T.o.p.i.c 3

FOOD PRESERVATION

This topic covers food spoilage and preservation methods

LESSON OUTCOMES (LO)

Upon completion of this lesson, students should be able to:

3.1 explain causes of food spoilage

3.2 describe various techniques of preservation and their applications

3.1

FOOD SPOILAGE

Food Spoilage Factors

- **Biological**
  - microbes
  - parasites, insects, pests, rodents
- **Bio-chemical**
  - enzymes
- **Chemical**
  - lipid oxidation
  - non-enzymatic browning
- **Physical**
  - harvesting
  - processing
  - distribution
  - storage

Causes of Food Spoilage

- The major types of spoilage are due to microbiological, biochemical, physical and chemical changes
- All of these factors can act together
  - e.g.: heat, moisture, and air could affect the activities of bacteria and enzymes

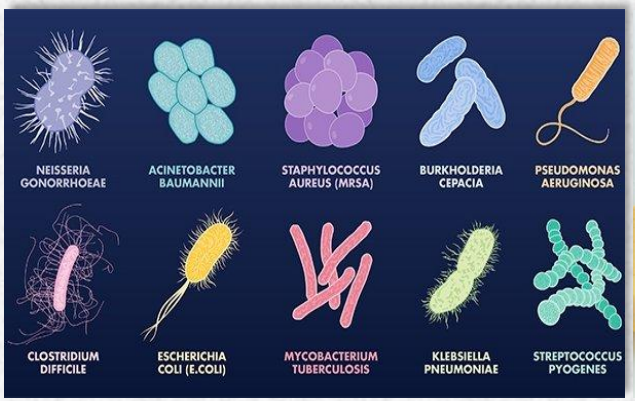
Biological Factors

i. Spoilage due to growth and activity of **microbes**

- Microbes are everywhere
- use food supply as a source of nutrients for their own growth, which results in deterioration of food by:
  - producing enzymatic changes
  - contributing off-flavours
  - breaking down of a product
  - synthesizing of new compounds

- Favorable condition for growth:
  - Bacteria - warm, moist, low acid, protein-rich
  - Yeast – warm, acidic (pH4-5), sugar-rich
  - Mould – moist, humid, acidic, sugar and starch-rich

- Bacteria are <u>most difficult to kill</u> and are the most common causes of spoilage
  - present in 2 forms
    - Vegetative - easily destroyed at boiling temperature
    - Spore – destroyed by harsh treatments, e.g.;
      - application of heat 100°C for a long time (6 hours)
      - 121°C under 15 psi pressure for 30 min



ii. Spoilage due to parasites, insects, pests and rodents

Parasites

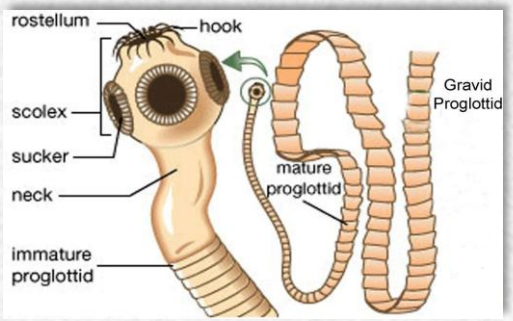
- live on or in a host (derive benefit from it)
- found on various food, e.g. meat, seafood, fresh produce

Insects and Pests

- consume and contaminate food
  - facilitate microbial attack

Rodents

- consume and contaminate food through droppings, urine and filth
  - also carries of pathogens



Biochemical factors

Enzymes

- biochemical catalysts that present in all living organisms and tissues
- responsible for specific desirable or undesirable changes in foods, e.g.:
  - desirable - ripening of fruits, starch conversion into sugar
  - undesirable - enzymatic browning, post harvest senescence
- If enzymatic activities are **uncontrolled**, the off-colours, off-odours, and off taste may develop in foods
  - activities are controlled by temperature, water activity, pH and chemicals

- Enzymes can act between 0°C and 60°C but 37°C is optimum temperature
  - can be permanently inactivated by heat
    - Above 60°C - heat quickly destroys enzymes and stops living cells from working
    - All enzymes are inactivated at 80°C
- Decreased temperatures therefore work by slowing down these changes

Chemical factors

Lipid Oxidation

- influenced by oxygen, water, high temperature, light, presence of iron and copper
- food become off-flavor and off-odour

Non-enzymatic Browning

- is one of the major causes of deterioration
- takes place during frying, cooking, storage of dried/concentrated foods through:
  - Maillard reaction - formation of brown insoluble pigments
  - Caramelization - bitter and brown pigment
  - Ascorbic acid oxidation - brownish juice

Physical factors

- damage during harvesting, processing or distribution
  - increases the chance of chemical or microbial spoilage and contamination because the protective outer layer is bruised or broken
- improperly packaged foods, dented/broken packages
  - provide places for microorganisms, air, light and creatures to enter
- improper storage temperature

e.g., chilling injury, freezer burn,

3.2

PRESERVATION METHODS

why do we process food?

- To make food edible
  - some are inedible in their natural state
- To increase the shelf life of the product
  - destroys microorganisms and enzymes responsible for food spoilage
  - available all year round regardless of seasonality
    - reduced post-harvest loss
- To maintain the quality and stability of a product
  - Includes adding components that were lost during processing or were not present
- To increase the variety of food products, making them more convenient
  - meets the demands of on-the-go lifestyle
- To ensure food is affordable for all

PRESERVATION

- is a set of **methods** that convert raw materials into food for human consumption

PRESERVATION

Typical Preservation Methods

1. **Chemical Inhibitors** *(see Topic 2)*
2. **Heat Treatment**
3. **Dehydration**
4. **Chilling & Freezing**
5. **Fermentation**
6. **Irradiation**

Chemical Inhibitors, **HEAT TREATMENT,** Dehydration, Chilling & Freezing, Fermentation, Irradiation

- The purposes are to:
  - reduce/destroy microbial and enzymatic activities
  - impart physical/chemical changes to meet certain quality standards

- e.g.: blanching, pasteurization and sterilization

Heat Treatment

Blanching

- inactivates enzymes that might alter the taste, colour and texture
- soften vegetable tissues
- **Techniques:**
  - Immersing in boiling water
  - Exposing to steam 2-10 minutes

