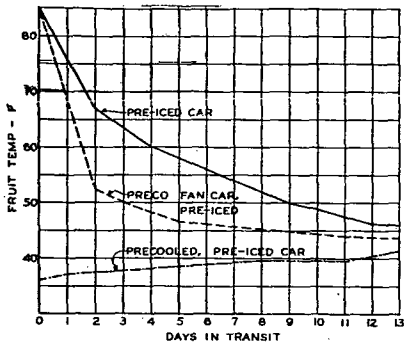


Pre-iced car. Replenish—do not re-ice.
Preco Fan car—pre-iced car. Replenish—do not re-ice.
Precooled—pre-iced car. Replenish—do not re-ice.

Fig. 7 .... Temperature of Packed Oranges in Transit under Three Different Methods of Refrigeration

then loaded into pre-iced cars which are replenished at the first icing station and re-iced at least once in transit. Similar results may be accomplished by loading the fruit directly into pre-iced fan-equipped cars, re-icing at the first icing station and then daily for the next two days (Fig. 7).

Limiting Storage Factors

The maximum time that packed California oranges can be held in storage and ultimately give consumer satisfaction in any market in the United States or Canada is affected by the following factors:

A. Factors Originating Prior to Storage
1. Climatic and environmental
2. Cultural and pest control
3. Degree of maturity
4. Picking under adverse weather conditions
5. Care in handling under all conditions
6. Ethylene treatment
7. Cleanliness of the packing-house
8. Other packing-house operations such as cleaning, treating, waxing, grading, etc.

B. Factors Originating During Storage
1. Air volume during precooling and storage
2. Temperature and relative humidity of supply air
3. Uniformity of air circulation
4. Ventilation

C. Factors Originating in Transit
1. Type of refrigeration
2. Length of time in transit

D. Factors Originating on the Market
1. Storage conditions while fruit is in the hands of the jobber and retailer
2. Time required to dispose of the fruit to the ultimate consumer

A few of these factors will be discussed briefly to emphasize the importance of a thorough knowledge of all phases of handling and treating the fruit from the grove to the market.

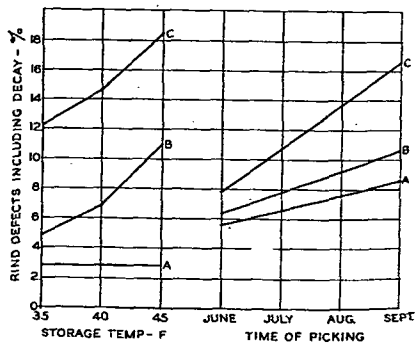
Fig. 8 indicates the effect of storage temperature and degree of maturity on the keeping quality of packed oranges. As the storage temperature is increased (minimum air volume, 3000 cfm per car), there is a corresponding increase in all rind defects (pits, spots, age, etc.), and decay. Also as the maturity of the fruit increases, it becomes more susceptible to injuries, rind breakdown, and decay. Fig. 9 indicates the effect of air volume (other factors being equal) on the development of rind defects, and decay, and the loss in weight. As the air volume increases the weight loss and all rind defects and decay decrease. As much actual damage to the fruit results from two weeks' storage in rooms using 750 cfm per car plus two weeks under standard refrigeration as in four weeks at recommended storage conditions and the same shipping conditions of standard refrigeration.

Fig. 10 indicates the seasonal variation for Navel and Valencia oranges for a four-year period. The fruit was taken from the same groves on approximately the same picking dates each season.

The effect of each individual factor on the development of decay, severe rind defects and deterioration in eating quality is cumulative, and unless a sound policy is adopted in regard to picking and the selection of fruit used for storage, considerable loss may result. Visual inspection of the fruit at the time of removal from storage may indicate a sound condition, when in reality severe damage may have occurred, but the actual breakdown may not become apparent until the fruit reaches the market or is in the hands of the consumer.

The potential storage life of packed oranges varies according to the variety and the conditions previously mentioned. Normally, however, for fruit picked, handled and stored under the conditions recommended, this storage life is as follows (including the time in storage in California, in transit under refrigeration and the time during which it is in the hands of the various dealers before it reaches the ultimate consumer):

Navel Oranges	Ethylene Treated	Untreated
Early maturity to fully mature	6 weeks	8 weeks
Full, mature to over-ripe	4 weeks	5 weeks
Valencia Oranges		
Early maturity to fully mature	6 weeks	8 weeks
Fully mature to over-ripe	4 weeks	6 weeks



A. Two weeks under standard refrigeration
B. Two weeks at indicated temperature (35 F, maturity effect) plus two weeks at standard
C. Same as B except four weeks in storage room

Fig. 8 .... The Effect of Storage Temperature and Degree of Maturity on the Development of Rind Defects and Decay During Storage of California Valencia Oranges

Considering all the factors that influence storage life, it becomes apparent that the maximum storage life is not always predictable unless all adverse factors can be recognized and taken into consideration. To give consumer satisfaction, California oranges should have at least two additional weeks storage life remaining when unloaded at the market.

