Strengthing Weak Links in the Cold Chain

by Jim Thompson, Department of Biological and Agricultural Engineering, UCD

Presented at Asia-Pacific Refrigerated Trade '98 Conference, March 4, 1998, San Francisco, CA

Perishable fruit, vegetables and ornamentals begin to loose quality as soon as they are harvested. Many of these products can be transported to market in refrigerated marine or land transport if they are handled properly to slow their rate of quality loss. Quality loss in one link of the cold chain adds to the loss sustained in the previous links. Product condition at market reflects the cumulative quality losses at each step in handling.

There are four environmental conditions that can be managed to get good quality product to market: 1) product temperature, 2) humidity surrounding the product, 3) ethylene gas concentration around ethylene sensitive products, and 4) atmospheric composition. Temperature is the most important of the four and influences the effects of the other three. Recommended levels of these conditions for most commodities can be found by visiting our website.*(http://postharvest.ucdavis.edu)*

Our recommendations are based on laboratory experiments and are the optimum range of conditions. If followed they will produce the best quality at market and increase the opportunity of increased sales and expanding markets. In commercial practice it can be difficult to achieve the optimum ranges without significant investment in company owned-equipment, personnel training, and government-financed infrastructure. I will list the best ways to maintain the cold chain for perishable products and also make some recommendations on compromise alternatives that will help slow quality loss when the optimum is not possible. The compromises will usually not do the best job of quality preservation but may be adequate in the short term.

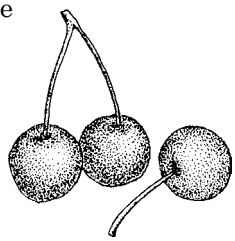
LINK 1 — Harvest to Initial Cooling

Most perishables need to be cooled to recommended temperatures as quickly as possible after harvest. A few hours of delay between harvest and cooling can have measurable effects on the deterioration rate of many perishable products. Trucks should take product to the cooler on a regular basis rather than wait to get a full load. Some products are cooled before packing because of long transport times or long waits before packing. Many products are more sensitive to mechanical damage when they are cold and packing equipment must be designed to gently handle cooled products. Limiting harvest to the cooler parts of the day allows longer delays before cooling.

Compromise alternatives to short delays before cooling can be anything that keeps the product cooler in the field. Shades reduce heating from the direct sun. Misting systems can be added to the shaded area to keep it even cooler and raise the humidity. Moisture loss can also be reduced by putting wilting sensitive products such as leafy green vegetables in vented plastic bags. The venting is needed to prevent undesirably low oxygen concentrations and allow condensed water to eventually evaporate. In tropical areas fruit is sometimes covered with fresh banana leaves. Wetted foam covers have been used by sweet cherry growers to reduce water loss.

LINK 2 — Initial Cooling

The most common methods of fast initial cooling are forced air, hydrocooling, package icing and vacuum cooling. If these are not available, initial cooling can be done by just placing product in a refrigerated storage room and managing the product carefully to speed cooling. There should be air



space between boxes, good box venting, and a good air flow in the room to force cold air past each package. This will allow most products to cool in less than 24 hours. Poor room air flow, tightly stacked product, and poor box venting will extend cooling to many days. The least desirable compromise is to load warm product in a refrigerated transport system. Most have limited ability to cool and the product may stay at excessive temperatures for long periods, especially if box venting is not compatible with the air flow system in the container.

LINK 3 — Short Term Storage

Many products are stored for short periods before transport. This allows loads to be accumulated and provides time to bring the product down to its optimum storage and transport temperature. The best management system keeps the air temperature at or slightly below the optimum and has enough air flow [about 100 cfm per ton of product ($0.047\ m^3 \cdot s^{-1} \cdot T^{-1}$)] to finish cooling. If ethylene sensitive products are mixed with ethylene producers, then ethylene scrubbers are needed. A new chemical is being developed which makes products insensitive to ethylene damage and may be an alternative to scrubbers in the near future.

If short term storage is not available then a compromise solution is to load the product into a refrigerated vehicle immediately after cooling. This requires that the vehicle be onsite during the entire time the load is accumulated. Warm product in a refrigerated vehicle will probably cause the refrigeration system to operate at maximum capacity for many hours. Switch to supply air temperature control, if this feature is available, to prevent product freezing. If vehicle has only return air temperature control, set thermostat 2° to 5°C (4° - 9°F) above the freezing or chilling damage temperature of the product. Another option for non chilling-sensitive products is to cool with crushed ice so that the ice will maintain low temperatures. Ice is expensive, requires a water resistant box and melt water drips from the box. Some of these problems can be minimized by forced air or hydrocooling the product then adding ice packaged in plastic bags. Ice is then only used for maintaining temperature and melt water can be contained.

LINK 4 — Marine Transport

Bottom air delivery marine transport has tremendous capability of maintaining temperature in chilled products if it is used correctly. Product should be well cooled before loading. The floor plenum needs to be covered to prevent air from bypassing the product. Open areas should be covered and palletized product may need special care to prevent refrigerated air from bypassing though pallet openings. Boxes should be vented and stacked to allow vertical air flow. Thermostats should be set to the lowest possible temperature, remembering that high sugar content fruits have freezing temperatures below 32° F (0° C). Mix only products that are compatible in their temperature and relative humidity requirement and in ethylene and odor sensitivity and production.

A compromise alternative to poor initial cooling is to finish cooling in transit. Product must be packaged and stacked to allow vertical air flow for this to be effective. Ethylene absorbers, such as potassium permanganate pellets, can be used to absorb ethylene if incompatible products are shipped together. Controlled or modified atmosphere systems are supplements to good temperature management practices. They are not alternatives to good temperature management.

LINK 5 — Destination Handling

Maintain the cold chain at destination by quickly unloading product to a refrigerated vehicle or cold storage. Customs inspections are often done in unrefrigerated areas and quick clearance procedures are necessary to maintain product temperature.

If it is not possible to maintain the cold chain at destination, product can be packaged in insulated or plastic foam boxes to slow warming. Package ice or ice contained in bags are also helpful in maintaining temperature. Product packed in modified atmosphere bags must be kept below critical temperatures. If the product warms above its critical threshold the package should be opened to prevent low oxygen damage. Product in plastic bags which has been warmed and later returned to a cold environment may experience condensation on the inside of the bag. Exposing product to free moisture for more than 24 hours may lead to increased decay. Poor temperature management at destination may limit the feasibility of marketing product in bags.

The key to managing the cold chain is to measure product temperature at each stage. Inexpensive temperature recorders are now available that allow product temperature to be

tracked from harvest to destination. Weak links in the cold chain can be identified with temperature history information, allowing managers to develop improved handling methods to maintain product quality and safety.