Pasteurization

- destroys all pathogenic microbes (cause illness)
- does not kill microbes that cause spoilage
- **Techniques:**
  - **LTHT** (Low Temp. High Time)
    - 63°-66°C, ≥ 30 min followed by rapid cooling below 10°C
  - **HTST** (High Temp. Short Time)
    - ≥ 72°C, ≥ 15 sec., followed by rapid cooling below 10°C
    - continuous process

Sterilization

- complete destruction of all microbes
- undergo a high level of heat treatment
- **Techniques: e.g.**
  - **UHT** (Ultra Heat Treatment)
    - ≥ 132°C, ≥ 1sec.
    - continuous process
  - **Canning -** processing temp depends on the food acidity:
  - **High acid** (pH below 4.5)
    - Up to 100°C, 5-15 min.
    - e.g. citrus fruits
  - **Low acid** (pH above 4.5)
    - 115°-121C, 10-15 PSIG
    - e.g. meat, fish

Blanching

Pasteurization

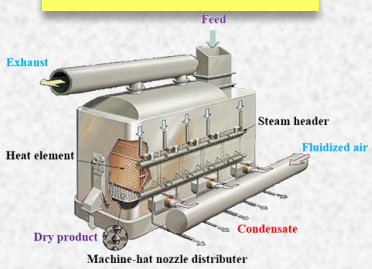
Sterilization

Chemical Inhibitors, Heat Treatment, **DEHYDRATION,** Chilling & Freezing, Irradiation

- Reduces food water content by the application of heat (usually in the presence of a controlled air flow)
  - delays bacterial growth
  - slows down enzymatic activity

DEHYDRATION

- Hot Air (Adiabatic)
  - Sun
  - Mechanical
    - Kiln
    - Cabinet
    - Tunnel
    - Fluidized Bed
    - Spray
- Osmotic
- Freezing
- Solid Surface
  - Drum
- Concentration



Hot Air (Adiabatic) Drying

Foods are dried by direct contact with natural or forced air

Sun Drying

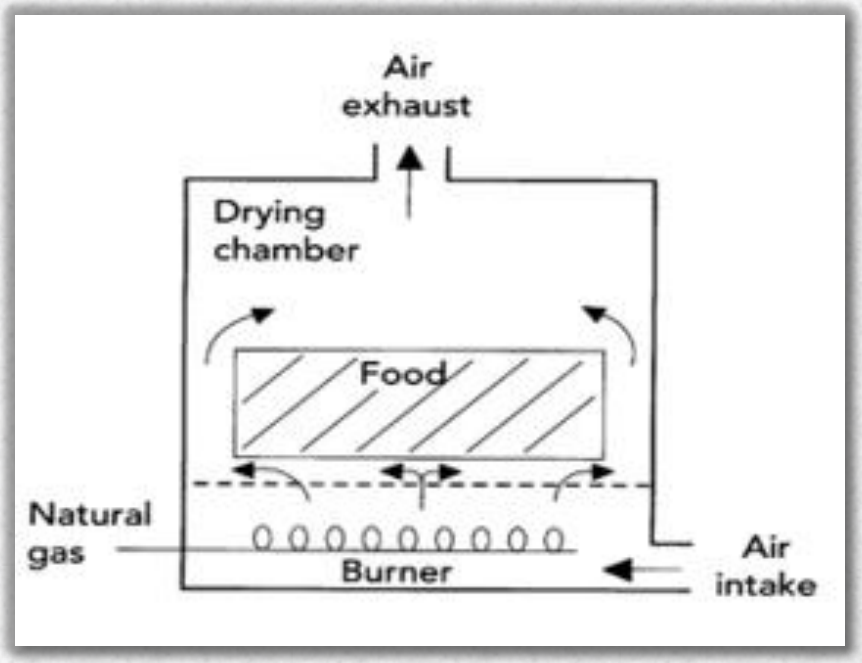
- relies on the sun and natural airflow
- a slow gentle process that really bring out the flavor of food
- inefficient, exposed to dirt, insects, rodents, bird

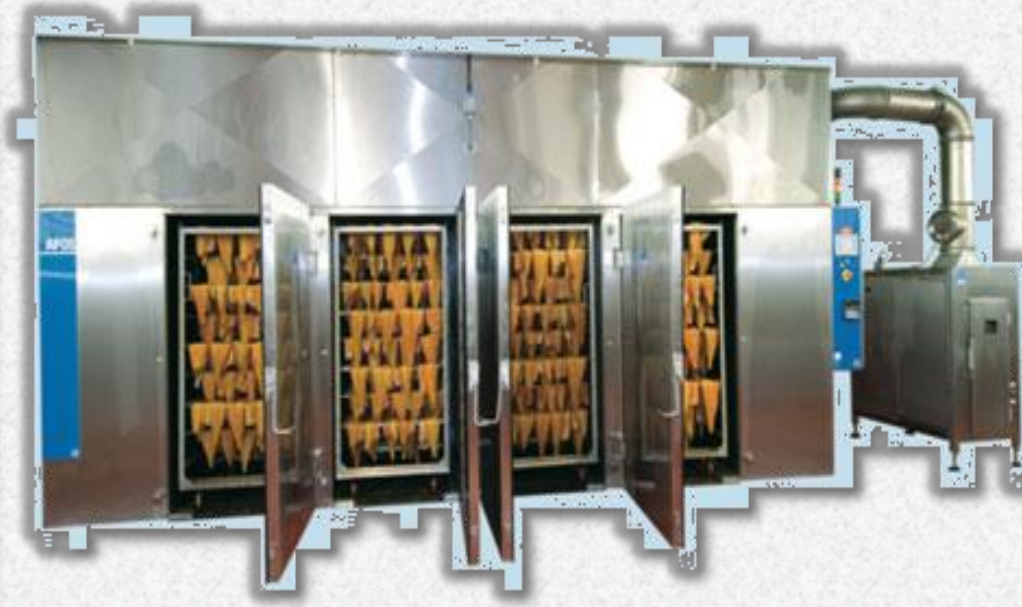
Mechanical Drying

- removes water from food by forcing either ambient air or hot air
- heated air is used for rapid drying

