22.0	5.0
8	Slotted	Closed	30″	25.0	6.4
8	Slotted	Closed	24″	19.0	6.0
16	Slotted	Slot at base	30″	38.3	10.9
16	Slotted	Slotted	30″	34.5	18.3
16	Slotted	Closed	30″	38.5	13.0
16	Slotted	Closed	24″	31.4	18.6
9	Slotted	Slotted	30″	16.4	4.6
9	Slotted	Closed	30″	20.0	10.0
9	Field Boxes			8.8	4.1

$$\text{Cooling coefficient} = \frac{\text{Cooling of product (°F/hr.)}}{\text{Air temp. diff. between product and air (°F)}}$$

$$\text{Half-cooling (hrs.)} = \frac{\text{Ln } 2}{\text{Cooling coeff.}} = \frac{0.69}{\text{Cooling coeff.}}$$