horticultural crops are living organisms, carrying on many biological processes essential to the maintenance of life. They must remain alive and healthy until processed or consumed. Energy that is needed for these life processes comes from the food reserves that accumulated while the commodities were still attached to the plant [4].

Respiration is the process by which the food reserves are converted to energy. Through a complex sequence of steps, stored food reserves (sugars and starches) are converted to organic acids and subsequently to simple carbon compounds. Oxygen from the surrounding air is used in the process while carbon dioxide is released. Some of the energy is used to maintain the life processes while excess energy is released in the form of heat, called "vital heat." This heat must be considered in the temperature management program.

The respiration rate varies with commodity, in addition to variety, maturity or stage of ripeness, injuries, temperature, and other stress related factors. Strawberries have a high respiration rate, 12 to 18 mg CO_2/kg-h (2,700 to 3,900 Btu per ton per day) at 0°C (32°F) [3]. The major determinate of respiration activity is the product temperature. Since the final result of respiration activity is product deterioration and senescence, achieving as low a respiration rate as possible is desirable. For each 10°C (18°F) temperature increase, respiration activity increases by a factor 2 to 4 [3]. For example, the respiration of strawberries at 10°C (50°F) is 49 to 95 mg CO_2/kg-h (10,800 to 20,900 Btu per ton per day), four to five times greater than at 0°C (32°F). Therefore, strawberries must be rapidly precooled to slow their metabolism (physiological deterioration) in order to provide maximum quality and storage life for shipping and handling operations.

Strawberries are not a chilling-sensitive crop (crops which must be stored at temperatures generally above 10°C (50°F) to prevent physiological damage). Therefore, they can be safely cooled to a temperature of 0°C (32°F). The recommendation listed in the introduction indicated the requirement of precooling to near 0°C (32°F) within 1 hour of harvest and maintaining at 0°C (32°F) throughout the marketing channels. The required rate of cooling during precooling can be expressed in terms of the half-cooling time or the 7/8-cooling time. These values remain constant for the particular set of precooling conditions from which they are determined. The half-cooling time is the time required to remove one half of the temperature difference between the initial pulp temperature and the cooling medium temperature. For commercial precooling, it is recommended [6] that 7/8 of the difference between the pulp temperature and the cooling medium temperature be removed prior to storage and transport. Under ideal circumstances the 7/8 cooling time is equal to about three times the amount of the half-cooling time.

For example, if strawberries are harvested at 30°C (86°F) and cooled in a forced-air cooler with an air temperature of 1.1°C (34°F) the half-cooling time would be the time required to remove 14.5°C (26°F) or for the strawberries to cool to 15.5°C (60°F)[3]. For the same situation, the 7/8-cooling time would be the time required to remove 25.3°C (45.5°F)[4] or for the strawberries to cool to 4.7°C (40.5°F). By developing a precooling schedule [6] the 7/8-cooling time could be established. Therefore after precooling for a time period equal to the 7/8-cooling time or by determining the pulp temperature was 4.7°C (40.5°F)[5], the strawberries would be removed from the precooler and moved to cold storage for additional cooling to 0°C (32°F).

Cooling schedules should be utilized to maximize efficiency. Use of a schedule allows cooling times to be adjusted based on the initial temperature of the berries. Strawberries coming from the field at 18.3°C (65°F) do not need to be cooled for as long as fruits arriving at 32.2°C (90°F). Leaving strawberries in the forced-air cooler longer than necessary can lead to undesirable water loss because of rapid air movement. On the other hand, inadequate cooling can lead to rapid deterioration due to high temperatures.

Cooling methods

The selection of a particular precooling method is determined by several factors, including: the rate of cooling required, compatibility of the method with the commodities to be cooled, subsequent storage and shipping conditions, and equipment and operating costs.

During precooling, the sensible heat (or field heat) from the product is transferred to the ambient cooling medium. The rate of heat transfer, or cooling rate, is critical for the efficient removal of field heat and is dependent upon three factors: time, temperature, and contact. In order to achieve maximum cooling, the product must remain in the precooler for sufficient time to remove the heat

[2] [30 - 1.1] * 1/2 = 14.5 ([86 - 34] * 1/2 = 26)
[3] [30 - 14.5] = 15.5 ([86 - 26] = 60)
[4] [30 - 1.1] * 7/8 = 25.3 ([86 - 34] * 7/8 = 45.5)
[5] [30 - 25.3] = 4.7 ([86 - 45.5] = 40.5)