FDE 447
COLD PRESERVATION TECHNOLOGY

Content:

***Preliminary processes for fruits and vegetables**

-Pre-cooling

-Waxing

***Cold storage management**

pre-cooling

The purpose of pre-cooling:

- Removal of field heat
- Reduce energy required for cold storage
- Marketing flexibility

  *market at an optimum time (economy, quality)

  *market over a long distance

Pre-cooling temperature

- Generally horticultural produce are cooled to their storage temperature:
- For example: Grapes are cooled to 1-4°C, Potato to 5-9°C (do not wash with water)
- Mango, tomato and banana to be cooled to >10°C

- All fruits and vegetables are mostly cooled by a room cooling and or mechanical refrigeration

Precooling

- Highly perishable products such as broccoli, ripe tomatoes, carrots, leafy vegetables, apricots, strawberries, peaches, and plums must be cooled as soon as possible after harvesting.

- Cooling is not necessarily or as important for long-lasting fruits and vegetables such as potatoes, pumpkins, green tomatoes, and apples.

Proper pre-cooling preserves product quality by

- inhibiting the growth of decay producing microorganisms
- restricting enzymatic and respiratory activity
- inhibiting water loss
- reducing ethylene production

The most commonly used pre-cooling methods:

- Hydrocooling
- Forced-air cooling
- Top or liquid icing
- Vacuum cooling

Hydrocooling

- Dumping produce into cold water, or running cold water over produce, is an efficient way to remove heat, and can serve as a means of cleaning at the same time.
- Water is a good heat transfer medium compared to air.
- In addition, hydrocooling reduces water loss and wilting. Use of a disinfectant in the water is recommended to reduce the spread of diseases.
- Hydrocooling is not appropriate for berries, potatoes to be stored, sweet potatoes, bulb onions, garlic, or other commodities that cannot tolerate wetting.
- Hydrocooling is appropriate for celery, asparagus, peas, carrot, sweet corn, cherry and peach.

Forced-air cooling

- Fans are used in conjunction with a cooling room to pull cool air through packages of produce.
- The cooling rate depends on the air temperature and the rate of air flow.
- Fans should be equipped with a thermostat that automatically shuts them off as soon as the desired product temperature is reached.
- Forced-air cooling systems are not as effective as hydocooling systems.

Top or liquid icing

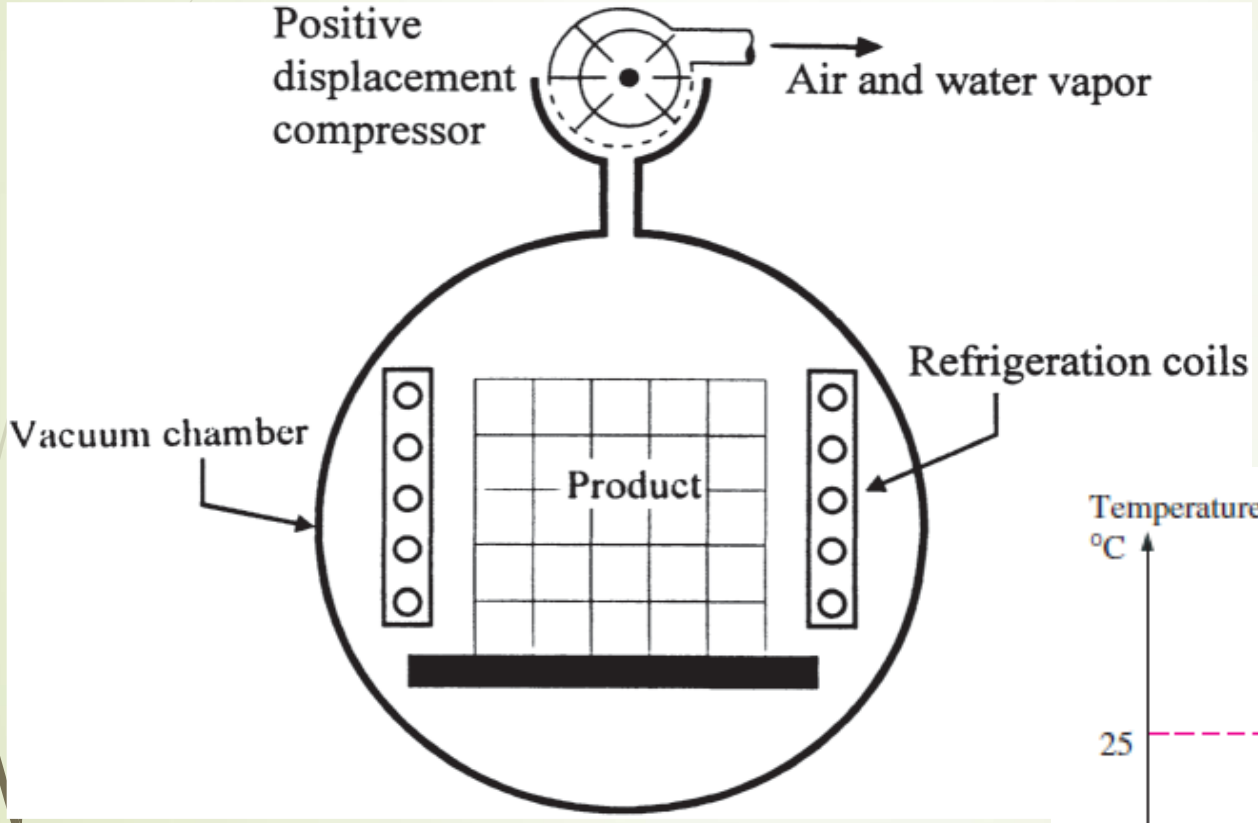
- Icing is particularly effective on dense products and palletized packages that are difficult to cool with forced air.
- In top icing, crushed ice is added to the container over the top of the produce by hand or machine.
- For liquid icing, a slurry of water and ice is injected into produce packages through vents or handholds without removing the packages from pallets and opening their tops. Icing methods work well with high-respiration commodities such as sweet corn and broccoli.
- Also, ice provides moisture as well as refrigeration.
- One pound of ice will cool about three pounds of produce from 30° C to 4° C.
- Icing is appropriate for cabbage, melone, peach, carrot,

