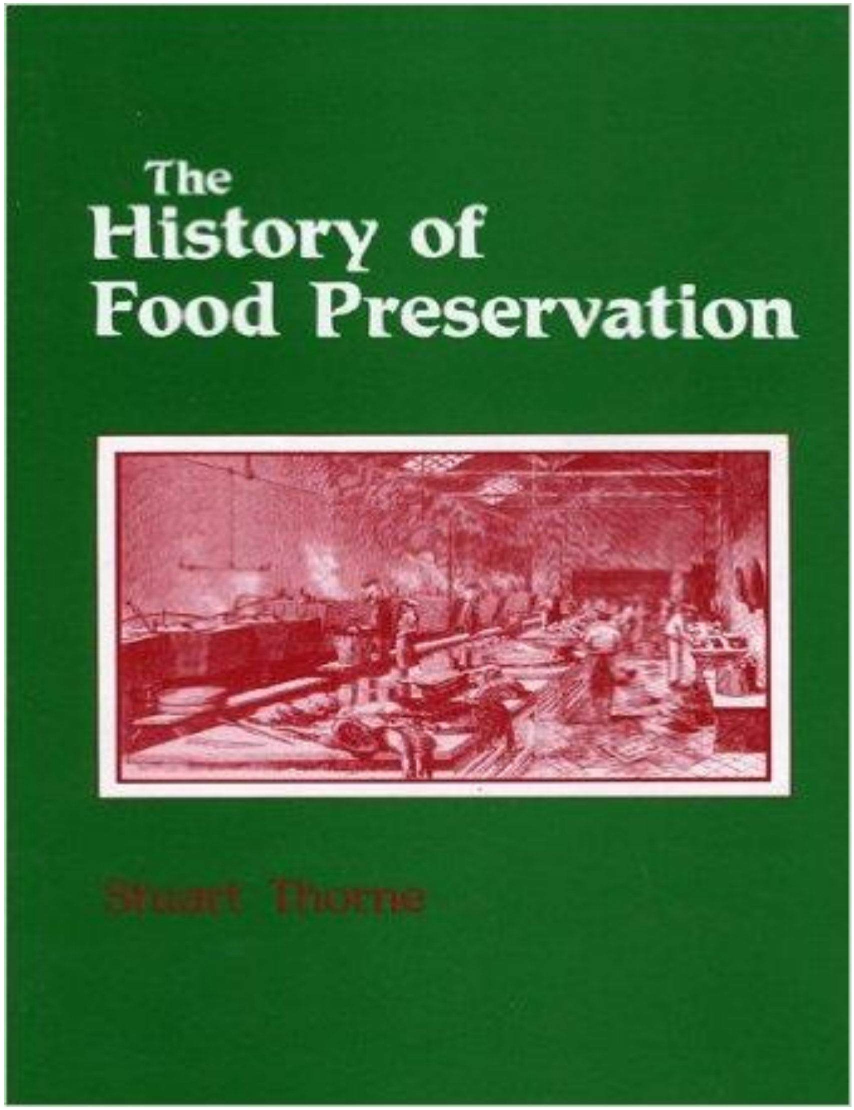


LECTURE 1

History of Food Preservation Techniques

Objectives

- Student’s will be able to:
  - Define *food preservation*
  - Summarize the common historical methods of food preservation
  - Describe current technologies for food preservation
  - Discuss current trends in food preservation

Old vs. Modern Preservation

Old

-Drying

-Fermenting

-Salting

-Smoking

Modern

-Freezing

-Fermenting

-Irradiation

Pastuerization

ture

Lecture 1

Activity

- Why does fresh bread go bad?
- Why do fresh donuts go bad?
- Why do packaged bread or donuts not go bad?

Food Preservation

- Methods of treating foods to delay the deterioration of the food.
- Changing raw products into more stable forms that can be stored for longer periods of time.
- Allows any food to be available any time of the year in any

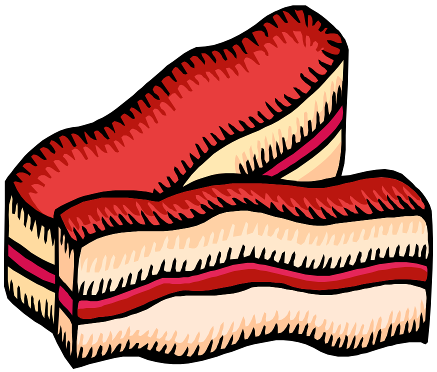
area of the world.

Food Processing

- In order to change the raw products, the processing technique should be developed.
- The engineers design the equipments and techniques of processing to delay the deterioration of the food

Historical Methods of Food Preservation

- Primitive and tedious methods
  - –Drying
  - –Salting
  - –Sugaring
  - –Pickling
  - –Cold storage

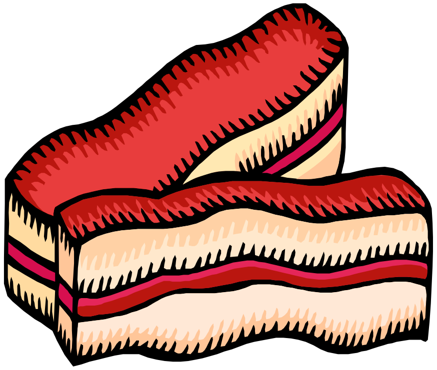


Drying

- Used to preserve fruit, vegetables, meats, and fish.
- Mainly used in the south – warmer climate.
- Causes the loss of many natural vitamins.

Salting

- Used extensively for pork, beef, and fish.
- Costly due to high price of salt.
- Done mainly in cool weather followed by smoking.



Sugaring

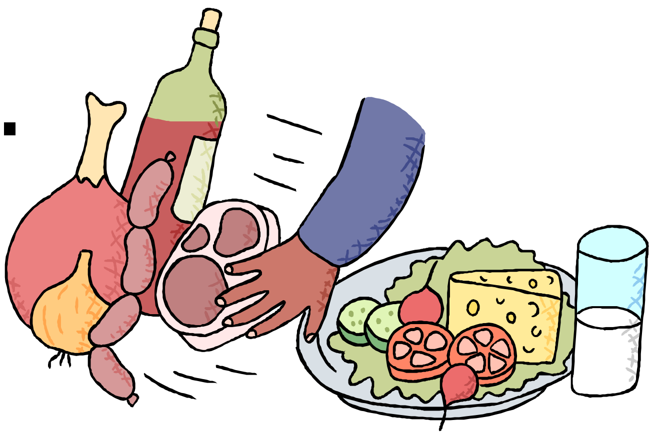
- Used to preserve fruits for the winter.
- Jams and jellies.
- Expensive because sugar was scarce commodity in early America.

Pickling

- Fermenting
- Used to preserve vegetables.
- Use mild salt and vinegar brine.
- Increases the salt content and reduces the vitamin content of the food.
- Oldest form of food preservation.

Factors Affecting Diet – Colonial Times

- Where you lived.
- Long winters in the north led to different diets in in the south.
- Nutritious diets were unknown to early Americans.



Reasons for Dietary deficiencies

- Fruits and vegetables were available only during short seasons.
- Inadequate and time consuming food preservation methods.
- Lack of facilities for rapid transport of food from long distances.
- Contamination of food supplies.

Diet Today

- We can eat fresh vegetables from anywhere in the world today!!
  - –Bananas
  - –Strawberries
  - –Pineapples

- Prior to 1930’s and 40’s food preservation basically remained as it was in colonial America.
  - Pickling, salting, sugaring, cold storage, drying.

Factors that Changed Food Science Technology

- Canning – revolutionized food preservation and made it more available.
- Commercial freezing and refrigeration – allowed preservation of meats.
- Refrigerated rail cars and trucks – increased the availability of fresh fruits, vegetables and meats.
- Food preservatives.

Food Preservatives

- Retard or reduce the growth of undesirable microorganisms, mold and bacteria.
- Do not affect from food texture or taste.
- Safe for human consumption.
- Extend shelf-life of food.
  - Shelf-life – length time before a food product begins to spoil.

Today's Food Industry

- Improvements have led to the replacement of the housewife as the major preparer or food preserver.
- Today it is done by machine and shipped to stores all over the world.