Kiln Dryer

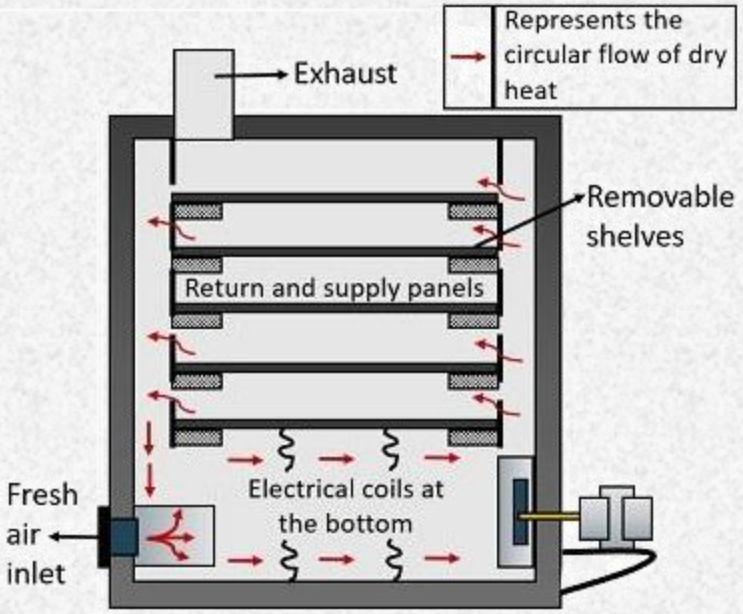
- consists of two-floor installation:
  - Top – fresh food placed on perforated floor
  - Bottom – burner
- hot air (~ 60°C) is forced from the bottom floor by a ventilator





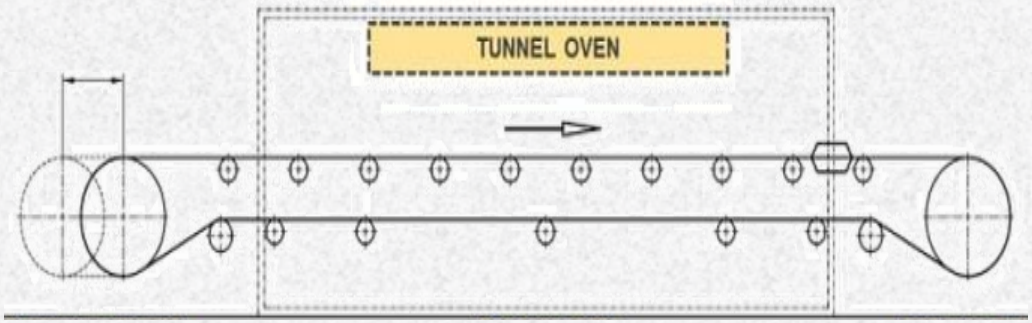
Drying Cabinet

A conventional oven with a thermostatic setting of ~60°C for drying of foods



Tunnel Dryer

- fresh food placed on a trolley or a conveyor belt is pushed from one end of the tunnel chamber and then removed from the another end
- the food is dried while being moved through the hot chamber (~ 55°C)



Fluidized Bed Dryer

- food particulates placed on a perforated plate is blown up with hot air (~100°C) from the pores
  - the force of the hot air is just enough to suspend the food in a gentle tumbling motion
    - exposes all sides of food to the hot air and minimizes the resistance to heat on the food surface
- the food is fed from one side of the dryer and dried food is removed from the other end.

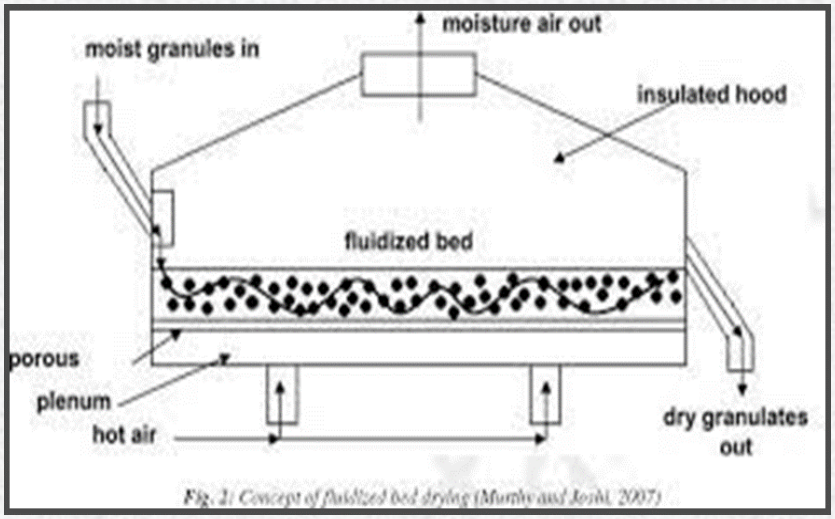
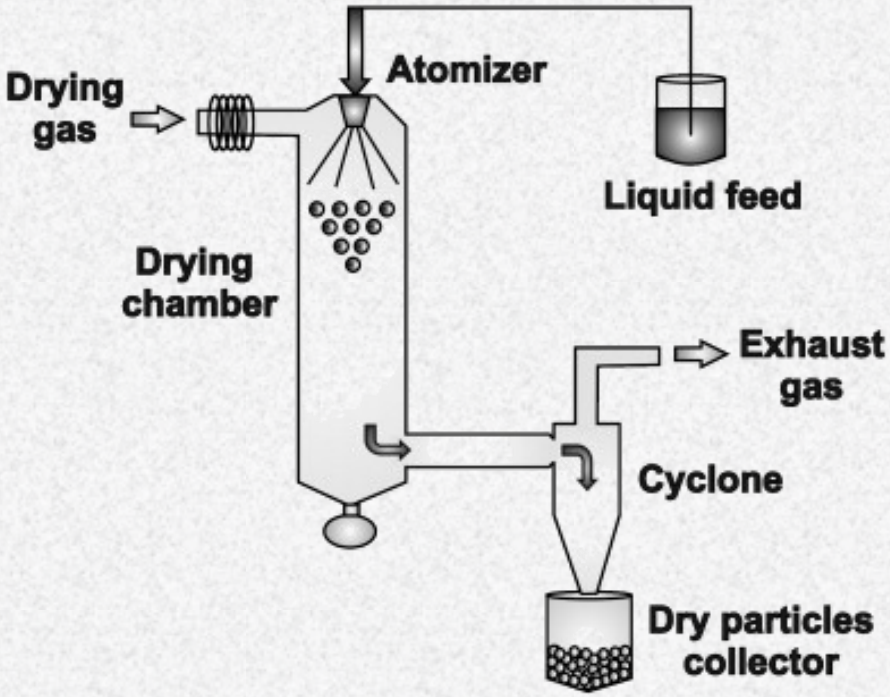
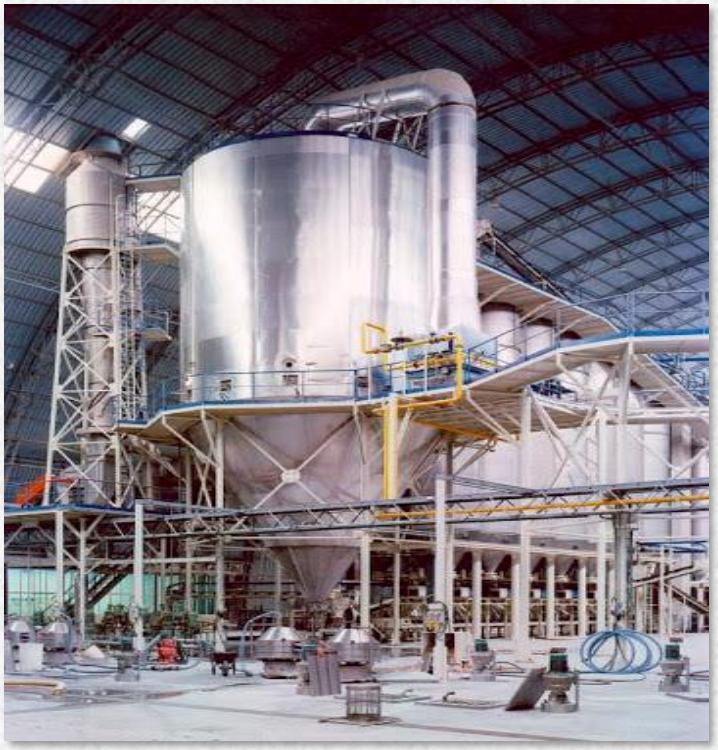


