Table 5 .... Storage Life of California Table Grapes

Variety	Storage Life, Months
Emperor, Ohanez, Ribier	3–5
Malaga, Red Malaga, Cornichon	2–3
Thompson Seedless, Tokay	1–2½
Muscat, Cardinal	1–1½

harvest infections can be reduced by applying fungicides in the vineyard during the growing season. *Captan* has been one of the most effective materials tested for this purpose.

The normal storage life of the principal varieties of California table grapes at 30 to 31 F is shown on Table 5. Under exceptional conditions sound fruit will keep longer than indicated; for example, Emperor grapes have been held in good condition for 7 months, and Thompson seedless for 4 months.

The storage life of grapes is affected in large degree by the attention given to selecting and preparing the fruit. Grapes should be picked at the best maturity for storage, especially Sultanina and Ohanez. Stems and pedicels should be well developed and the fruit should be firm and mature. Soft and *weak* fruit should not be stored. The display lug is a satisfactory package for storage since it can be cooled and fumigated easily.

Export chests can be effectively fumigated provided dunnage strips space the containers at least ¼ in. apart vertically and the paper liners are tucked down inside of each side of the chest. Sawdust must not be added until just before the chests are shipped.

Precooling to 40–45 F is advised for grapes that are to be in transit a day or two before reaching storage. Special care should be taken that good transit refrigeration practices are used for grapes shipped to storage so that decay will not get started. Grapes intended for storage, except those in sawdust packages, should be fumigated when shipped. It is not good practice to delay fumigation until the grapes reach a distant plant, for in the picking and packing of grapes many berries are injured sufficiently to permit mold to get started unless the fruit is fumigated promptly.

For *labrusca* (Eastern type) grapes storage temperatures of 31 to 32 F and humidities of 80 to 85 percent are recommended. Care in packing and handling the fruit, a minimum of delay before storage, and prompt cooling are important for best results with these varieties, as they are with the *vinifera* or California grapes. The Eastern varieties are not fumigated with sulfur dioxide because of their susceptibility to injury from it. The storage life of the important commercial varieties at 32 F is shown in Table 6.

Table 6 .... Storage Life of Eastern Grapes

Variety	Storage Life, Weeks
Catawba	5–8
Concord, Delaware	4–7
Niagara, Moore	3–6
Worden	3–5

DESIGN AND OPERATION OF FRUIT STORAGE HOUSES

The refrigeration required for fruit storage houses involves the customary consideration of: (1) losses through walls, ceilings and floors, (2) air leakage by infiltration and opened doors, (3) heat given up by the product when it is cooled, (4) heat given off by the product through respiration, and (5) miscellaneous sources of heat such as motors and men working in the rooms. For further information, see Chapter 27 of the 1961 Guide and Data Book.

The performance of the storage plant will depend in a large measure upon: (1) the provision of adequate capacity in compressor, condenser, and cooling tower for peak loads; (2) sufficient evaporator and secondary refrigerating surface to permit operating at high back pressures, thus preventing low humidities and permitting economical operation; and (3) efficient air distribution, with velocities high enough to effect rapid cooling of warm produce and volume great enough to permit operation during storage with only a small temperature rise between incoming and outgoing air. For further information, see Chapters 11, 28, 32, 35, and 37 of the 1961 Guide and Data Book.

Systems In General Use

Many of the older storage plants have rooms equipped with either brine or ammonia coils attached to the ceiling or walls. Air circulation is provided by natural convection, which leaves much to be desired in respect to rapid cooling and providing uniform temperature throughout the room. These deficiencies have been overcome in some instances by enclosing the coils with baffles and installing fans to provide positive circulation of air from the storage room over the coils. Rooms that are individually refrigerated have several advantages as compared to those on a common air bunker. They can be operated as individual units in respect to temperatures or humidities or fumigation treatments without affecting the rest of the plant. Individual unit coolers are suitable for small rooms, but when installed in large rooms should be used with some system of ducts to give good air distribution.

Many of the fruit storage plants constructed in recent years employ brine sprays as a means of providing a large cooling surface at low cost. The cooling unit usually consists of a bank of ammonia coils over which brine is sprayed. Air from the storage rooms is circulated through the spray chamber and is discharged into ducts that supply the storage rooms. A suitable brine eliminator is used to prevent droplets of brine from being carried into the air ducts. In some plants a similar air cooling and circulating system is used in which the bunkers have dry coils to take the place of brine spray.

Ice bunkers have been used in some fruit storage plants either as a means of cooling the storage rooms in case of breakdown of the mechanical refrigerating machinery, or to take care of peak loads such as are called for in precooling. The bunkers are sometimes built along one side or end of the storage room and fans are installed that circulate air from the bunkers to the storage space. Suitable air temperatures can be obtained during precooling by salting the ice. After the fruit has been cooled, mechanically refrigerated unit coolers are used to maintain desired temperatures. Some ice is usually left in the bunkers and several of the bunker fans are operated intermittently during storage to hold humidities at 87 percent or higher. Several modifications of this type of installation have been made, including the use of refrigerated coils in the ice bunker with a lengthwise partition between the ice compartment and the coils, so that by means of a damper, air can be circulated with the bunker fans either through the ice bunker or past the coils. An ice bunker of this type is sometimes installed in centrally refrigerated plants in such a manner that it can be used in lieu of the brine spray chamber or in conjunction with it to cool air delivered to storage rooms.

Temperature and Humidity Records

Temperatures are commonly taken in fruit storage rooms by a thermometer hung in the aisle or on one of the walls.