- Food preservation is needed, especially today with the large world population.

Current Technologies in Food Preservation

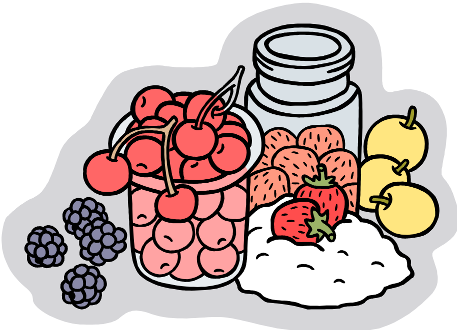
Lecture 1

Activity

- List the foods you like to eat all year.
- Use this list to eliminate foods that were not available 10,20,30 years ago.
- Eliminate foods not available in your area.

Types of Food Processing

- Heating
- Blanching
- Vacuum Packaging
- Drying
- Refrigeration
- Freezing
- Chemicals



Heating

- Started in 1800's.
- Known as canning – putting hot food in jars to seal.
- Food is cooked to extremely high temperatures, put into jars and lids are placed on them.
- Lids are sealed from the heat and this prevents bacteria from growing and spoiling the food.

Blanching

- Used for vegetables.
- Heat the food with steam or hot water to 180-190 degrees F.
- This prevents bacteria from growing.
- Hot food is cooled in ice water.

Benefits of Blanching

- Shrinks the product, better for filling the container.
- Destroys enzymes in the food.
- Fixes the natural color of vegetables – holds their color.

Vacuum Packaging

- Removes oxygen.
- Oxygen reacts with food causing undesirable changes in color and flavor.

Drying

- Oldest form of food preservation.
- Methods
  - Sun drying
  - Hot air drying – mechanical dehydrator
  - Fluidized-bed drying
  - Drum drying – milk, fruit, veg. juices, cereals
  - Spray drying – milk, eggs, coffee, syrups
  - Freeze drying -
  - Puff drying – Fruit or vegetable juices

Refrigeration

- Early time, ice and snow was used.
- Now the most popular method of food preservation.
- 85% of all foods are refrigerated.
- Greatly changed our eating habits.

Freezing

- Used by Eskimos and Indians
- Frozen foods are a staple in almost every home.

Chemicals

- Salt was first chemical used to preserve foods.
- $NaCl$ – salt; makes water unavailable to microorganisms.
- Changes the pH of the food not allowing microorganisms to live.

LECTURE 2 :

FOOD FREEZING AND REFRIGERATION

COURSE GOALS:

- To acquaint the student with the chemistry and physics of the freezing process in both model systems and in food.
- To provide an explanation for many standard industry practices.
- To discuss the consequences of freezing on food and other biological systems, and to provide a framework on which the student can build a fuller appreciation of the techniques and technical problems of freezing.

OUTLINE of LECTURE 2:

- **Introduction**
- **The methods of freezing**
- **Quality aspects of frozen foods**
- **The basic science of food freezing**
- **The freezing process**
- **Chemical and physical consequences**
- **Cell freezing and freezing damage**
- **Reactions in frozen systems**
- **Microbiology**
- **Processes of deterioration during frozen storage**
- **Modeling the freezing process**
- **Thawing**
- **Miscellaneous, including cryobiology**

PRESERVATION OF FOODS BY LOWERING THE TEMPERATURE

THEORY:

Lowering The Storage Temperature Of The Food Will Reduce Or Prevent Spoilage By Microorganisms And/Or Chemical Reactions.

PART 1 : REFRIGERATION

I. **REFRIGERATION -** Temperatures typically between (7.2 - 0° C).

THEORY:

- LOWER TEMPERATURE WILL REDUCE SPOILAGE.

Chilling

- Fridges have been used since the 1920’s.
- It is only possible to use fridges for a short amount of time as microbial activity still takes place and the food will still decay.
- Fridges should kept at between 1^{o}C and 8^{o}C.
- Many foods that are sold in shops are refrigerated during transit and storage.
- Fish usually has a shelf life of about 3-5 days in the fridge.

Chilling (cont’d)

Chilling slows down:

- The rate at which micro-organisms multiply
- The rate of any chemical reactions which could affect the quality of food
- They need to stay at or below this temperature until they are used
- For this reason they are always sold from the chiller cabinets in shops.

Chill storage: 0 to 5 ^oC, only psychrotrophs can grow relatively slowly. e.g. generation time for pseudomonas available in fish is 6-8 hours at 5 ^oC compared to 26 hr at 0 oC.

Mesophiles can grow at chilling temperature but not necessarily killed.

Certain psychrotropes such as pseudomonas do grow and cause food poisoning.

Moisture loss – a major problem.

Protected by several types of packaging

Advantages of Chilling

- There is very little change in flavour, colour, texture or shape.
- Fresh foods can be kept at maximum quality for a longer time.
- The consumer can be offered a much larger range of fresh and convenience foods.
- Nutrients are not destroyed.

Chilled foods are grouped into three categories according to their storage temperature range:

1. -1ºC to +1ºC (fresh fish, meats, sausages and ground meats, smoked meats and breaded fish).

2. 0ºC to +5ºC (pasteurized canned meat, milk, cream, yoghurt, prepared salads, sandwiches, baked goods, fresh pasta, fresh soups and sauces, pizzas, pastries and unbaked dough).

3. 0ºC to +8ºC (fully cooked meats and fish pies, cooked or uncooked cured meats, butter, margarine, hard cheese, cooked rice, fruit juices and soft fruits).

II. FREEZING – TEMPERATURES

- < 32°F (0° C)
- Change in water from liquid to solid.

THEORY:

1. Lower temperature. Will reduce spoilage.
2. Water is unavailable for microorganisms and chemical reactions.

WHY FREEZE?

1. In general frozen foods are better nutritionally and organoleptically than other processed foods.
2. Long shelf life
3. Convenient - shorter cook times

DISADVANTAGE:

- Energy intensive

Principles of Freezing

- Does not sterilize food.
- Extreme cold (0^oF or -18^oC colder):
  - Stops growth of microorganisms and
  - Slows chemical changes, such as enzymatic reactions.

Freezing

- Freezing is the unit operation in which the temperature of a food is reduced below its freezing point and a proportion of the water undergoes a change in state to form ice crystals. The immobilization of water to ice and the resulting concentration of dissolved solutes in unfrozen water lower the water activity (a_w) of the food

- Preservation is achieved by a combination of ***low temperatures***, ***reduced water activity*** and, in some foods, pre-treatment by blanching.

Freezing

- Frozen food can be kept for a very long period of time. Usually about 3 months.
- Deep freezing is the reduction of temperature in a food to a point where microbial activity cease.
- A freezer should be kept at -18°C to -25°C.

Effect of Freezing on Food

- Low temperatures do not significantly affect the nutritional value of food, but thiamin and vitamin C may be destroyed when vegetables are blanched (briefly immersed in boiling water) before freezing.
- If fish is frozen too slowly, some of its cells may rupture and release nutrients into the liquid that drips from the fish when it thaws.
- Some flavours become weaker and some become stronger when food is frozen.

Advantages of Freezing

- Many foods can be frozen.
- Natural color, flavor, and nutritive value retained.
- Texture usually better than other methods of food preservation.
- Foods can be frozen in less time than they can be dried or canned.

Advantages of Freezing

- Simple procedures.
- Adds convenience to food preparation.
- Proportions can be adapted to needs unlike other home preservation methods.
- Kitchen remains cool and comfortable.

Disadvantages of Freezing

- Texture of some foods is undesirable because of freezing process.
- Initial investment and cost of maintaining freezer is high.
- Storage space limited by capacity of freezer.

How Freezing Affects Food

Chemical changes

- Enzymes in vegetables
- Enzymes in fruit
- Rancidity

Texture Changes

- Expansion of food
- Ice crystals

ISSUES with FROZEN FOODS

1. Chemical reactions can occur in unfrozen water.
   A. Some foods blanched or sulfited before freezing.
   B. Vacuum packaging to keep out oxygen.

ISSUES with FROZEN FOODS (cont.)

2. Undesirable physical changes
   A. Fruits and vegetables lose crispness
   B. Drip loss in meats and colloidal type foods (starch, emulsions)
      - Freeze product faster
      - Control temperature fluctuations in storage.
      - Modify starch, egg systems, etc.