Fig. 2: Concept of fluidized bed drying (Murthy and Joshi, 2007)

Spray Dryer

- a food solution is atomized into small droplets and rapidly evaporated into solid powder by forced hot air (~140°C) in the drying chamber
- the powder is then separated from the drying gas using a cyclone





Osmotic Drying

- use of osmotic principle
- cut fruits/vegetables are immersed in a hypertonic solution (sugars or salts)
- difference in concentration will cause the removal of water from the food
- the rate of removal can be enhanced by increasing the hypertonic concentration and temperature

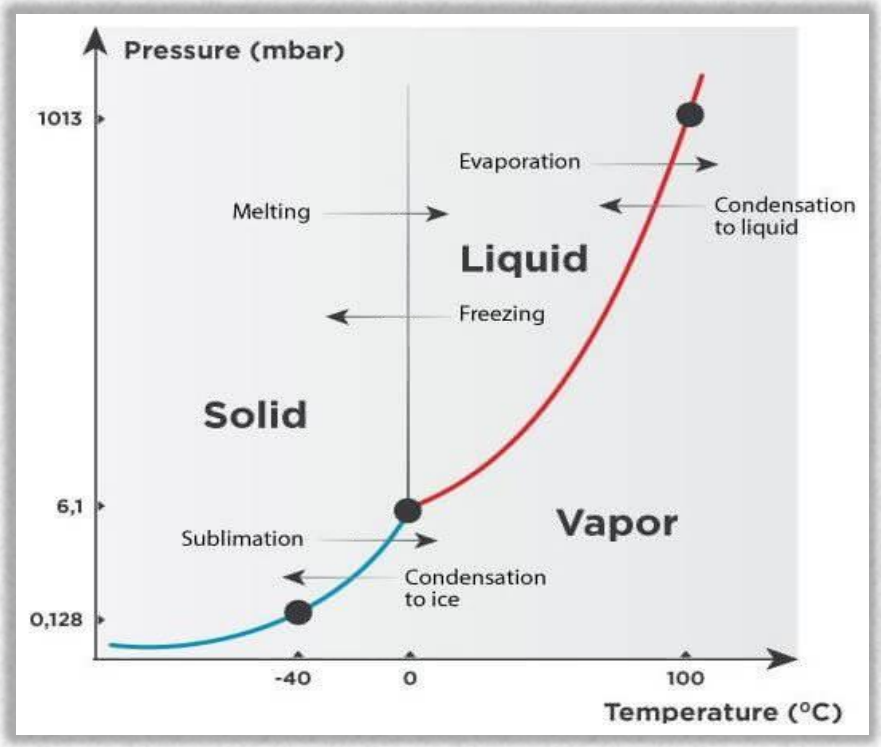
The principle of osmosis

When a semipermeable membrane separates two fluid spaces, water will flow from an area of lower solute concentration to one of higher solute concentration to achieve equilibrium so that the osmotic pressures are balanced.

Freeze Dryer

A three-step process:

- rapid freezing of fresh food (-5° C)
- extreme low `heating' (-50° C) in a vacuum chamber
- evaporating ice crystals (-45°C, 60 min.) into water vapor (sublimation- solid to gas without become liquid)

