

The refrigeration loads and unit selections may be determined by the foregoing methods.

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PRECOOLING

Methods of Precooling, Cooling with Air, Cooling with Contact Ice, Cooling with Top Ice, Cooling with Water, Cooling with Vacuum, Effects of Containers and Stacking Patterns

THE term precooling as used in the produce industry refers to the rapid removal of heat from a commodity prior to shipment or storage. Since the term rapid is relative it may, according to the method used and the needs of the commodity, involve a period of from $\frac{1}{2}$ to 24 hr or more. Precooling is essential to the proper handling of the more perishable fruits and vegetables. Ripening, deterioration, and decay development occur much more rapidly at high than at low temperatures. The more quickly field heat is removed after harvest, the longer the product can be maintained in good marketable condition.

Storage rooms designed for holding produce under refrigeration normally do not have either the refrigeration capacity or the air movement needed for rapid cooling. In most cases cooling in transit is also unsatisfactory. In conventional ice-refrigerated rail cars, with fans operated from the car wheels, air movement during the first 24 hr in transit is too variable for rapid cooling. Mechanically refrigerated rail and truck equipment generally does not have enough capacity for transit precooling. However, there is some evidence that newly developed equipment which provides continuous, high-speed fan operation in ice-refrigerated cars will be satisfactory for the rapid removal of field heat during the first 18 to 24 hr after completion of loading. Nevertheless, precooling for either storage or transport is generally a distinct and separate operation, requiring special facilities and equipment, which may be rooms with additional refrigerating surface and air volume, or supplementary refrigeration and blower capacity for cooling loads in rail cars or highway vans.

Precooling can be accomplished by a number of methods, but in the simplest terms it is transfer of heat from the commodity to a cooling medium, such as air, water, or ice. The heat exchange system must carry heat from the product to the source of refrigeration. Such a source can be ice, ammonia or halocarbon refrigerant evaporator coils, or cold brine.

The effectiveness of any of the conventional methods of precooling is controlled by four factors: (1) the nature of the cooling medium, (2) the temperature differential between the product to be cooled and the cooling medium, (3) the volume and velocity of the cooling medium, and (4) the accessibility of the product to the cooling medium. Because of heat transfer factors, some cooling media are more effective than others. Because cooling can be accomplished much more rapidly with water than it can with air, hydrocoolers are effective for those commodities which will withstand exposure to water and for which very rapid cooling is desirable.

Cooling rate is substantially affected by the difference in temperature between the product and the cooling medium. Since commodity temperatures at the beginning of precooling are not generally subject to control, the use of a large temperature differential to promote rapid cooling requires a coolant temperature as low as practicable without freezing.

With a given differential between commodity and refrigerant temperatures and a constant exposure, the rate of

cooling will be governed by the volume and velocity of the refrigerating medium. The rate of heat transfer is directly related to the velocity of the cooling air or water, and adequate volume is essential for thorough contact and the maintenance of velocity. The sweeping action of the coolant reduces the intermediate temperature zone around the product. As the velocity of the air or water increases, this intermediate zone decreases and the surface temperature of the product approaches that of the cooling medium. There is, of course, an optimum velocity for each situation, beyond which the small increase in cooling rate does not justify the added cost.

Accessibility of the product to the cooling medium refers to the thoroughness with which the air or the water can come in contact with all surfaces of the product to be cooled. An individual ear of corn will cool more rapidly than a packed crate of corn, and an individual peach will cool faster than a basket of peaches, when both go through the same hydrocooler. In a tightly packed crate or basket, the water may not reach any surface of some products. Pads or liners in the container that restrict the flow of the refrigerant may also hinder heat transfer. When cooling with air in a room or car, spaced stacks will cool much more rapidly than a solid block, unless the containers in the solid block are ventilated and stacked so that air can be forced through instead of around the containers. When a package is cooled by movement of air over its outer surfaces, cooling is more rapid if all surfaces, not just the ends or sides, of the package are exposed. The chimney load of carton-packed produce is difficult to cool by conventional methods because only a small portion of the total package surface is exposed. This factor of accessibility will be discussed in more detail in a later section.

METHODS OF PRECOOLING

As previously noted, many methods of precooling are available to the handler of fresh produce. Selection of method depends on the needs and adaptability of the commodity and the availability of equipment. Results with any of the methods will be satisfactory only when the available knowledge is applied to conduct the process at optimum effectiveness.

Cooling with Air

With moving air as the refrigerating medium, produce can be precooled satisfactorily in refrigerated rooms adapted to that purpose, in refrigerated rail cars or highway vans, on continuous conveyors in tunnels, or by the forced-air method of passing air through the containers by pressure differential. Each of these methods is used commercially, and each is suitable for certain commodities when properly applied.

Produce can be satisfactorily precooled in rooms, cars, or vans when the following conditions are met: (1) an adequate source of refrigeration, (2) an air volume of 6000 to 8000 cfm per carlot equivalent of product, with air directed in such a way that all containers in the load are exposed to