2. Undesirable physical changes (cont.)

C. Freezer burn
  - Package properly
  - Control temperature fluctuations in storage.

D. Oxidation
  - Off-flavors
  - Vitamin loss
  - Browning

E. Recrystallization

The major groups of frozen foods

- Fruits

(strawberries, oranges, raspberries) either whole or pureed, or as juice concentrates

- Vegetables

(peas, green beans, sweet corn, spinach, and potatoes)

- Fish fillets and sea foods

(cod, plaice, shrimps and crab meat) including fish fingers, fish cakes or prepared dishes with an accompanying sauce

- Meats

-(beef, lamb, poultry) as carcasses, boxed joints or cubes, and meat products (sausages, beefburgers, reformed steaks)

- Baked goods

- (bread, cakes, fruit and meat pies)

- Prepared foods

(pizzas, desserts, ice cream, complete meals and cook–freeze dishes).

Technology of frozen foods

The effect of refrigeration on foods is two folds :

- A decrease in temperature results in a slowing down of chemical, microbiological and biochemical processes.
- At temperature below 0^oC water freezes out of solution as ice, which is equivalent in terms of water availability to dehydration or a reduction in a_w.

Effect of freezing on tissues

- Foods do not have sharp freezing points, but freeze over a range of temperature depending on the water content and cell composition.
- Rapid freezing, and storage without wide fluctuations in temperature, lead to small intracellular ice crystals and maintenance tissues with minimum damage to cell membranes.

Effect of freezing on microorganisms

- The growth of microorganisms in foods at temperatures below about –12^{o}C has been confirmed. Thus storage of frozen foods at about –18^{o}C and below prevents microbiological spoilage.

- Although microbial numbers are usually reduced during freezing and frozen storage (except for spores), frozen foods are not sterile and can spoil as rapidly as the unfrozen product if temperature are sufficiently high and storage times at these temperatures are excessive.

Methods of freezing

Freezing techniques include :

- The use of cold air blasts or other low temperature gases coming in contact with the food, e.g. blasts, tunnel, fluidized bed, spiral, belt freezers.

- Indirect contact freezing, e.g. plate freezers, where packaged foods or liquids are brought into contact with metal surfaces (plate, cylinders) cooled by circulating refrigerant (multi-plate freezers).

- Direct immersion of the food into a liquid refrigerant, or spraying liquid refrigerant over the food (e.g. liquid nitrogen, and freon, sugar or salt solutions).

TYPES OF FREEZING:

1. AIR FREEZING - Products frozen by either "still" or "blast" forced air.
   - cheapest (investment)
   - "still" slowest, more changes in product
   - "blast" faster, more commonly used
2. INDIRECT CONTACT - Food placed in direct contact with cooled metal surface.
   - relatively faster
   - more expensive

TYPES OF FREEZING (cont.):

3. DIRECT CONTACT - Food placed in direct contact with refrigerant (liquid nitrogen, "green" freon, carbon dioxide snow)
   - faster
   - expensive
   - freeze individual food particles

Commercial Freezing

- Blast freezing – a very cold air blasted on the food cools food very quickly.
- Close indirect contact – food is placed in a multi-plate freezer and is rapidly frozen.
- Immersion – food is placed into a very cold liquid (usually salt water – brine) or liquid nitrogen, this is known as cryonic freezing.

Freezing Equipment 1

- Mechanical Freezers

  - Evaporate and compress the refrigerant in a continuous cycle

Freezing Equipment 2

- Cryogenic Systems

  - Use solid and liquid CO_2, N_2 directly in contact with the food

Cooled-air freezers

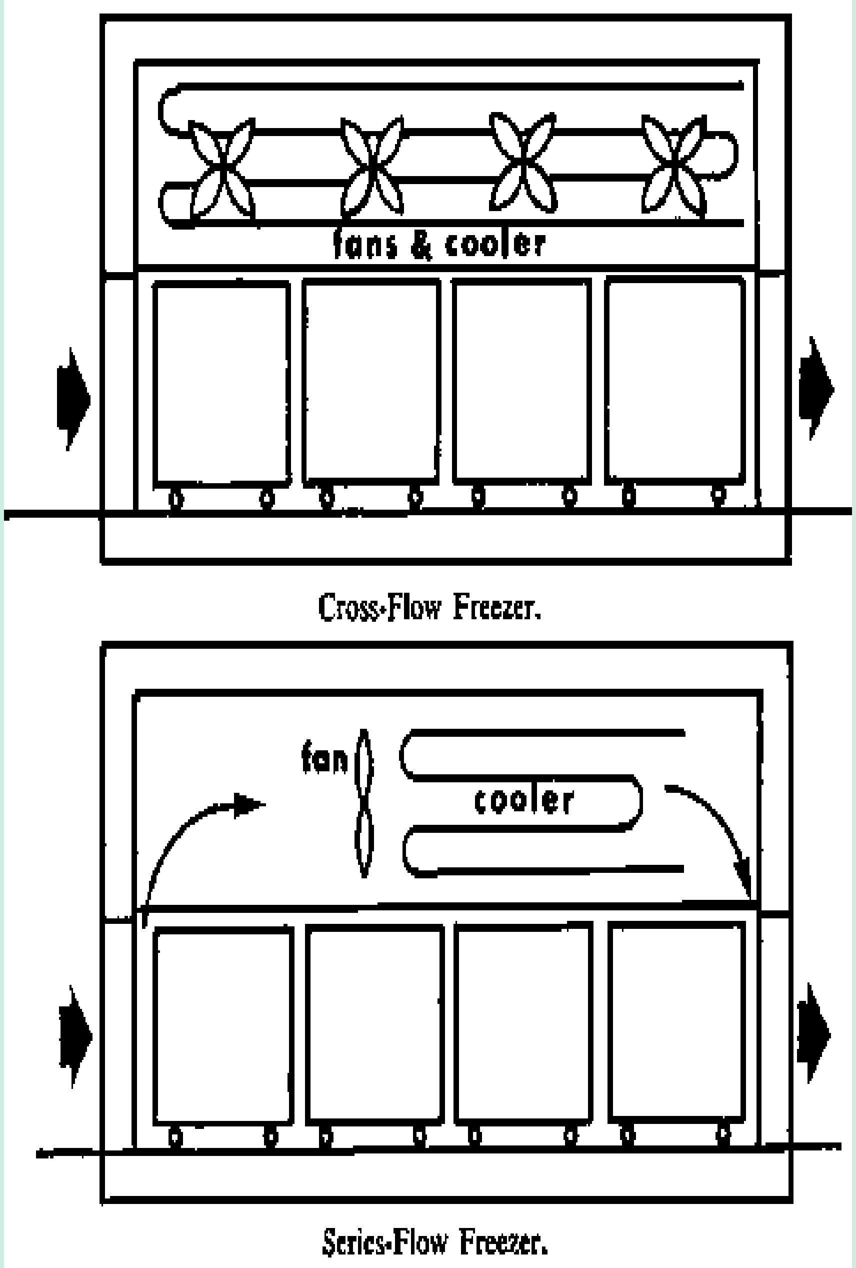
- C*hest freezers* food is frozen in stationary (natural-circulation) air at between -20ºC and -30ºC.

- Chest freezers are not used for commercial freezing owing to low freezing rates (3–72 h).