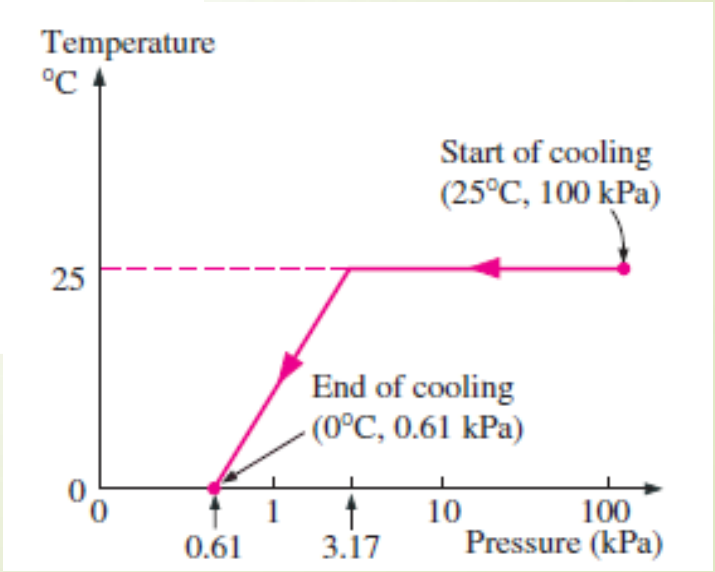
Pre-cooling by vacuum application

In vacuum cooling, the product is placed in an air-tight chamber which is then evacuated. When the partial

- pressure of the water vapor in the chamber drops below the vapor pressure of the water on the surface and in the tissue of the product, the liquid evaporates to cool the product.
- Field heat can be removed from leafy vegetables such as lettuce, spinach, endive, parsley, and others using vacuum cooling.
- Moisture loss by the product during cooling may ranges from 0.5 to 5% without detriment to the product, but moisture losses higher than about 5% of the product weight are likely to result in some wilting.
- The time required for commercial vacuum cooling units to reduce the product temperature to the 0 to 1°C range is about a half hour for lettuce to one or two hours for some other products.

