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DEPARTMENT OF FOOD TECHNOLOGY

COURSE CODE & NAME: 19FTT301 & Refrigeration & Cold Chain Management

III YEAR / V SEMESTER

UNIT : IV LOW TEMPERATURE STORAGE SYSTEMS

TOPIC 1 : Pre-cooling systems

What does Pre-cooling mean?

- Pre-cooling refers to removal of field heat (quick cooling) after harvest; if not, its deterioration is faster at higher temperature of 1 hour at 32^0C = 1day at 10^0C or 1 week 0^0C.

- The entire products must be pre-cooled as early as possible to the recommended storage temperature and relative humidity.

- Pre-cooling is done just above chilling and freezing temperature.

Advantages of pre-cooling

1. It removes the field heat
2. Reduces the rate of respiration and ripening
3. Reduces the loss of moisture
4. Reduce bruise damage during transits
5. Reduces the production of ethylene
6. Reduces /inhibits the growth of spoilage organisms
7. Eases the load on the cooling system (refrigeration) of transport or storage chamber
8. Above factor helps in extends the product shelf life

Pre cooling depends on the following factors

1. Air temperature during harvesting (during summer pre-cooling time is more)
2. Time between harvest and precooling
3. Nature of the crop (High perishable crop require immediate pre-cooling)
4. Difference in temperature between the crop and cooling medium
5. Nature/Velocity of the cooling medium
6. Rate of transfer of heat from the crop to the cooling medium.
7. Type of package material used – Use of water proof ventilated boxes for good air circulation in the room is helpful. Plastic boxes/ fiber board cartons which have been treated with wax will render them water proof.

Mechanism of pre-cooling

- Conduction and convection are the two main heat-transfer mechanisms used for cooling of produce.
- With conduction, the heat is transferred within a produce to its coldest surface. This is direct movement of heat from one object to another by direct methods (from fresh produce to water or warmer to cooler).
- With convection, the heat is transferred away from the surface of the produce via a cooling medium such as moving water or air.
- The rate of cooling depends on individual volume and the exposed surface of product.
- The difference in temperature between product and the refrigerating medium also needs to be taken into account.

  For example: large exposed surfaces, leafy vegetables cool almost 5 times faster than large fruit such as melons (more volume, less surface).

Types of pre-cooling methods

A. Cold air

i. Room cooling

ii. Forced air cooling (presser cooling)

B. Cold water / Hydro cooling

***C. Top icing* – direct contact with ice**

D. Evaporation of water from produce –

i. Evaporative cooling

ii. Vacuum cooling

E. Hydrovac cooling – combination of hydro and vacuum cooling

Commodity –wise cooling methods

Cooling methods	Commodities
Room cooling	All fruits and vegetables
Forced air cooling	Fruits and fruits type vegetables, tubers and cauliflowers
Hydro cooling	Stems, green leafy vegetables, fruits and fruit type vegetables
Package icing	Roots, stems, cauliflowers, green onion, brussel sprouts
Vacuum cooling	Stems, Leafy and flowers type vegetables
Transits cooling **-Mechanical** **-Top iceing & channel icing**	All fruits and vegetables Roots, stems green leaf vegetables and cantaloupes

Cold Air cooling

- ***i. Room cooling***
- In room cooling, heat is transferred slowly from the mass of the produce (by convection) to the cold air being circulated around the stacked containers.
- This is most common and widely used method. Here cold air is passed from the fan and cool by convection process.
- Its commonest use is for products with relatively long storage life and marketed soon after harvest.
- Under this system, cold air from evaporator enters the room, moves horizontally and then passed through the produce containers and return to the evaporator

Advantage

- Produce can be cooled and stored in the same room without the need of transfer and hence it is economical.
- Almost all crops are suitable for this type of cooling but it is mainly used in citrus fruits, potato, onions, garlic, citrus etc.

Disadvantage

- It takes more time to cool the products- the removal of heat slowly makes this system unsuitable for highly perishable commodities. This is because the product needs at least 24 hours to reach the required storage temperature.

ii Forced air cooling or pressure cooling

- In this system ‘cold air is passed by force from one side to other side using big fan’.
- Cold air movement is through the containers rather than around the containers.
- Air is blown at a high velocity leading to desiccation of the crop. To minimize this effect, air is blown through cold water sprays.

Advantage

- Cooling is 4 to 10 times more rapid than room cooling and its rate depends on airflow and the individual volume of produce.
- It is a good alternative for crops requiring rapid heat removal which cannot tolerate wetting or chlorine of cooling water.
- This system can be applied to all crops particularly berries, ripe tomatoes, bell peppers and many other fruits, cabbage, green peas, cucumber, brinjal, muskmelon, watermelon and mushroom.

Disadvantage

- It is slow compared to hydro cooling.
- Adequate airflow is necessary. This is because fruits in the center of packages tend to lose heat at a slower rate, compared to those on the exterior.
- This system is also called as high humidifier. High RH of 90 - 95% is to be maintained in the precooler to avoid dehydration during cooling.