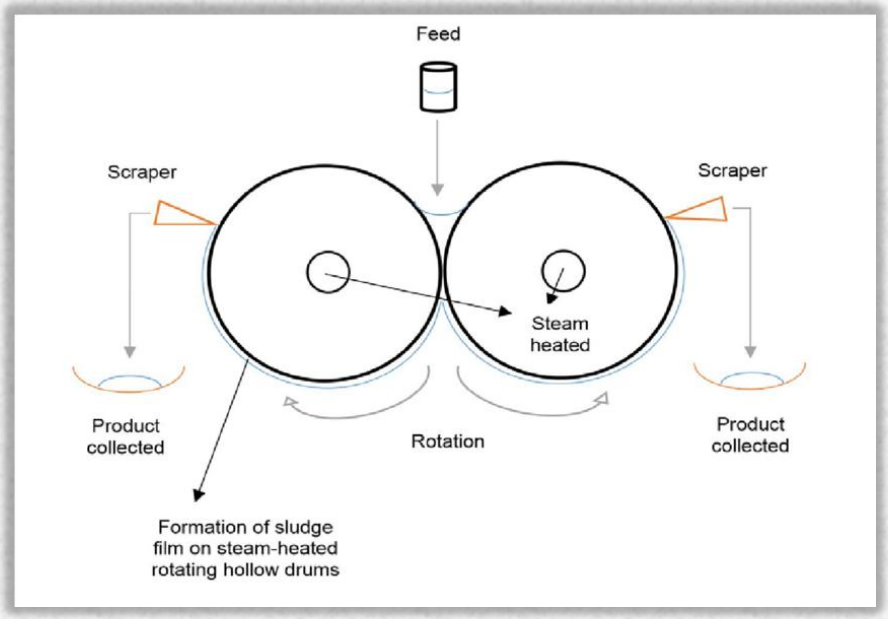


Solid Surface Drying

- food is dried directly on a heated solid surface

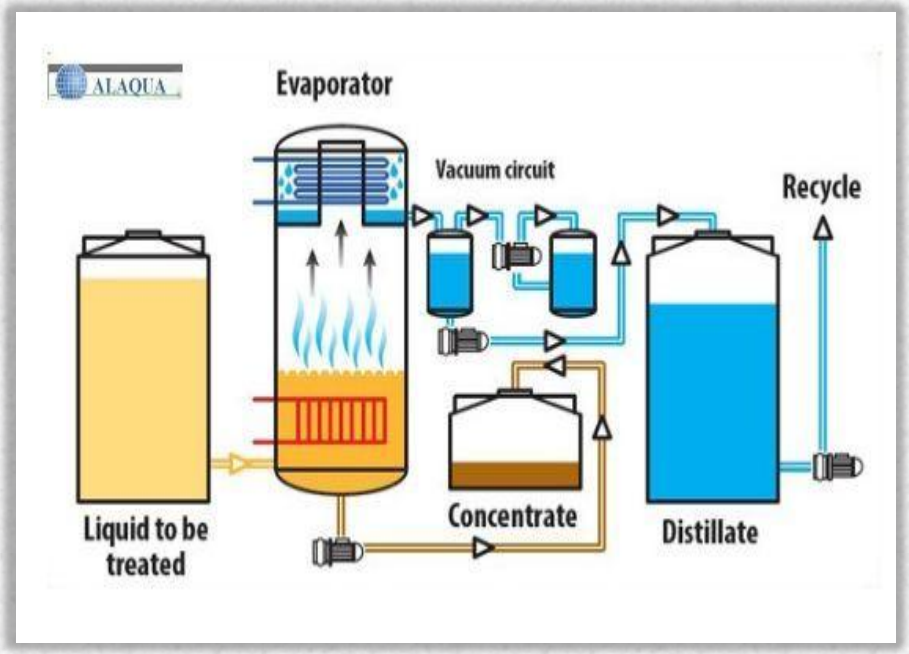
Drum Dryer

- food puree/paste is placed over rotating heated drum/s (100-120°C) that produce sheet-liked dried product
- the product is scrapped to finished flakes or powder



Concentration

- usually used under vacuum in order to sustain evaporation at the lower temperatures
  - (a vacuum pressures of 2-4 psi, equivalent to water boiling temperatures of 55 – 70 °C)
- evaporation remains the most widely used method to concentrate liquid foods



Chemical Inhibitors, Heat Treatment, Dehydration, **CHILLING & FREEZING,** Fermentation, Irradiation

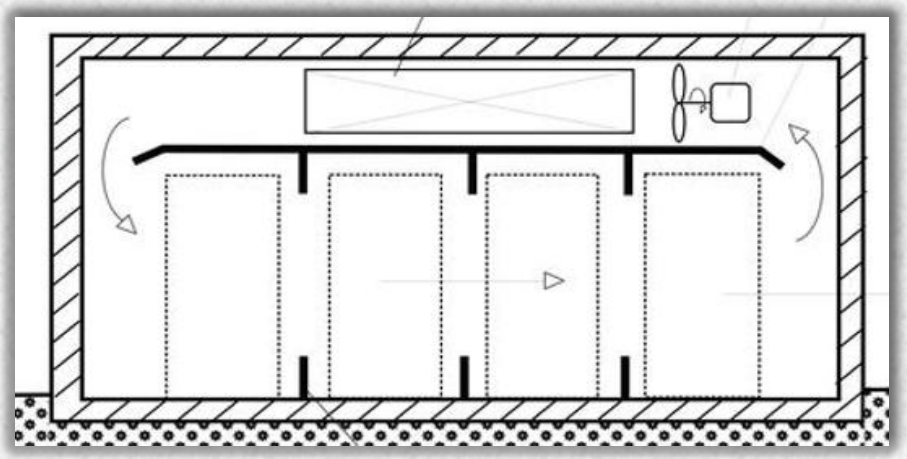
Chilling

- temperature is keep between 0 - 5 °C
  - reduces rate of biochemical changes and microbial activity
- minimal changes to sensory characteristics and nutrient contents

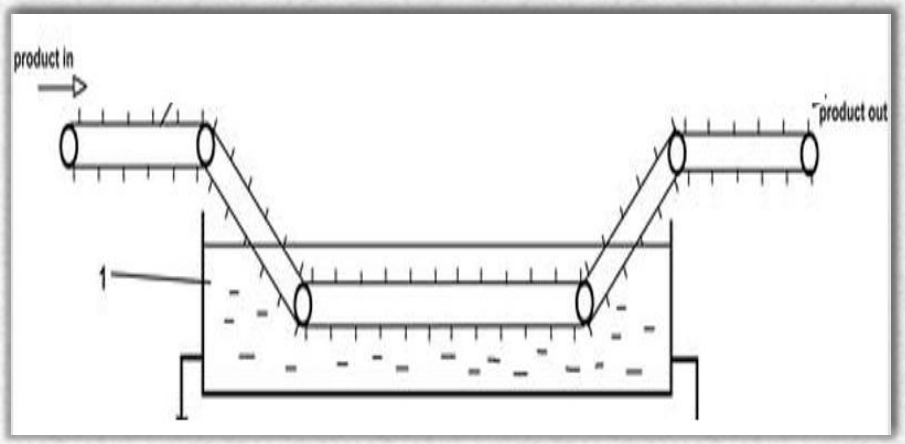
Methods, e.g.:

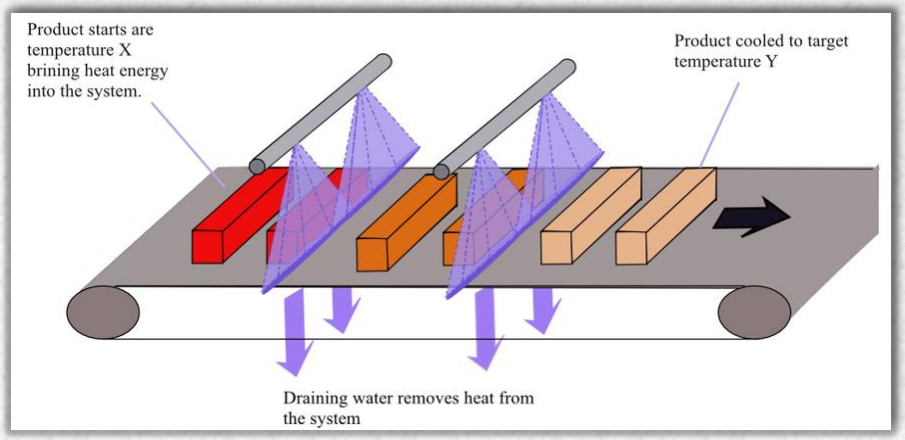
- ***Ice chilling***
  - use of ice flakes

- ***Air chilling***
  - circulating cold air at high speed (4 m/s), i.e. chilling tunnels (continuous) or chilling rooms (batch)



- ***Chilling with liquid***
  - immersed/sprayed with cold agent, e.g.: salt water (brine)
  - requires less time than air chilling





Freezing

- lowering the temperature to -18 °C or below
  - water in food is converted into ice crystals
    - reduces available water (water activity)
      - stops the growth of microbes
  - slowdown the rate of enzymatic activity

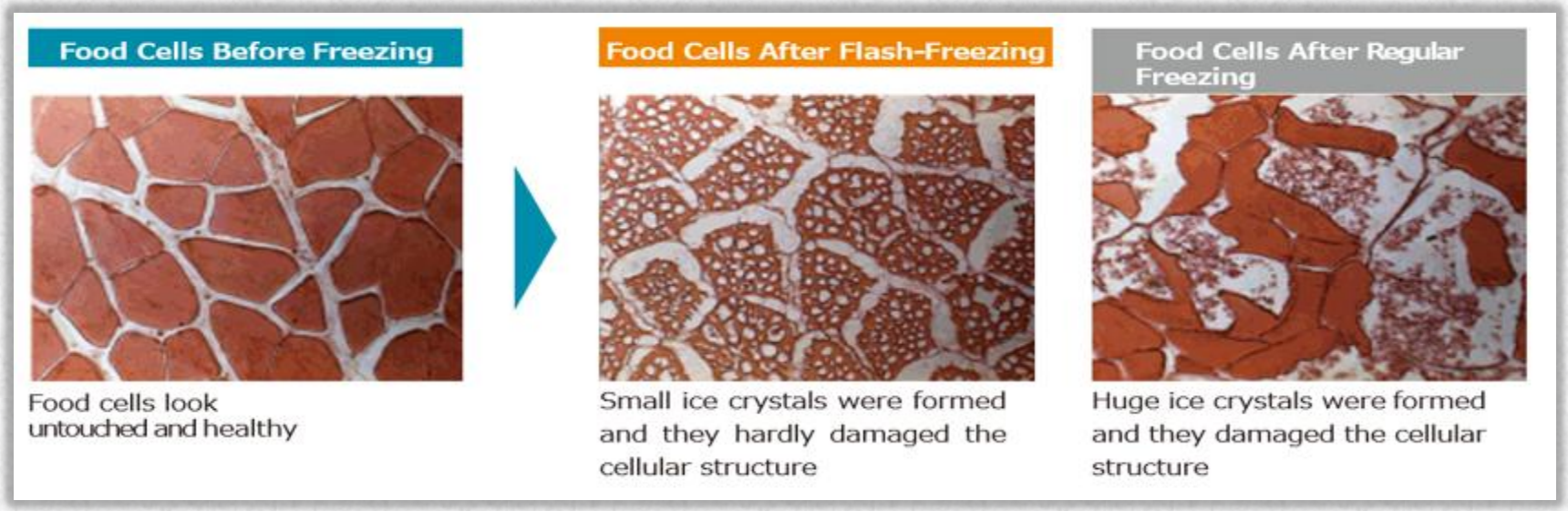


Techniques:

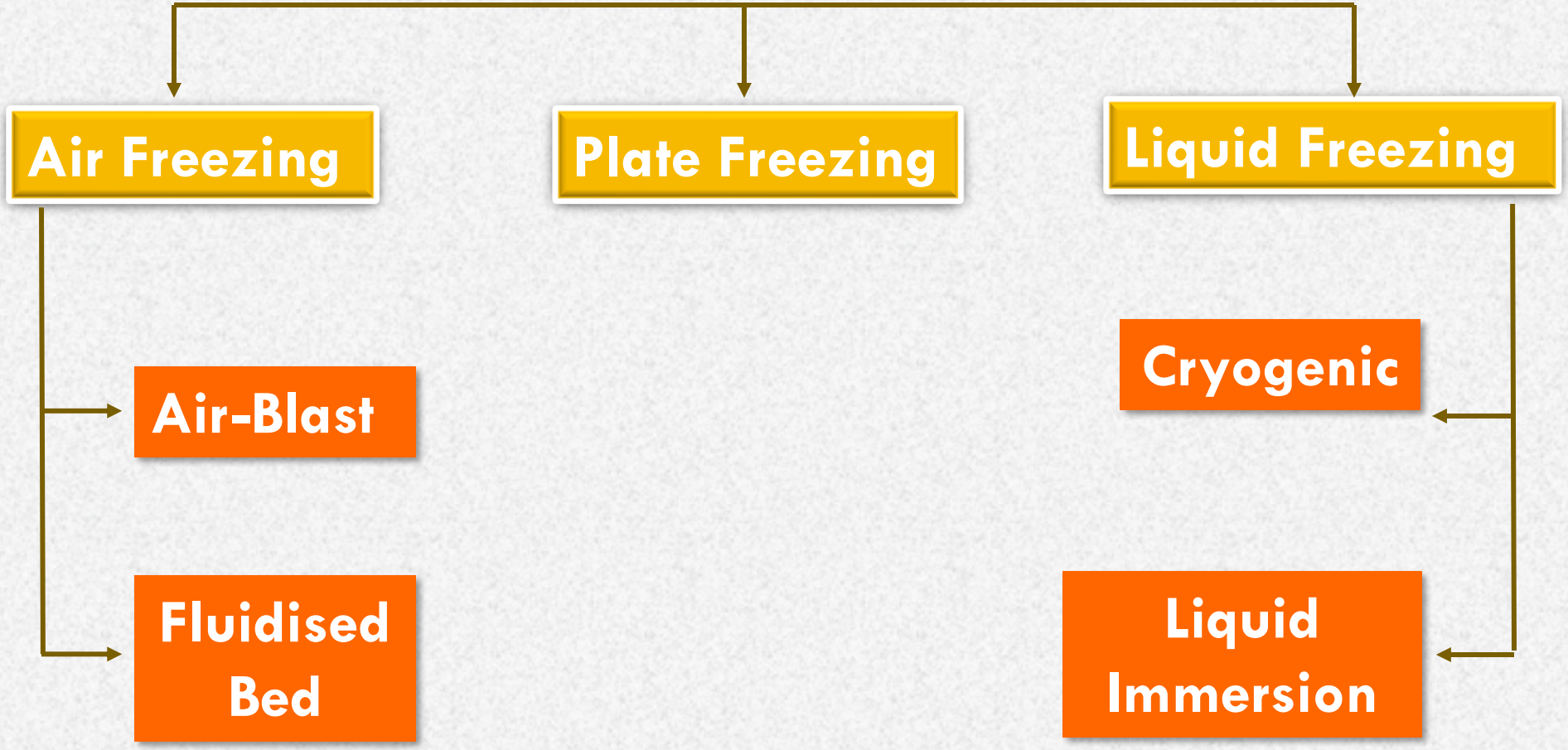
- **Slow freezing**
  - forms large ice crystals
    - during thawing, they rupture the food's cells
      - causes undesirable changes in texture (dehydrated) and appearance, and loss of nutrients
- **Quick freezing**
  - forms small ice crystals
    - no significant effect on texture, appearance and nutrient loss