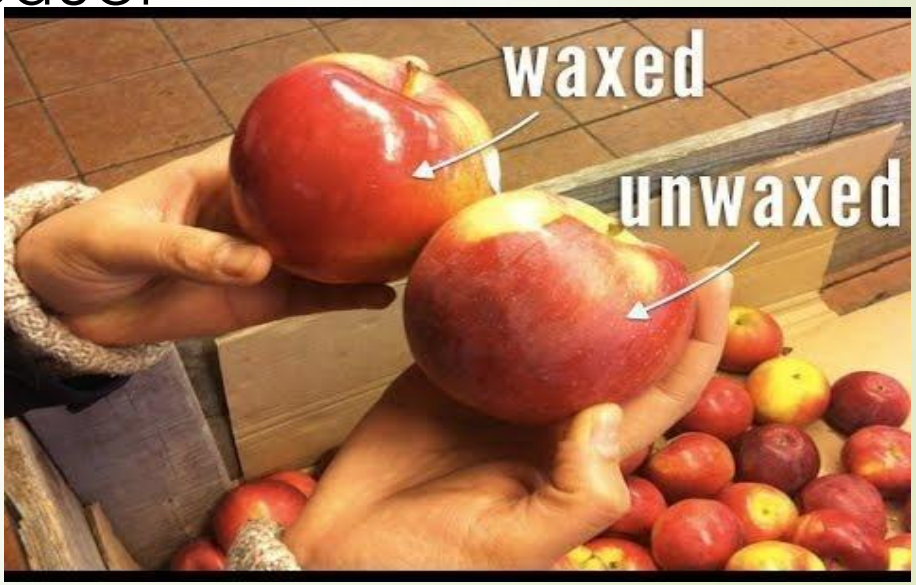
- Products with large surface area per unit mass and a high tendency to release moisture are well suited for vacuum cooling.
- Vacuum cooling is appropriate for cauliflower, spinach, green beans and lettuce.





Waxing

- waxing is done to supplement or replace the natural wax on the surface of a commodity, which may be removed during cleaning and packing.
- Waxing consists of applying a thin layer of edible wax to the outer surface of the product



Advantages:

- prevents moisture loss
- Reduce respiration rate
- İmprove appearance
- Long shelf life
- Reduce post harvest decay

Cold storage management

- Temperature control
- relative humidity levels,
- air circulation,
- adequate space between storage bins, trays and containers,
- the mixing of compatible produce, as well as the management of product in and outflow which should follow the ‘First In, First Out’ principle.

Storage mix

- Different produce has different storage demands with regards to factors, such as optimum temperature, level of relative humidity, levels of ethylene production and sensitivity, and chilling sensitivity.
- Hence, the storage of single commodities is less complex than the storage of multiple commodities; however, the latter can still be the more viable option depending on external circumstances.
- Besides damages due to mismatches in temperature, also odors can be transmitted and ripening and decay can be affected through the exposure to ethylene, which can result in changes in color, flavor and texture.
- Further, only high quality produce should be 'allowed' in the cold storage and produce should be sorted accordingly

Examples of odor transfers which should be avoided:

- apples/pears with celery, cabbage, carrots, potatoes or onions
- celery with onions or carrots
- citrus with strongly scented vegetables
- pears/apples with potatoes à former acquire unpleasant taste
- green pepper will taint pineapples
- onions, nuts, citrus, potatoes should be stored separately

Examples of ethylene producing and ethylene sensitive products:

- Ethylene producing: e.g. apples, avocado, bananas, pears, peaches, plums, tomatoes
- Ethylene sensitive produce: e.g. lettuce, cucumbers, carrots, potatoes, sweet potatoes

Stacking

- Adequate airflow and the even distribution of cold air need to be ensured.
- It is important to note that air always takes the path where resistance is lowest, and hence partly or unevenly filled storage facilities will have poor cooling rates.

The following points should be considered:

- A gap of at least 8 cm between walls and the floor, and the stacks of produce should be kept in order to ensure air flow
- Well-ventilated storage boxes/containers/crates will improve cooling speed, such as PVC crates or ventilated boxes made of cardboard[3]
- adequate space in between storage pallets should be about 10-15 cm.

Operation and maintenance

- Cold storage is a very costly and energy intensive undertaking and therefore the door to the cold storage should be opened as few times as possible and that also in the early morning or evening hours.
- Also the usage of lighting and fans should be kept at a minimum.
- **Logbook:** operators should keep track of incoming and outgoing, as well as produced stored, including anticipated arrival time, quantity, quality, anticipated storage time, storage conditions required, sales price on day stored, actual sales price, energy consumed, etc. of new produce.
- **Inventory:** an up-to-date inventory should be kept including information about location within cold storage, type, quantity and harvest date of produce, use of pre-cooling method, date produce entered the facility, etc.
- **Loading:** in general, loading rates should be 4-5% of total capacity. The cold storage should be divided in areas for short-term and longer-term storage space.

Hygiene

- In order to prevent pathogen built-up within the facility, strict hygiene measures are pivotal.
- All hygiene measures have to take necessary safety measures for staff into consideration.

- Clean thoroughly at the end of each season: wash walls and floor with sanitizers, such as hypochlorite solution.
- Use of ozone generators to prevent molds and fungi.

- Regular ventilation to avoid built-up of ethylene, carbon dioxide and odors.