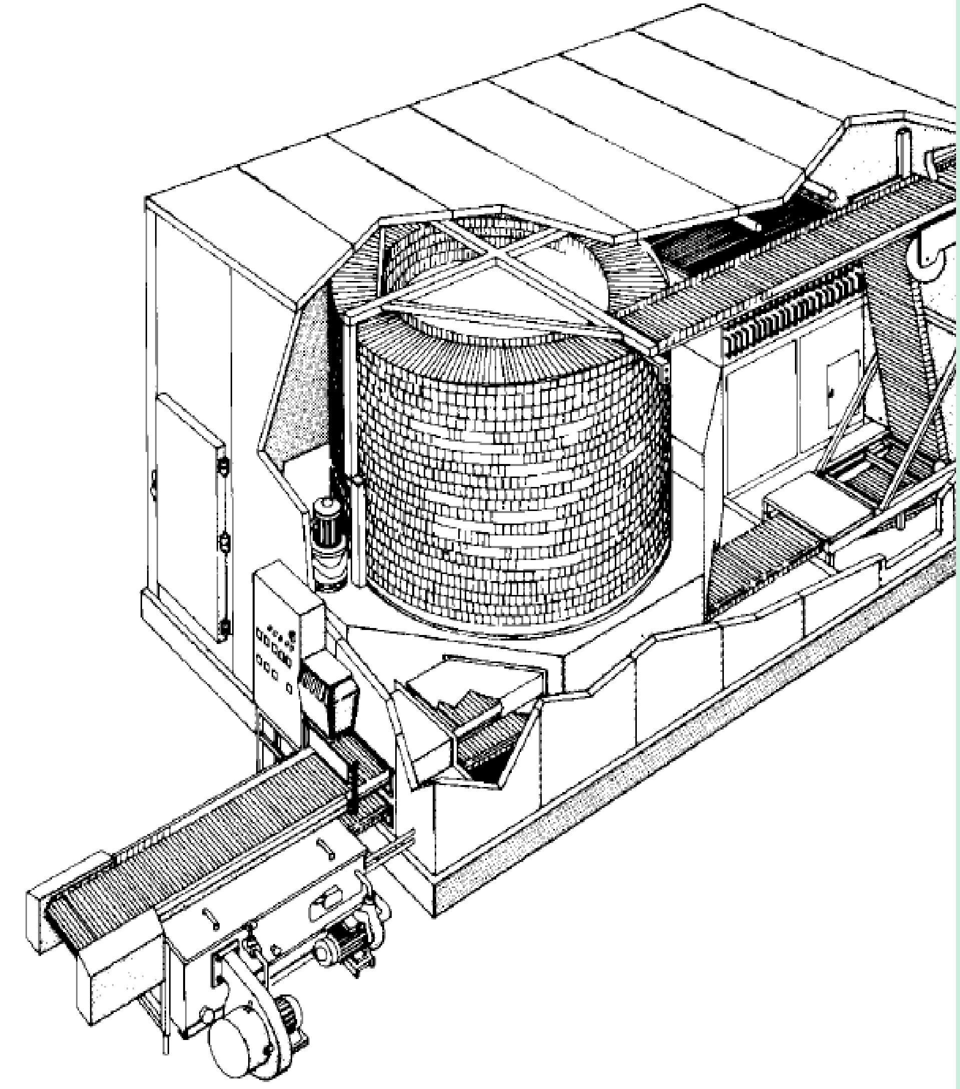
- A major problem with cold stores is ice formation on floors, walls and evaporator coils, caused by moisture from the air or from unpackaged products in the store.

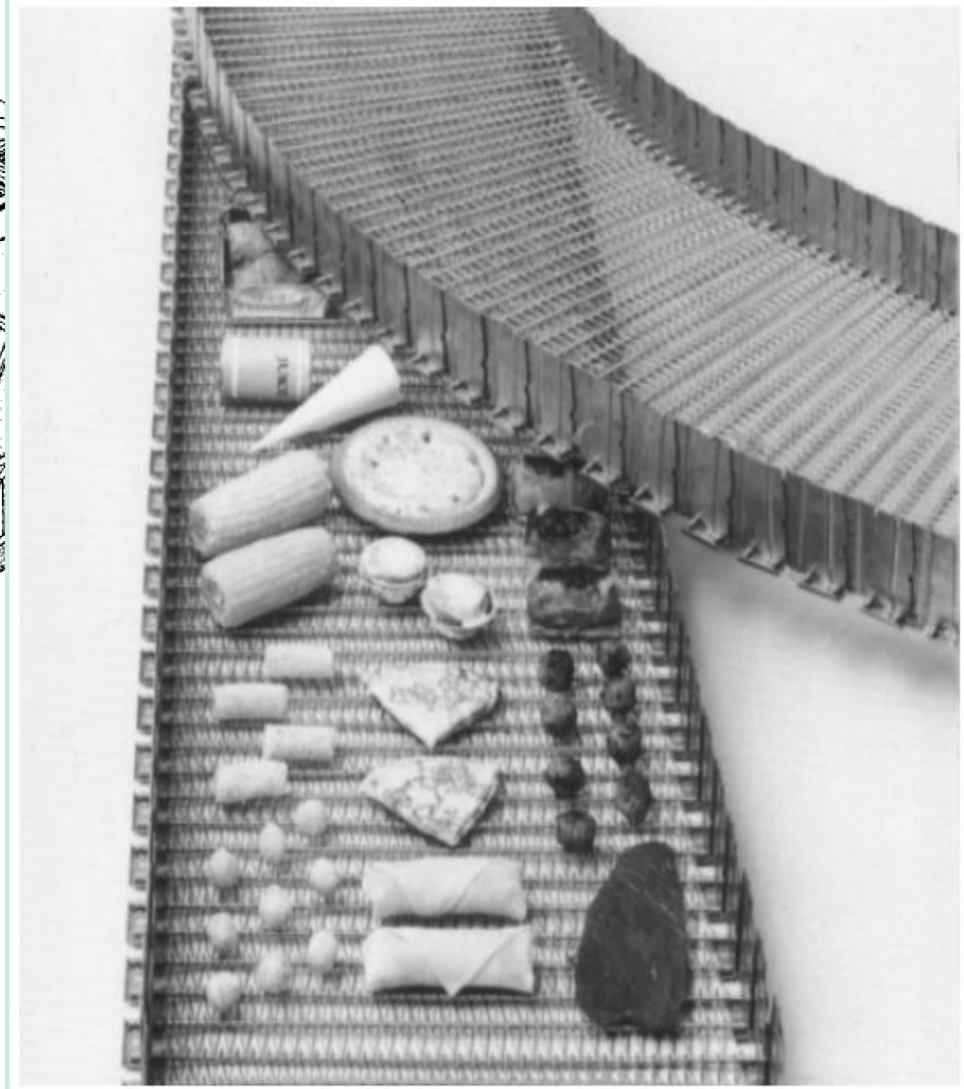
Blast freezers

- Air is recirculated over food at between -30ºC and -40ºC at a velocity of 1.5–6.0 m s1.
- The high air velocity reduces the thickness of boundary films surrounding the food and thus increases the efficiency heat coefficient.
- In batch equipment, food is stacked on trays in rooms or cabinets.
- Continuous equipment consists of trolleys stacked with trays of food or on conveyor belts which carry the food through an insulated tunnel.
- The trolleys should be fully loaded to prevent air from bypassing the food through spaces between the trays.


fans & cooler
Cross-Flow Freezer.
fan
cooler
Series-Flow Freezer.

- ***Belt freezers*** (spiral freezers) have a continuous flexible mesh belt which is formed into spiral tiers and carries food up through a refrigerated chamber.
- In some designs each tier rests on the vertical sides of the tier beneath and the belt is therefore ‘selfstacking’.
- This eliminates the need for support rails and improves the capacity by up to 50% for a given stack height.



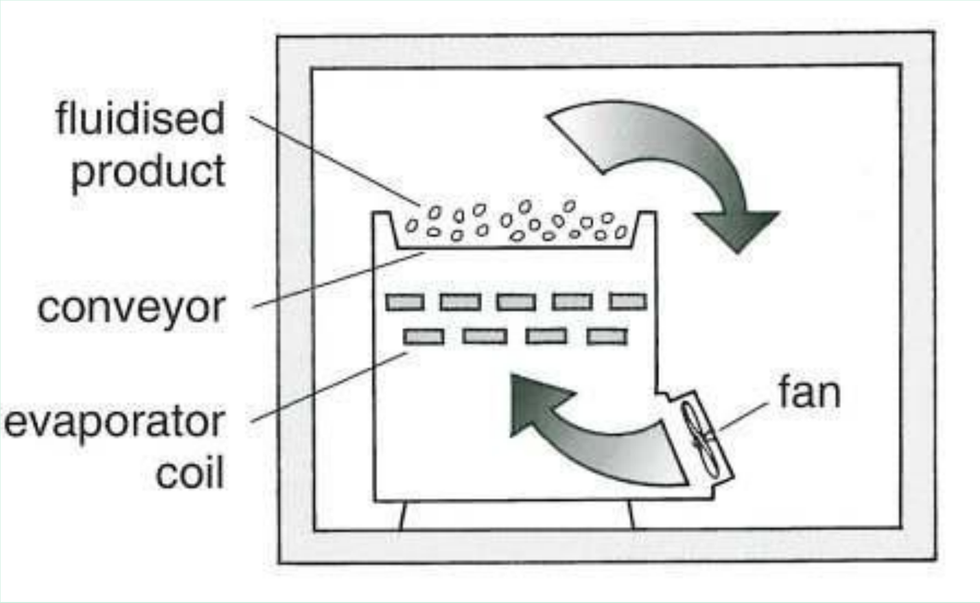


Fluidized bed freezer

-Vertical jets of refrigerated air are blown up through the product, causing it to float and remain separated.