Slow vs Quick

360 min. vs 30 min.
(same product & size)



TYPICAL QUICK FREEZING METHODS



Air Freezing

Air-Blast Freezer

- rapid forced circulation air freezes food at extremely low temperatures
- temperature varies from -10 to -120°C depends on the types of foods

Fluidised Bed Freezer

- foods placed on a mesh conveyor belt move through a freezing zone in which cold air is directed upward
  - food particulates will tumble and float
    - exposes all sides of the food to the cold air and minimizes the resistance to cold on the food surface

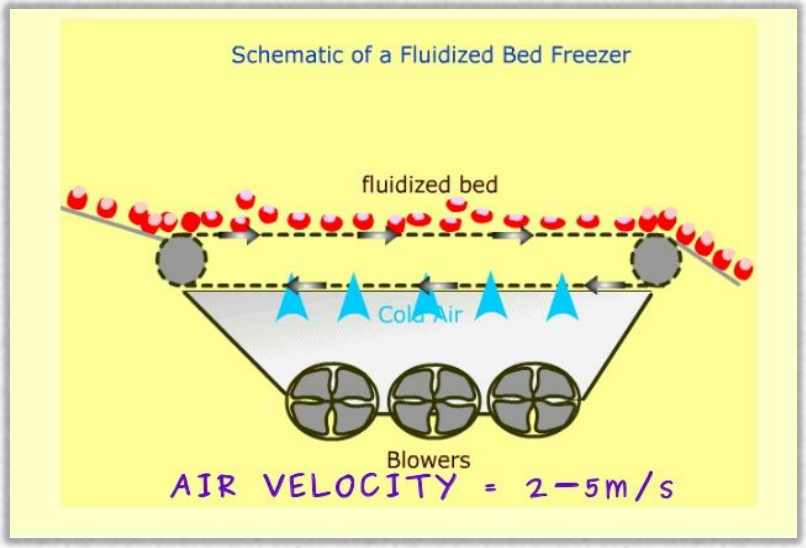
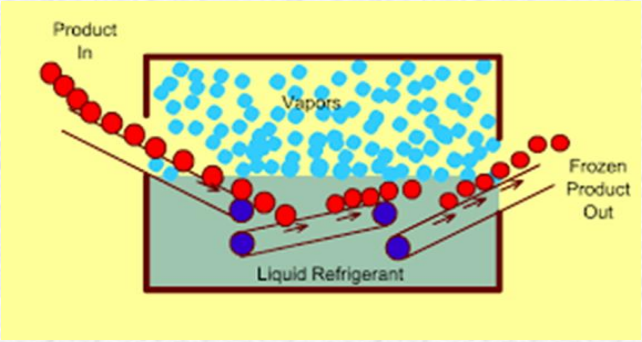


Plate Freezing

- food is firmly pressed between metal plates that are cooled to subfreezing temperatures by internally circulating refrigerants.
- Normally for flat products fish fillets and beef patties

Liquid Freezing

- fastest freezing, no crystals
  - extracts a large amount of heat at an extremely fast rate
- food is moved through a spray of liquid nitrogen (-195°C) **(CRYOGENIC)** or directly immersed in liquid nitrogen **(LIQUID IMMERSION)**



Chemical Inhibitors, Heat Treatment, Dehydration, Chilling & Freezing, **FERMENTATION,** Irradiation

- conversion of carbohydrates into alcohol or organic acids and carbon dioxide using microorganisms, i.e. yeasts or bacteria under anaerobic conditions
  - gives unique and desirable taste, aroma, texture and appearance

Fermented food, e.g.:

- Vegetable-based:- cucumber, chilli, kimci, sauerkraut
- Fruit-based: mango, tea, coffee, kambucha
- Milk-based: yogurt, cheeses, sour cream
- Meat-based: sausage, pepperoni
- Fish-based: *budu, belacan, cincalok, pekasam*
- Cereal-based: beers, soy sauce, *tempe, tapai,* breads, vinegars

Chemical Inhibitors, Heat Treatment, Dehydration, Chilling & Freezing, Fermentation, **IRRADIATION**

- application of ionizing radiation to food (gamma rays, electron beam, x-rays) to reduce/eliminate microbes, insects, parasites and sprouting
  - radiation energy disrupts DNA molecules of organisms; thus, they die or unable to reproduce
- produce/products are indentified by Radura logo
- In Malaysia, the use of irradiation on is regulated by the Food Irradiation Regulations 2011

(Domestic commercial irradiation started in 1997 - Sinagama Agensi Nuklear Malaysia Mint-Tech)

One Process:

Multiple Uses

Sprout Inhibition

Onion, Potato, Ginger, Garlic

Quarantine

Fruits

Insect Disinfestation

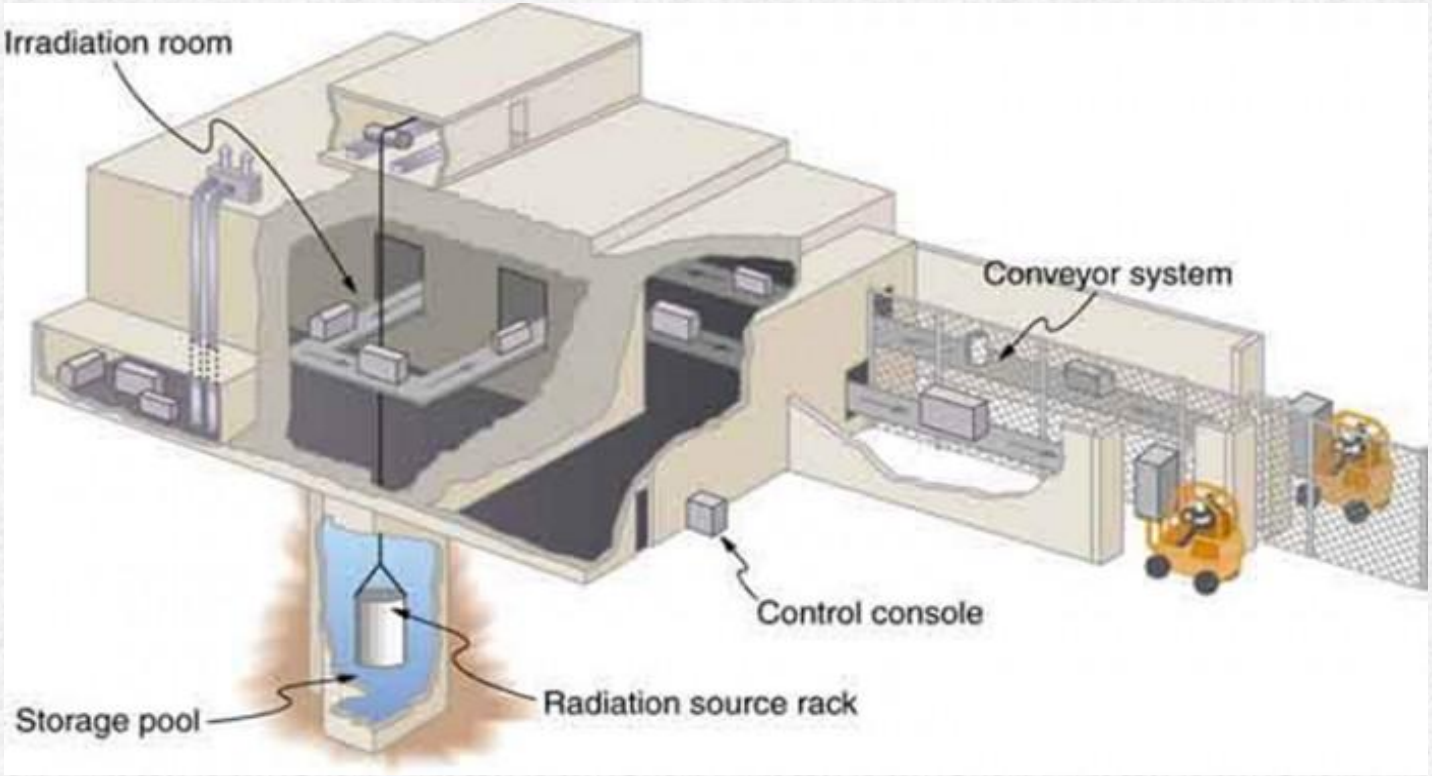
Cereals, Pulses, Dry Fruits

Shelf-life Extension

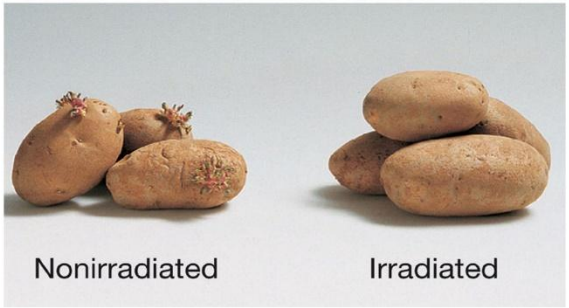
Chicken, Meat, Fish

Pathogen Reduction

Spices, Flesh Foods



The increased shelf life of irradiated food



THIRD SCHEDULE

[Subregulation 8(2)]

PERMITTED DOSES FOR IONIZING RADIATION OF FOOD

(1) *Classes of food*	(2) *Purpose of treatment*	(3) *Minimum dose (kGy)*	(4) *Maximum dose (kGy)*
Class 1 Bulbs, roots and tubers	Sprout inhibition	0.05	0.2
Class 2 Fresh fruits and vegetables	*(a)* Delay ripening *(b)* Shelf-life extension *(c)* Quarantine control	0.2 1.0 0.15	1.0 2.5 1.0
Class 3 Cereals and their milled products, nuts (including chestnut, coconut), oil seeds, pulses, dried fruits and their products	*(a)* Insect disinfestations *(b)* Reduction of microbial load *(c)* Sprout inhibition (chestnut)	0.25 1.5 0.1	1.0 5.0 0.25
Class 4 Fish and fish products and frog legs	*(a)* Reduction of pathogenic microorganisms *(b)* Shelf-life extension *(c)* Control of infection by parasites *(d)* Insect disinfestations	1.0 1.0 0.1 0.3	7.0 3.0 2.0 1.0
Class 5 Meat and meat products	*(a)* Reduction of pathogenic microorganisms *(b)* Shelf-life extension *(c)* Control of infection by parasites	1.0 1.0 0.3	7.0 3.0 2.0
Class 6 Dried vegetables, spices, condiments, dry herbs, tea	*(a)* Reduction of pathogenic microorganisms *(b)* Insect disinfestations	2.0 0.3	10.0 1.0
Class 7 Cocoa and cocoa products	*(a)* Reduction of microbial load *(b)* Insect disinfestations	2.0 0.3	5.0 1.0

RECAP

ESSON OUTCOMES (LO)

Upon completion of this lesson, students should be able to:

3.1 explain causes of food spoilage

3.2 describe various techniques of preservation and their applications