Unless the storage operator has established the fact that temperatures are uniform throughout the room, such readings are likely to be misleading and inadequate. To see that all parts of the room are at the desired temperature, readings should be made at several places. A record of air and fruit temperatures in the various storage rooms is information that the operator needs to determine the performance of the plant. This information can be obtained with glass fruit thermometers at the expense of space or labor to get to the middle of stacks of fruit; but it can be done more conveniently with distant reading thermometer equipment such as thermocouples or electrical resistance thermometers, with which some storages are equipped.

Storage instructions or recommendations usually specify an rh within a range of 3 to 5 percent. It is exceedingly difficult to read humidities as closely as this with the ordinary sling psychrometer at temperatures of 32 F or lower. An error of ½ deg in reading either the wet- or the dry-bulb thermometer will cause an error of 5 percent rh. Carefully calibrated thermometers graduated to $^1/_{10}$ deg with a range of 25 to 40 F are best adapted for this purpose in fruit storages. A convenient device for measuring humidities consists of a pair of these thermometers, mounted in a short length of metal casing attached to a spring or motor-operated fan which draws air past the thermometers at a speed of 3 fps or faster. To get dependable readings, the thermometers should be placed so that they will not be heated by the warm fan motor, and they should be read quickly to prevent warming. The advantage of this instrument over the sling psychrometer is that it can be left in the room long enough to get a true wet bulb reading. This may require 15 min or more if ice is formed on the wet bulb. Under these conditions, a thin coating of ice is preferable to a thick one in getting accurate readings. Hair hygrometers are satisfactory if not subjected to sudden large changes in humidity and temperature and if checked regularly with a psychrometer.

Another and perhaps more accurate method to determine the relative humidity is to record, electrically, the dew-point temperature of the air and to use a resistance thermometer of suitable sensitivity to record the ambient or dry-bulb temperature. From these temperature records the relative humidity can be calculated.

Removal from Storage

When fruit is removed from storage, care should be taken to prevent undue warming and condensation of moisture which promote decay and deterioration. Most storages are built on railroad sidings, and canvas tunnels should be provided between the car and the storage through which the fruit can be conveyed; to minimize the warming of the fruit and condensation of moisture upon it.

When fruit is removed from storage for distribution to wholesale and retail markets, there is little that the storage operator can do to prevent undesirable condensation. Warming the packages until they are above the dew point of the air would prevent it, but this takes time and space and is seldom practicable. Deterioration in flavor and condition proceeds rapidly after long storage periods. Decay likewise develops quickly in fruit after removal from storage. Therefore, the fruit should be moved to consumers as rapidly as possible.

BANANAS

The refrigerating equipment and design factors used in the banana industry can best be understood if there is a general understanding of the background of this tropical fruit. Bananas are available worldwide, but the United States imports bananas mainly from Central American countries as well as Mexico, the West Indies, Colombia, and Ecuador. There are many varieties of cultivated bananas, botanically related but having various handling characteristics and disease resistance. The principal banana varieties grown commercially are the Gros Michel, Cavendish, Lacatan, Giant Cavendish, and the Claret or Red banana. Other than the red banana, these varietal differences are not generally distinguishable to ordinary consumers. Most of the bananas marketed in the United States are the Gros Michel variety.

Although bananas are susceptible to several diseases, three which seriously affect the economics of the industry are Panama Disease, Sigatoka, and Dry Rot or Moko.

Panama Disease chiefly affects the Gros Michel variety and is caused by a soil fusarium which attacks the plant through the root systems and destroys them. Considerable research has been undertaken in an attempt to eliminate Panama Disease but, as yet, this goal has not been achieved. When Panama Disease causes the abandonment of Gros Michel producing acreage, disease resistant varieties of bananas or other crops may be planted, as the fertility of the soil is in no way affected.

The second disease, Sigatoka, is a leaf blight transmitted by airborne spores from one plant to another. The leaves are destroyed and the fruit fails to mature to marketable size. Effective control can be established by periodic spraying.

The third and lesser disease, Moko or Dry Rot, is a form of bacterial wilt. This is the same disease that affects other plants such as the potato, tomato, and eggplant. The only effective control is the destruction of the diseased plants. Helpful measures include the sterilization of harvesting tools and sanitary procedures such as clearing the infected area and allowing the land to lie fallow before replanting.

Considerable banana acreage is located in river valleys and is subject to flood losses after heavy rains. After a severe flood, it may take 15 months to replant an area to get it back into production. These floods tend to spread Panama Disease to areas not previously infected. Wind storms also inflict serious damage to banana plantations. The banana plant, by nature, has a shallow root system and a large leaf area, and relatively low velocity winds will topple the plants to the ground. The diseases and deterioration factors which affect the fruit in the stateside handling and ripening are discussed in Chapter 51.

Harvesting and Transportation

Bananas do not ripen satisfactorily on the plant in the tropics, therefore, the fruit is harvested green and at a stage of development which will allow it to be transported in refrigerated carriers to the country of destination and arrive there still green. Another reason for cutting the banana green is that the susceptibility of the fruit to injury by scarring, bruising and splitting is greatly increased as ripening advances. However, even with green fruit, precautions must be taken to minimize damage in transit and at the various points of transfer. Starting at the farm in the tropics, one of the first steps taken after cutting is the attaching of a loop of heavy string to the smaller end of the stalk which facilitates hanging from conveyors and in ripening rooms. The fruit is then transported, usually on padded carts, to receiving stations where it is washed to remove spray residue, dust and other foreign matter that may either cause damage or detract from the appearance of the fruit. After the stem is washed, a transparent polyethylene sleeve is placed over the fruit where it remains for the rest of the journey to the banana ripening rooms. The polyethylene provides protection against abrasive scarring during transportation and has the supplementary advantage