-This is a continuous process which takes up to 10 minutes.

- The product, e.g. peas, beans, chopped vegetables or prawns, move along a conveyor belt.

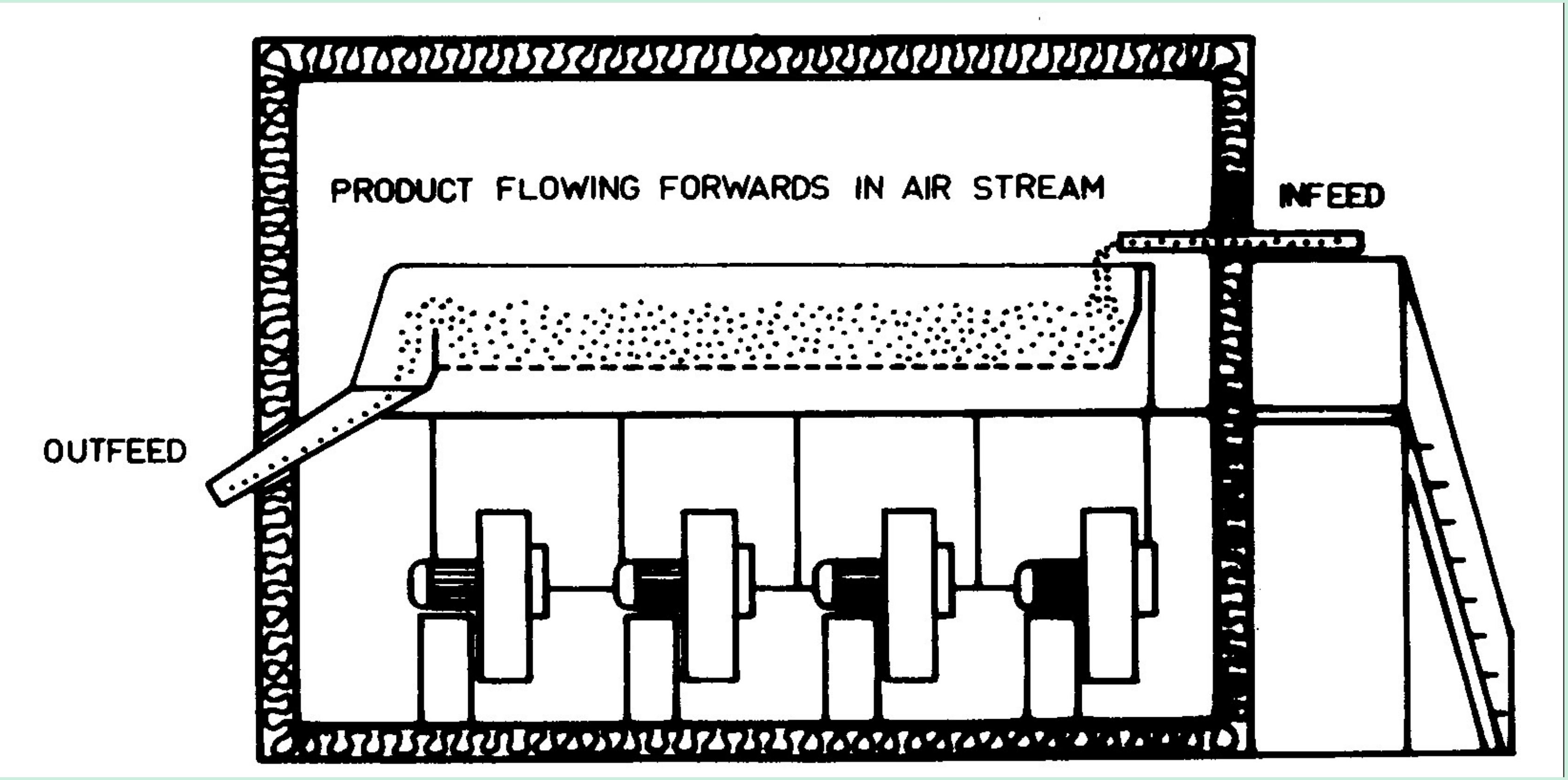


- ***Fluidized-bed freezers*** are modified blast freezers in which air at between -25ºC and -35ºC is passed at a high velocity (2–6 m/s) through a 2–13 cm bed of food, contained on a perforated tray or conveyor belt.
- In some designs there are two stages; after initial rapid freezing in a shallow bed to produce an ice glaze on the surface of the food, freezing is completed on a second belt in beds 10–15 cm deep.

Rapid Freezer: Fluidized Bed

- Food is contained on a perforated tray or conveyer belt.
- Air between -25 to -35^{o}C is passed at high velocity (2-6 m/s).
- Each food comes in contact with air individually.

IQF: Individually Quick Frozen



A typical fluidized bed freezer

Cooled-surface freezers

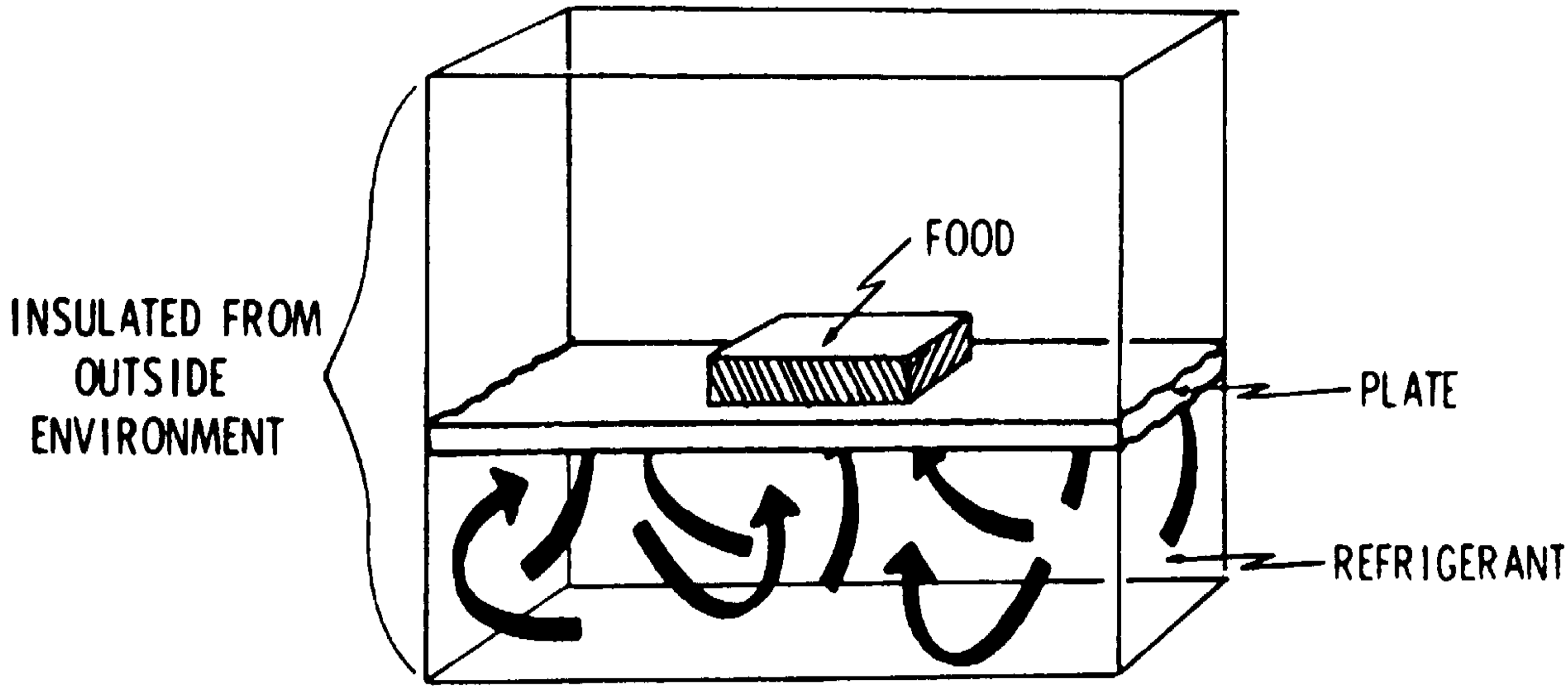
- *Plate freezers* consist of a vertical or horizontal stack of hollow plates, through which refrigerant is pumped at ----40ºC . They may be batch, semi-continuous or continuous in operation. Flat, relatively thin foods (for example filleted fish, fish fingers or beef burgers) are placed in single layers between the plates and a slight pressure is applied by moving the plates together.