Precooling Process

In California precooling is used for oranges but not for lemons and grapefruit, while in Florida precooling is a common practice for all citrus fruits, particularly such specialty fruits as Temple oranges, tangerines, tangelos and the Murcott Honey orange.

Precooling means the rapid removal of the internal heat of the orange as soon as it has been processed and packed for shipment. One reason for precooling is to improve the keeping qualities of the fruit. The other is to save ice during transportation to market in railway refrigerator cars. If storage is necessary because of unfavorable market conditions, the oranges are precooled at about 38 F. Precooling should always be carried below 50 F, but never lower than 36 F.

The carbon dioxide content of precooling rooms should be kept below 0.2 percent by the introduction of outdoor air. For normal fruit at 38 F storage temperature, 10 cfm per carload is sufficient. However, if the fruit is over-ripe or of low quality, it may be necessary to lower the carbon dioxide concentration to 0.1 percent.

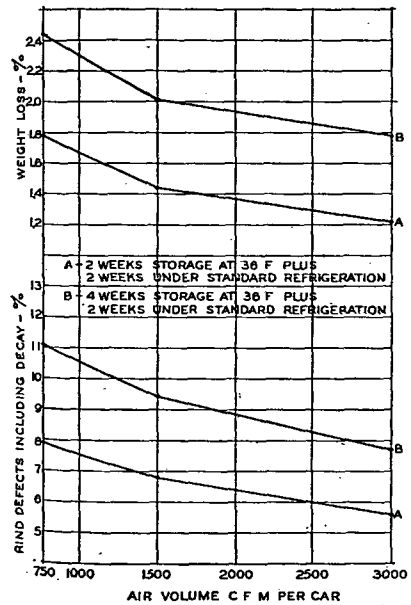


Fig. 9 .... Effect of Air Volume During Storage of California Valencia Oranges on Loss in Weight and Development of Rind Defects and Decay

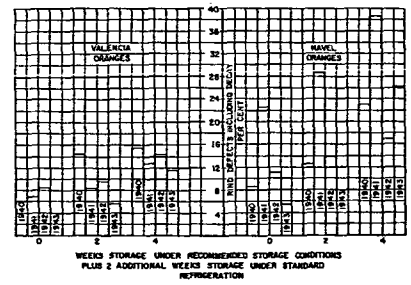


Fig. 10 .... Seasonal Variation of Development of Rind Defects During Storage of California Valencia and Navel Oranges

A precooling plant should be designed with a maximum storage capacity of ten times the daily precooling capacity. Thus a five car per day precooler should have a total storage capacity of 50 cars. Allowing three days (72 hr) for precooling, there will be 15 cars in the precooling process each day. At 3000 cfm per car, they will require 45,000 cfm supply air. Assuming rooms of five carloads capacity each, there will also be one room being loaded preparatory to precooling and and one being unloaded after precooling. This makes a total of 25 cars in process leaving 50—25, or 25 cars in storage under maximum load conditions. At 1000 cfm per car, the storage rooms require 25,000 cfm supply air. Thus the plant will require an air handling system of 45,000+25,000, or 70,000 cfm total. At least five precooling rooms of five cars capacity each, plus a 25-car storage room will be required. The usual design would be to have 10 rooms, each of five cars capacity, so that the fruit would not have to be moved from precooling to storage room. Each room would be used for either precooling or storage by varying the supply air quantity. Normally the fruit is held for an average of a week to 10 days under refrigeration before shipment.

In California precooling rooms are generally three times as long as they are wide. A 20×60 ft room will hold five cars of fruit with cartons stacked six-high on bottoms, or six cars with eight-high stacking. Normal design is six-high for precooling, but additional storage capacity may be obtained by stacking seven-high when necessary for long storage. It is possible to stack cartons eight-high on bottom with a clear ceiling height of 11½ to 12½ ft, and some storage rooms are designed for such high stacking. Pallets are in general use in large storage rooms.

EQUIPMENT SELECTION

Brine spray air washers, using a central station system, are used to a great extent in orange precooling work. Such systems are probably the most successful and satisfactory, especially for large plants, although unitary systems with cooling units in each room are sometimes used. Either dry-coil or wetted-coil units may be used. Because of the low temperature and high humidity, defrosting is a problem when using a dry-coil unit. Special defrosting means such as water defrost, hot discharge gas, or outdoor air duct connections must be provided. Wetted-coil brine spray units eliminate the defrosting problem but