

to 6°C (9 to 10.8°F) can exist between the first (coldest) container and the last (hottest) container. In some packinghouses, the operators use the fruit on top of the first container to gauge the degree of cooling because it is the most readily accessible fruit. A large temperature gradient within the pallet of blueberries could exist when the top fruit of the first container has reached 7/8 cooling. This shows that care must be taken when choosing a fruit to measure the temperature to determine when cooling is completed.

Condensation in a package of berries prevents the berries from being easily seen by consumers and can potentially wet the berries, although research indicates condensation does not increase the incidence of decay [13]. Since condensation in packages is perceived as a problem by marketers and consumers, the packages should be designed to prevent condensation. Condensation in a package is a function of the amount of water vapor inside the package, the transpiration rate of blueberries, and the temperature and relative humidity in the cold room. Warm blueberry packages placed in a cold room are susceptible to condensation because the package temperature drops rapidly below the dew point temperature. Since blueberries are usually packed warm and then cooled, the package should remain free of condensation during any change of temperature. The top of the package should be designed to reduce water loss from the berries, at the same time the package should allow enough ventilation so as to not increase the cooling time and to prevent condensation inside the package. Use of a perforated top was found to be the best solution [6].

## Refrigerated storage, and shipping

After precooling, blueberries should be stored briefly in refrigerated storage prior to shipment. Figure 8 illustrates that forced-air cooling is 12 to 16 times faster than still-air (room) cooling [2]. The cooling rate would have been faster if the cooling room air was at the recommended temperature (0°C (32°F)) rather than 7°C (44°F). Refrigerated trucks should be precooled prior to loading the precooled blue-berries. After precooling, top icing of blueberries is not desirable during holding or transport.

## Modified atmosphere

Refrigeration is sometimes supplemented with modified atmosphere during transit or storage. With solid loads, the modified atmosphere may be

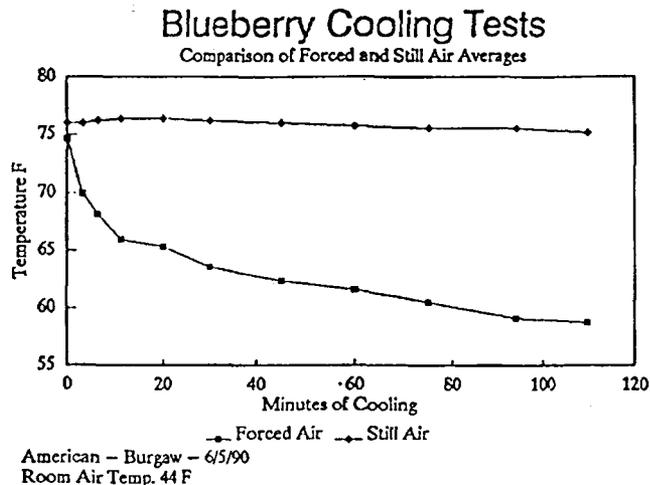


Figure 8. Comparison of averages of still and forced-air cooling [2].

established for the entire transport vehicle. Plastic shrouds can be placed over individual pallets equipped with a base that can be sealed. Pallet bags are installed after cooling, usually just before loading for transport. Carbon dioxide (CO<sub>2</sub>) is then injected into the package to establish the desired atmosphere. Use of plastic films with selected permeability to control the carbon dioxide and oxygen within the individual containers has also shown promise. Elevated levels of CO<sub>2</sub> (10 to 30 percent) slow the respiration rate of the fruit and reduce the activity of decay causing organisms, thus extending storage and market life. Increasing CO<sub>2</sub> (10 to 30 percent) reduces the respiration rate and the incidence of decay through direct or indirect effects on pathogens. Lowering O<sub>2</sub> levels can reduce the respiration rate of the fruit. Optimal concentrations of 5-10% O<sub>2</sub> and 15-20% CO<sub>2</sub> are recommended for blueberries. CO<sub>2</sub> atmospheres of 30 percent or greater can cause off-flavor [7].

## Management guidelines

The following management guidelines or recommendations summarize the important postharvest information discussed above.

Blueberries should be handled gently at all times to maintaining quality since they are so easily bruised. Bruised berries are very susceptible to decay. Anytime a fruit is bruised, the bruised area will discolor. In addition, bruising increases water loss and enhances softening. Only sound fruit should be shipped, because decay fungi can easily spread throughout each shipping container. Berries without small dry stem scars are particularly perishable. Strict grading should eliminate out of