Plate freezing system

- In these types of freezing systems, the product is held firmly between two plates throughout the period of time required for product temperature reduction. The plates are the primary barrier between the cold refrigerant and the product. These types of freezing systems have a definite advantage when the product configuration allows for direct and close contact between the plate surface and the product surface.

Plate freezing

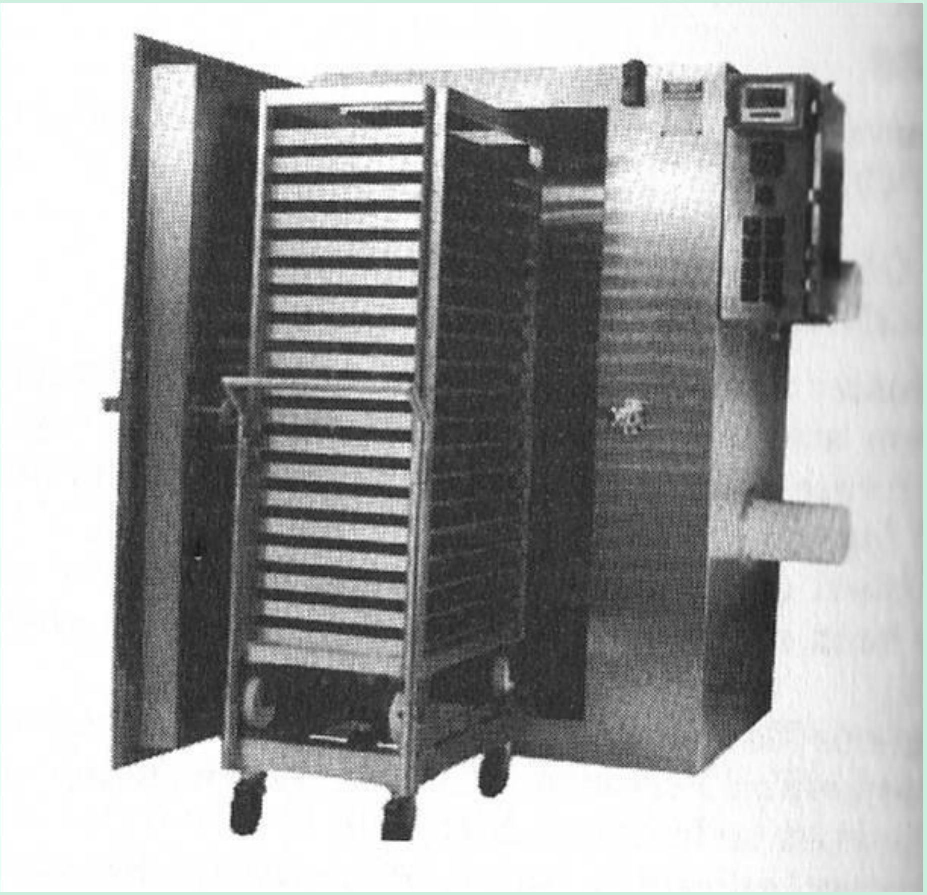
- Ideal for thin, flat foods such as steak, fish fillets or burgers.
- The food is placed between two “plates” which make contact with the food’s surface.
- This speeds up the freezing process & freezing occurs evenly throughout the food



6.2 figure Schematic diagram of indirect-contact freezing system.