Hydro cooling/Cold water cooling

- Principle - ‘the transmission of heat from a solid to a liquid is faster than the transmission of heat from a solid to a gas’. i.e. water is better heat conductor than air.
- Hydrocooling can be achieved by immersion or through means of a chilled water shower.
- Under this method, water is usually cooled by mechanical refrigeration, but ice may be used to make process faster. Chlorine (150-200ppm)/Iodine/Nutrients/Growth regulators/ Fungicides can be added in water to sanitize/ improve nutrient status and prevent post harvest diseases of the produce.

Advantage

- Hydro cooling avoids water loss and may even add water to the fruit.
- It helps in cleaning the produce, provides fast, uniform cooling for commodities.
- It is faster than forced air cooling.

Disadvantage

- Not all crops can be hydrocooled, because they need to be able to tolerate wetting, chlorine, and water infiltration.
- Tank water can be contaminated with micro organisms which can result in increased levels of spoilage during subsequent storage or marketing so chlorine should be added to avoid the problems.

Two types of hydro coolers are generally used.

- ***i. Shower/batch type*** - The water showers over the commodity, which may be in bins or boxes, or loosen a conveyer belt. A common design is to transport the crop on a perforated conveyer belt (the speed of the conveyer can be adjusted to the time required to cool the crop) and cold water is pumped from the tank and allowed to fall on the produce in sprinkled type and then falls through to the tank below then filtered, recycled and re cooled.
- Efficient cooling depends upon adequate water flow over the product surface. For product in bins or boxes, water flows of 75-100 lt. /min./ft.(400-600 l/min/m2) of surface area are generally used.

- ***ii. Immersion type*** – It is simplest type of a hydro-cooler in which produce is dipped in cold water. Here product are normally in bulk, is in direct contact with the cold water as it moves through a long tank of cold. This method is best suited for products that do no float, because, slow cooling would result if the product simply moved out of the water. Immersion hydro coolers convey product against the direction of water and often have a system for agitating the water. Depth of the water tank should be >30 cm and water tends to penetrate inside fruits, particularly those that are hollow such as peppers. Water temperature also contributes to infiltration. It is recommended that fruit temperature is at least 50C lower than liquid.
- Eg.: Radish, Asparagus, Artichoke, Green onion, capsicum and leafy vegetables.

Top icing

- This is one of the oldest ways to reduce field temperature.
- It is commonly applied to boxes of produce by placing a layer of crushed ice directly on top of the crop.
- It can also be applied as an ‘ice slurry’made from 60% finely crushed ice, 40% water and 0.1% sodium chloride to lower the melting point of the ice.
- Ice slurry give greater contact between produce and ice compared only top icing, and therefore result in quicker cooling.
- The main use for top icing is for road transport and it can be applied shortly after harvest. Top-ice on loads should be applied in rows rather than a solid mass. It is important not to block air circulation inside the transport vehicle. Ratios of water to ice may vary from1:1 to 1: 4.

Advantage

- Direct contact between the produce and the ice provides fast, initial conduction cooling.
- During transport to maintain a high relative humidity for certain products.

Disadvantage

- However, as the ice melts, an air space is created between the ice and the produce and the conduction cooling stops. Subsequent cooling is by radiation and convection, both of which are slower processes than conduction.
- It also increases costs because of the heavier weight for transportation and the need for oversized packages. In addition to this, as water melts, storage areas, containers, and shelves become wet.

Vacuum cooling

- Vacuum cooling takes place by water evaporation from the product at very low air pressure (At a normal pressure of 760 mmHg, water evaporates at 100ºC, but it does at 1ºC if pressure is reduced to 5 mmHg.).
- Produce is placed in a strong, airtight, steel chamber. Moisture loss is achieved by pumping air out of the chamber containing the product and reducing the pressure of the atmosphere around the product.
- It causing the water in the produce to vapourize.
- Cooling occurs because the heat energy for vapourization comes from the produce.
- *Advantage*
- Most rapid and uniform methods of cooling. Products that easily/rapidly release water may cool down rapidly.
- Eg.: Most suitable - Leafy vegetables, cabbage, carrots, capsicum, celery, corn, lettuce, mushrooms
- *Disadvantage*
- Not suitable - Tomato with low ratios between mass and surface area and effective water barrier like wax on surface is not suitable.
- Vacuum cooling causes about 1% product weight loss for each 50 of cooling.
- High cost and sophistication operation needed.

Ways to increase pre cooling- efficiency

- Pre cooling should be done as soon as possible after harvest.
- Harvesting should be done in early morning hours to minimize field heat and the refrigeration load on pre cooling equipment.
- Harvested produce should be protected from the sun with a covering until they are placed in the pre cooling facility.

Precautions

Since most tropical produce are sensitive to chilling injury, care must be taken not to precool or store the produce below the recommended temperature.

- All produce are sensitive to decay. Precooling equipment and water should be sanitized continuously with a hypochlorite solution to eliminate decay producing organisms.
- Care also must be taken not to allow produce to warm up after precooling. Condensation on pre cooled produce surfaces at higher air temperatures also spreads decay.

THANK YOU...