Cooling load

- The cooling load is the amount of heat that must be removed per unit time in a cooling system.

cooling load;

- Unsteady state
- Steady state

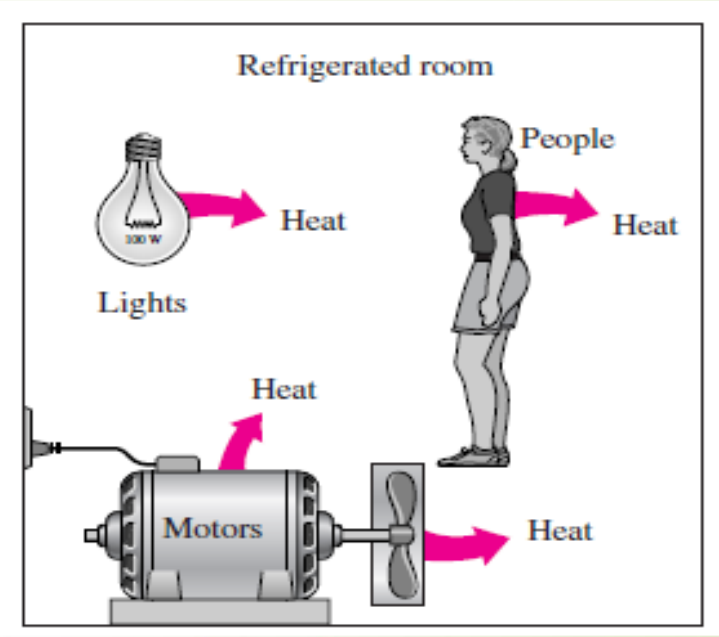
Unsteady cooling load: It is the amount of heat that must be removed within a certain period of time to cool the food from its current temperature to the constant temperature at which it will be stored.

Steady state cooling load: It is the amount of heat that must be removed within a certain period of time in order to keep the food that has been cooled down to storage temperature at a constant temperature.

Unsteady state cooling load includes:

- Sensible heat + respiration heat
- It should be considered only one time
- If pre-cooling is applied, this load is eliminated.

Steady state (internal) load includes:



The heat generated by

- the people,
- lights,
- Electric motors,
- Other heat dissipating equipment

in the refrigerated space.

- A person must generate more heat at lower temperatures to compensate for the increased rate of heat transfer at higher temperature differences. The heat dissipated by an average person in a refrigerated space maintained at temperature T in °C is expressed as

$$Q_{people} = 270 - 6T(^{\circ}C) \text{ (W/person)}$$

Heat dissipated by workers in cold storage

Temperature, °C	Dissipated heat, W
10	211
4.4	246
-1.1	278
-6.7	308
-12.2	352
-17.0	381
-23.3	410

Heat dissipated by lamps

- The rate of heat dissipation from lights is determined by simply sdding the wattage of the light bulbs and the fluorescent tubes.
- For example, a 100 W llight bulbs contribute 100 W to the refrigeration load.
- An electric motor housed inside the refrigerated space dissipates 1375 W of heat per kW of power.
- If the motor is housed outside the refrigerated space, but the element driven by it is inside the refrigerated space, 980 W of heat is emitted per kW of power of the electric motor.
- The warehouse gains heat with the air entering from outside due to those entering and leaving the warehouse. The amount of this heat is calculated in various ways (from theoretical or experimental data).

Cold storage temperatures of some fruits and vegetables

COMMODITY	STORAGE TEMPERATURE (^{0}C)	RELATIVE HUMIDITY (%)	SHELF LIFE
Asparagus	0-2	95	2-3 weeks
Beans (green)	5-7	90-95	7-10 days
Carrot	0	90-95	2-5 months
Cauliflowers	0	90-95	2-4 weeks
Cucumbers	7-10	90-95	10-14 days
Cabbage	0	90-95	3-6 weeks
Pepper	7-10	90-95	2-3 weeks
Couregettes,	0-10	90	5-14 days
Eggplants, Brinjals	7-10	90	1 week
Melons	0-4.4	85-90	5-14days
Okra	7-10	90-95	7-10 days
Onion (dry)	0	65-70	1-8 months
Potatoes (white)	5-10	93	2-5 months
Potatoes (sweet)	12-16	85-90	4-6 months
Tomatoes (ripe)	7-10	85-90	4-7 days
Tomatoes (green)	12-20	85-90	1-3 weeks
Watermelons	4.4-10	90	2-3 weeks
Apples	1-4.4	85-90	3-8 months
Avocados	4.4-12.5	85-90	2-4 weeks
Mangoes	12	85-90	2-3 weeks
Pineapples	7-12.5	85-90	2-4 weeks
Pawpaw	7.0	85-90	1-3 weeks
Carnations	0-2	90-95	3-4 weeks

Source: FAO 1989