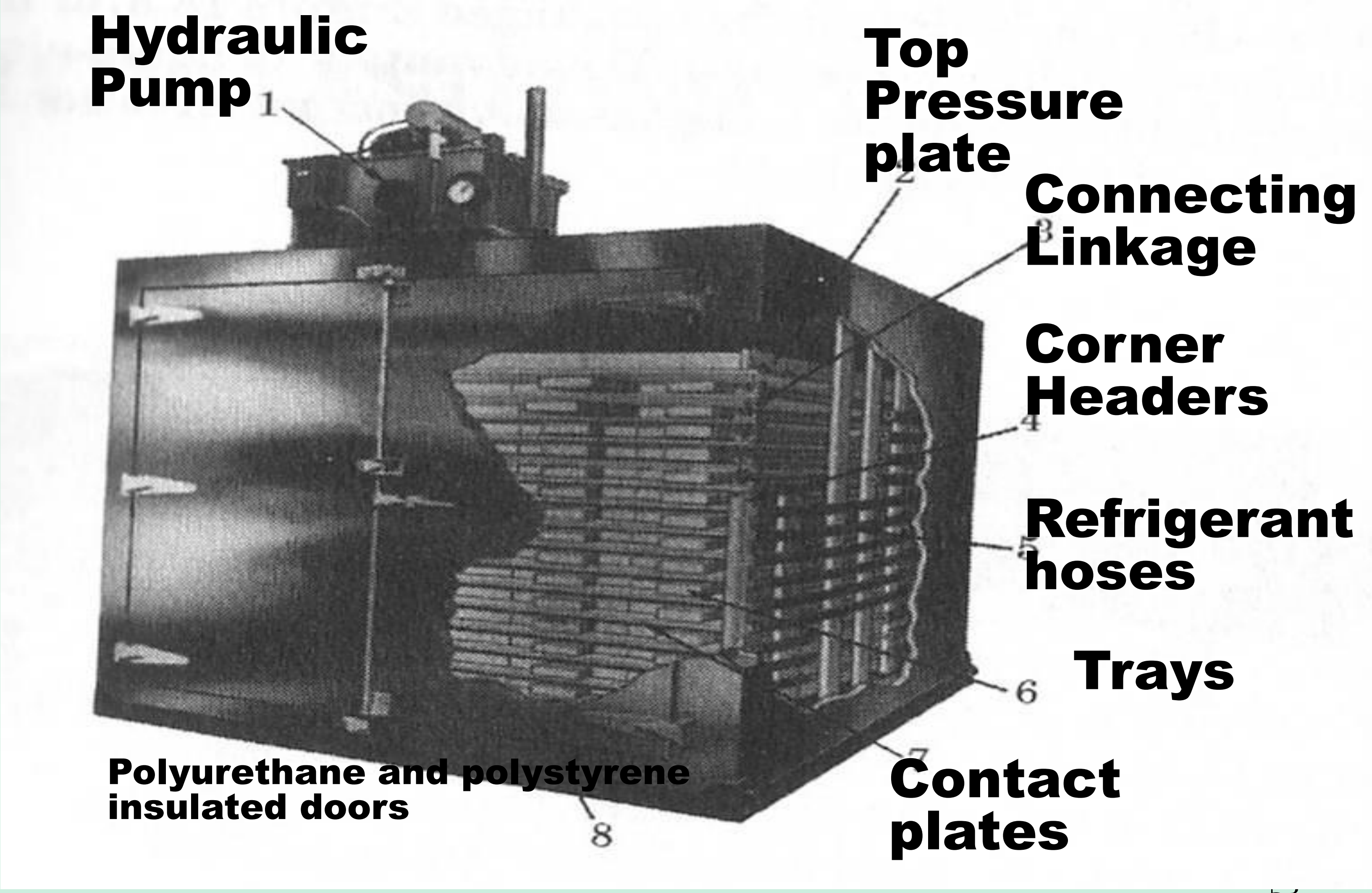
Batch Freezer

Blast Type



Source: Unit operations for food the food industries by: W.A. Gould

Double Contact Plate Freezer



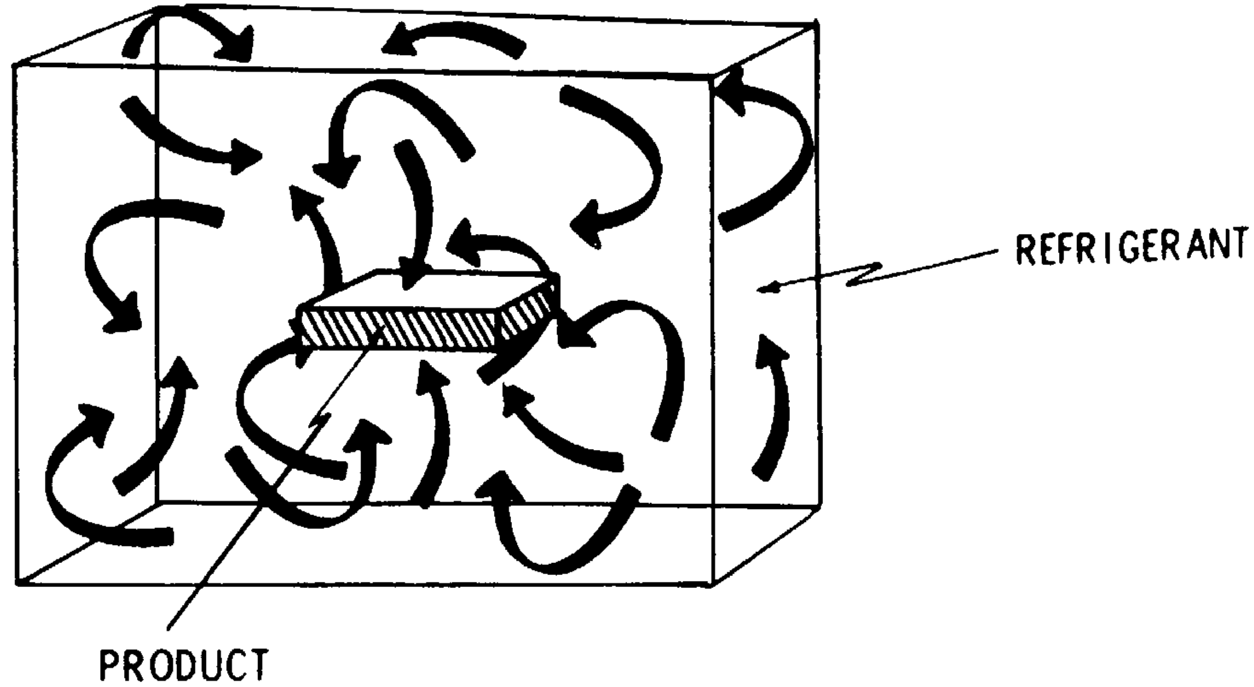
Source: Unit operations for food the food industries by: W.A. Gould

Cooled-liquid freezers

- **In *immersion freezers***, packaged food is passed through a bath of refrigerated propylene glycol, brine, glycerol or calcium chloride solution on a submerged mesh conveyor.

Immersion freezing

- In immersion freezing, food is placed in a refrigerant prior to freezing.
- Brine is often used for fish, and a sugar solution for fruits.
- This provides a layer which protects the food from the dry atmosphere of the freezer.



6.7 figure Schematic diagram of direct-contact freezing system.

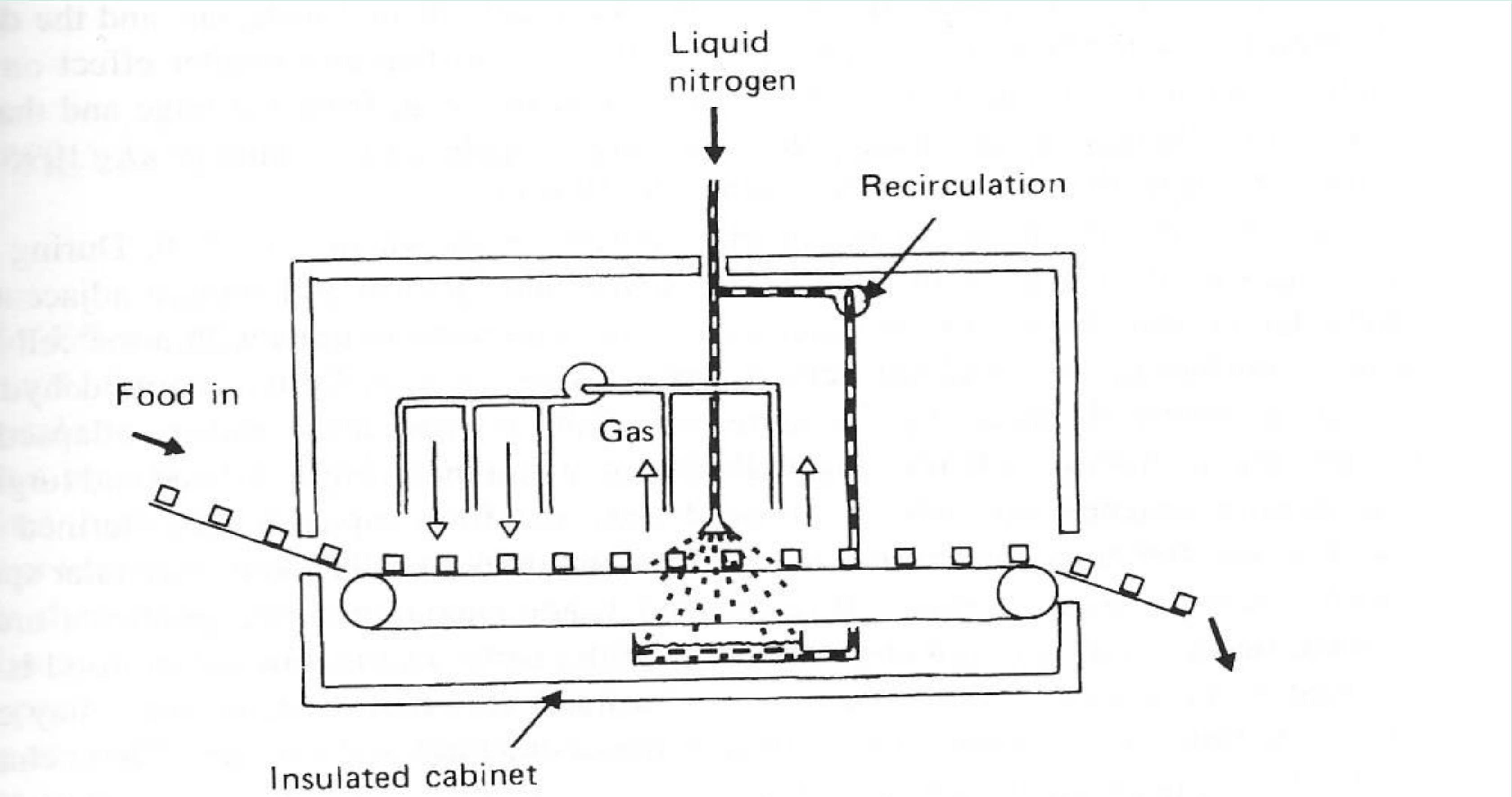
Cryogenic freezers

- Freezers of this type are characterized by a change of state in the refrigerant (or cryogen) as heat is absorbed from the freezing food. The heat from the food therefore provides the latent heat of vaporization or sublimation of the cryogen. The cryogen is in intimate contact with the food and rapidly removes heat from all surfaces of the food to produce high heat transfer coefficients and rapid freezing. The two most common refrigerants are liquid nitrogen and solid or liquid carbon dioxide.

Cryogenic Freezing

- Uses liquid nitrogen which is very cold (-196ºC) Food passes through a tunnel where nitrogen gas is sprayed downwards. A beefburger will be frozen in 1 minute at these extreme temperatures.
- This produces small crystals, and little moisture loss.
- This method is used when freezing prawns. The prawns are first dipped in liquid nitrogen to freeze the outside layer. This prevents the prawns sticking together and from sticking to the freezer belts.

