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CHAPTER 47

STORAGE OF APPLES, PEARS, GRAPES, AND BANANAS

Apples: Storage Temperature, Air Purification, Controlled Atmosphere, Storage Disorders; Pears: Controlled Atmosphere, Storage Disorders; Grapes: Storage Environment, Fumigation; Design and Operation of Fruit Storage Houses; Bananas: Harvesting and Transportation, Ripening, Effect of Temperature, Ripening Rooms, Refrigerating, Heating, and Humidity Systems, Controls, Packing and Shipping

ALL fresh fruits are alive and remain so during storage and marketing and even for some time after they are no longer in marketable condition. Being alive, they respire using stored chemical constituents, primarily sugars, and oxygen from the air to produce carbon dioxide and energy (heat). The reactions are extremely complex. The environment in which a harvested fruit is placed may greatly influence not only its rate of respiration but also other products formed in related chemical reactions within the fruit. All of these influence storage and market life.

In addition to deterioration after harvest by chemical changes within the fruit, two other forms of deterioration are important during storage and marketing; namely, dessication and diseases caused by microorganisms. Regardless of the kind of deterioration, its rate is greatly influenced by temperature. Deterioration of fruits by their own life processes or by microorganisms is reduced as temperature is lowered, so that the marketable life span may be perceptibly extended.

The specific relationships between temperature and rate of deterioration vary considerably between commodities and diseases. However, a reasonably accurate generalization assuming a deterioration rate of 1 for a fruit at 30 F would be as shown in Table 1. From these figures, it is obvious that the best temperature to slow down deterioration resulting from a fruit's own living processes or from pathogens is the lowest temperature that can safely be maintained without freezing the commodity. This would be approximately 1 to 2 F deg above the freezing point of the fruit in the most modern plants with efficient air distribution, and approximately 3 to 4 F deg above the freezing point in structures of older design.

Some fruits will not tolerate low storage temperatures. Severe physiological disorders that develop because of exposure to low temperatures are commonly classed as *chilling injury*. The precise reasons for this behavior are not understood, but it is known that normal biochemical functions are upset. The banana is a classical example of a fruit displaying chilling injury symptoms, and storage temperatures must be elevated accordingly. Certain apple varieties also exhibit this characteristic and for prolonged storage must be held at a temperature well above that usually recommended. The degree of susceptibility of an apple variety to chilling may vary with climatic and cultural factors.

The third important factor of deterioration, namely, dessication or water loss, results in shrivelling of the fruit and is strictly a physical factor related to the evaporative potential of the air. It may be expressed directly as vapor pressure deficit (P_D), a term indicating the combined influence of temperature and relative humidity (RH) on the evaporative potential of the air, normally expressed in millimeters (or inches) of mercury as follows:

$$p_D = p \frac{100 - (RH)}{100} \qquad (1)$$

where

p_D = vapor pressure deficit, millimeters (or inches) of of mercury.

p = vapor pressure of water at a given temperature, millimeters (or inches) of mercury.

(RH) = relative humidity, percent.

For example, comparing the evaporative potential of air in storage rooms at 32 F and 50 F dry-bulb, with 90 percent relative humidity in each room, the vapor pressure deficit at 32 F is 0.46 mm Hg, while at 50 F, it is 0.92 mm Hg. Thus, if all other factors were equal, commodities would tend to lose water twice as fast at 50 F dry-bulb as at 32 F at the same RH values. For equal water loss at the two temperatures, the RH would have to be maintained at 95 percent at 50 F in comparison to 90 percent at 32 F. These comparisons are not precisely true because the water in fruits contains a sufficient quantity of dissolved sugars and other chemical materials to cause the water to be in equilibrium with water vapor in the air at 98 to 99 percent RH instead of 100 percent RH. Lowering the vapor pressure deficit by lowering the air temperature is an excellent means of reducing water loss during storage.

Other important factors in fruit dessication include fruit size, the kind of protective surface on the fruit, and air movement. Of these, the storage operator can control only the last, and this control will be greatly influenced by the container, kind of pack and stacking arrangement or, in other words, the ability of the air to move past individual fruits.

As a rule, shrivelling does not become a serious market problem until fruits have lost about 5 percent of their weight, but any loss reduces the salable tonnage. It is not practicable to

Table 1 .... Approximate Relationship of Temperature and Deterioration Rate due to Physiological Processes and Microorganisms

Temp, F	Deterioration Rate
68	8–10
50	4– 5
41	3
37	2
32	1.25
30	1