time would be the time required to remove 25.3°C (45.5°F)[5] or for the blueberries to cool to 4.7°C (40.5°F)[6]. By developing a precooling schedule [14] 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 that the pulp temperature was 4.7°C (40.5°F), the blueberries 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. Blueberries coming from the field at 18.3°C (65°F) need less time in the precooler than fruits arriving at 32.2°C (90°F). Leaving blueberries 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 air. The rate of heat transfer, or cooling rate, is critical for the efficient removal of field heat and depends on 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 (7/8 cooling time). This is particularly important during busy periods when it may be tempting to "push" product through the precooler. A correctly sized precooler should have sufficient capacity so as to provide adequate resident time for precooling, while at the same time not slowing subsequent packing and/or handling operations. The cooling medium (air) must be maintained at a constant temperature throughout the cooling period. If the refrigeration system is undersized for the capacity of product requiring precooling, the temperature of the medium will increase over time. The cooling medium must also have intimate contact with the surfaces of the blueberry. Inappropriately designed containers can markedly reduce flow of the cooling medium.

The rate of cooling depends not only on time, temperature, and contact with the commodity, but also on the cooling method employed. As noted above, most blueberries in Florida are room-cooled with some forced-air cooling. Hydrocooling (showering or immersion in chilled water) is not recommended because wet berries are much more susceptible to decay. Cooling with crushed or slush ice is even worse because the berries are likely to sustain physical damage. Vacuum cooling would produce critical moisture loss and procedures using water spray could not be used. Again, room cooling of blueberries is not an acceptable precooling method because it is too slow nor is reliance on refrigerated trucks during transit.

Forced-air cooling (pressure cooling)

Forced-air cooling, which has been described in detail in various publications [1, 2, 6, 8, 12, 14], can solve many difficult cooling problems because it provides for cold air movement through, rather than around, containers. The system, which creates a slight pressure gradient to cause air to flow through container vents, achieves rapid cooling as a result of the direct contact between cold air and warm product. With proper design, fast, uniform cooling can be achieved through unitized pallet loads of containers. Various cooler designs can be used, depending on specific needs. Existing cooling facilities can often be converted to forced-air cooling, provided sufficient refrigeration capacity and cooling surfaces (evaporator coils) are available. Some variations in forced-air cooler design are described here.

Forced-air tunnel

This is the traditional forced-air cooling system. Essentially, two rows of palletized containers or bins are placed on either side of an exhaust fan leaving an aisle between rows. The aisle and the open end are then covered to create an air plenum tunnel (Figure 2). With the exhaust fan operating, a slight negative air pressure is created within the plenum tunnel. Cold air from the room then moves through any openings in or between containers toward the low pressure zone (the tunnel), cooling the product as it moves. The exhaust fan can be a portable unit that is placed to direct the warm exhaust air toward the air return of the cold room, or it can be a permanent unit which

[3] [30 - 1.1] * 1/2 = 14.5°C ([86 - 34] * 1/2 = 26°F)
[4] [30 - 14.5] = 15.5°C ([86 - 26] = 60°F)
[5] [30 - 1.1] * 7/8 = 25.3°C ([86 - 34] * 7/8 = 45.5°F)
[6] [30 - 25.3] = 4.7°C ([86 - 45.5] = 40.5°F)