Storage Systems

Food Storage

- The process in which both cooked and raw materials are stored in appropriate conditions for future use without any entry or multiplication of microorganisms.

Food Storage

- Balance the day to day fluctuations in product harvest and sales.
- Allows food to be eaten some time after harvest rather than immediately.
- Facilitates special treatments of certain commodities.
- Practiced by almost every human society and by many animals.

Goals of Food Storage

- To slow biological activities of product by maintaining the lowest temperature and controlling atmospheric composition.
- To slow growth and spread of microorganisms by maintaining low temperatures and minimizing surface moisture on the product.
- To reduce product moisture loss by reducing the difference between product and air temperature and maintaining high humidity in the storage room.

Food is Stored to…

- Preserve crops to consume out of season.
- Keep products in good conditions.
- Slow down aging.
- Protect from frost.
- Provide even supply.
- Avoid gluts.
- Prevent shortages.
- Obtain high prices.
- Enabling a better balanced diet throughout the year.

Food is Stored to…

- Preparedness for catastrophes, emergencies and period of food scarcity and famine.
- Religious reasons.
- Protect from animal and theft.

Storage Considerations-Temperature

- Temperature is the most important factor.
- The velocity of biological reactions increases 2 to 3 fold per every 10 ^{0}C rise in temperature.

$$Q10 = \frac{\text{Rate of deterioration at temperature T+10 } ^{0}\text{C (R2)}}{\text{Rate of deterioration at temperature T (R1)}}$$

- Q10 values can be used to determine rate of biological reactions and relative shelf life of perishable commodities.

Effect of temperature on deterioration rate of a non-chilling commodity

Temperature (^{0}C)	Assumed Q10	Relative velocity of deterioration	Relative post-harvest life
0		1.0	100
10	3.0	3.0	33
20	2.5	7.5	13
30	2.0	15.0	7
40	1.5	22.5	5

Storage Considerations-Temperature

- Storage temperature below the optimum range for a given commodity causes freezing or chilling injury.
- Storage temperature above the optimum range shorten storage life.
- Wide temperature fluctuations cause either water condensing or rapid water loss.

Storage Considerations-Temperature

- Determining optimum temperature depends on several factors.

✓Climate of the area where the crop originated.

✓The plant part.

✓The season of the harvest.

✓Crop maturity at harvest.

- Also depends on the design factors of the storage building.

Storage Considerations-Temperature

✓Refrigeration system

- Appropriate size to handle the maximum expected heat load.
- Air leaving the refrigeration coils should be close to the desired temperature in the room.

Storage Considerations-Temperature

- ✓Adequate wall and ceiling insulation.
- ✓Adequate air circulation (0.06-0.12 m^3/min per metric ton of product).
- ✓Containers must be stacked to form air channels past one or two sides of each unit.

Storage Considerations-Temperature

- ✓The fans must move air past the product.
- ✓Higher air flow is needed if these conditions are not met or if the product releases large amounts of heat.
- ✓Thermostats are kept at 1.5m above the floor in representative locations in the room.

Storage Considerations-Temperature - Freezing Injury

- ✓Occur in all commodities below 0 ^{0}C.
- ✓Some products can be repeatedly frozen and thawed without damage, while others are ruined by one freezing.
- ✓Injuries can be reduced if the product is allowed to warm up slowly to optimum storage temperature.
- ✓Injured products should be sold immediately.
- ✓Injury from freezing can appear in plant tissues.

Fruits and vegetables are classified by susceptibility to injury by temperatures below 0 ^{0}C.

Most susceptible	Moderately susceptible	Least susceptible
Beans **Cucumber** **Eggplant** **Lettuce** **Okra** **Pepper** **Tomato** **potato**	**Apples** **Cabbage** **Grapes** **Spinach** **Dry onions**	**Beet** **Cabbage** **kohlrabi**

Storage Considerations-Temperature - Chilling Injury

- ✓Products that require warm storage temperature (4 – 12 ^{0}C) can be damaged if they are subjected near freezing point.
- ✓Symptoms do not develop until the product has been returned to warmer temperatures.
- ✓More susceptible to diseases infections.

Fruits and vegetables are classified by susceptibility to injury by temperatures below 0 ^{0}C.

Commodity	Approximate lowest temperature (^{0}F)	Symptoms
Eggplant	45	Surface scald, alternaria rot, blackening of seeds.
Okra	45	Discolouration, water soaked areas, pitting, decay.
Potato	38	Sweetening.
Tomato (ripe)	45-50	Water soaking, softening, decay.
Banana	53-57	Dull grey-brown skin colour.
mango	50-55	Grey skin scald, uneven ripening.

Storage Considerations-Humidity

- Water is the main constituent of fresh fruits and vegetables.
- Harvested produce should be handled carefully to minimize both water loss and the presence of free water.
- Water loss from the produce reduces its saleable weight.
- Reducing water loss is important.

Storage Considerations-Humidity

- During post-harvest handling and storage fresh fruits and vegetables lose moisture through transpiration.
- Moisture loss occur due to the water vapour pressure gradient between the product and the environment.
- Evaporation at the product surface is an endothermic process.
- Respiration increases product temperature and thus the transpiration.

Storage Considerations-Humidity

- Perishable commodities must be kept at 90-95% of RH.
- RH below this causes excessive water loss and RH closer to 100% causes excessive growth of microorganisms and surface cracking of certain commodities.

Storage Considerations-Humidity

- Refrigeration equipment must be designed to maintain high RH.
- Evaporative coils that operate at lower temperature causes excessive amounts of moisture to be condensed on the coils resulting low relative humidity in the storage room.
- A hygrometer or a sling psychrometer should be used to monitor humidity.

Storage Considerations-Humidity

- Operating a humidifier in the storage area.
- Regulating air movement and ventilation in relation to storage room load.
- Maintaining refrigeration coil temperature within 2°F of the storage room air temperature.

Storage Considerations-Humidity

- Using moisture barriers in the insulation of the storage room or transport vehicle, and in the lining of the packing containers.
- Wetting the storage room floor.
- Using crushed ice to pack produce for shipment.
- Sprinkling leafy vegetables, cool-season root vegetables, and immature fruits and vegetables with water.

Storage requirements for common fruits and vegetables

Commodity	Temperature (^{0}C)	RH (%)	Approximate shelf life (months)
Apples	32	90-95	4-6
Pears	32	90-95	1-2
Carrot	32	90-95	4-6
Potato	38-40	90	5-8
Pumpkin	50-55	70-75	2-3
Leeks	32	90-95	1-3
Cabbage	32	90-95	3-4