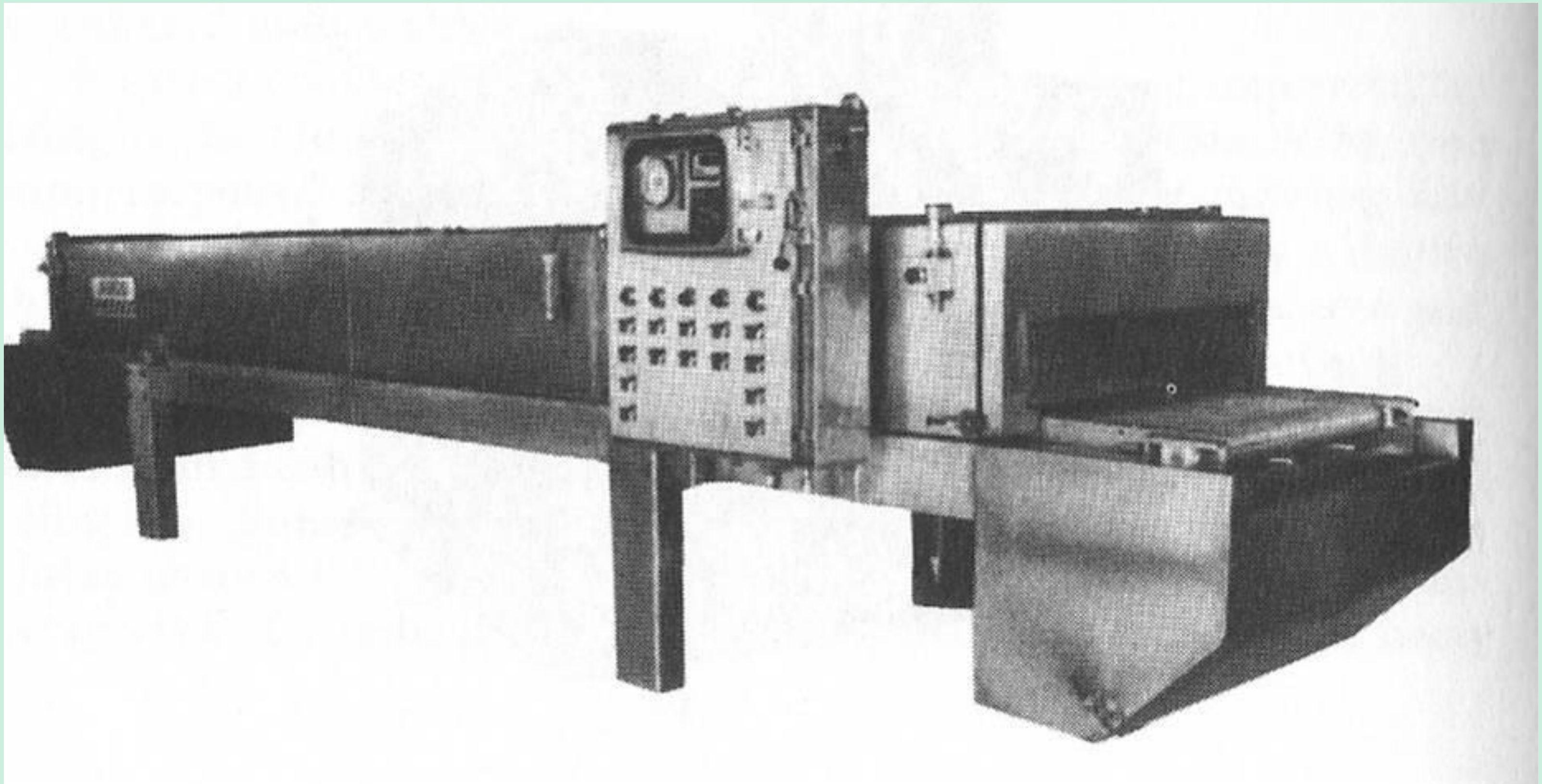
Cryogenic freezer



Source: Fellows (2000)

Cryogenic freezer

Ultra rapid: Direct Contact Liquid Nitrogen Tunnel Freezer

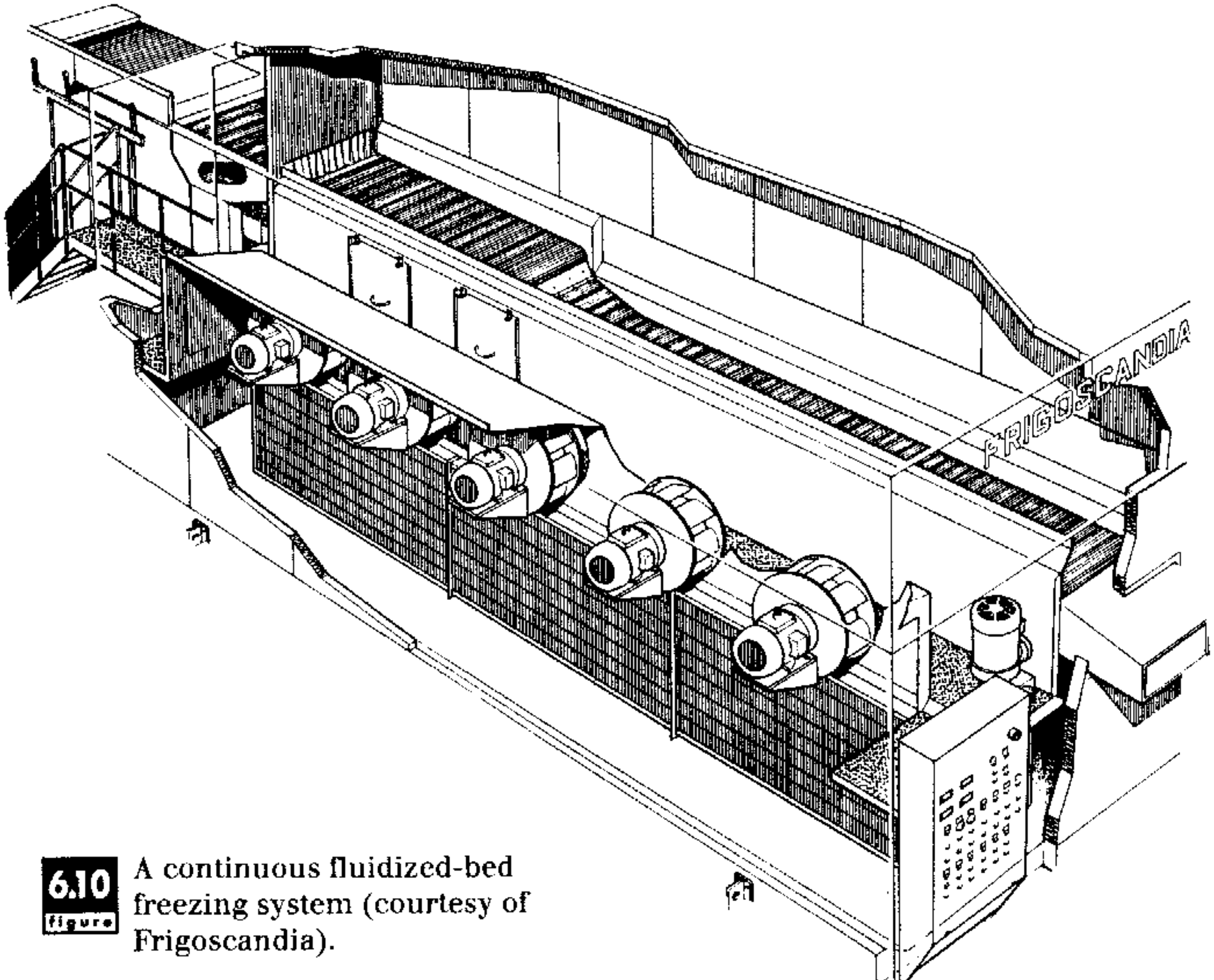


IQF

Source: Unit operations for food the food industries by: W.A. Gould

Continuous Fluidized Bed System

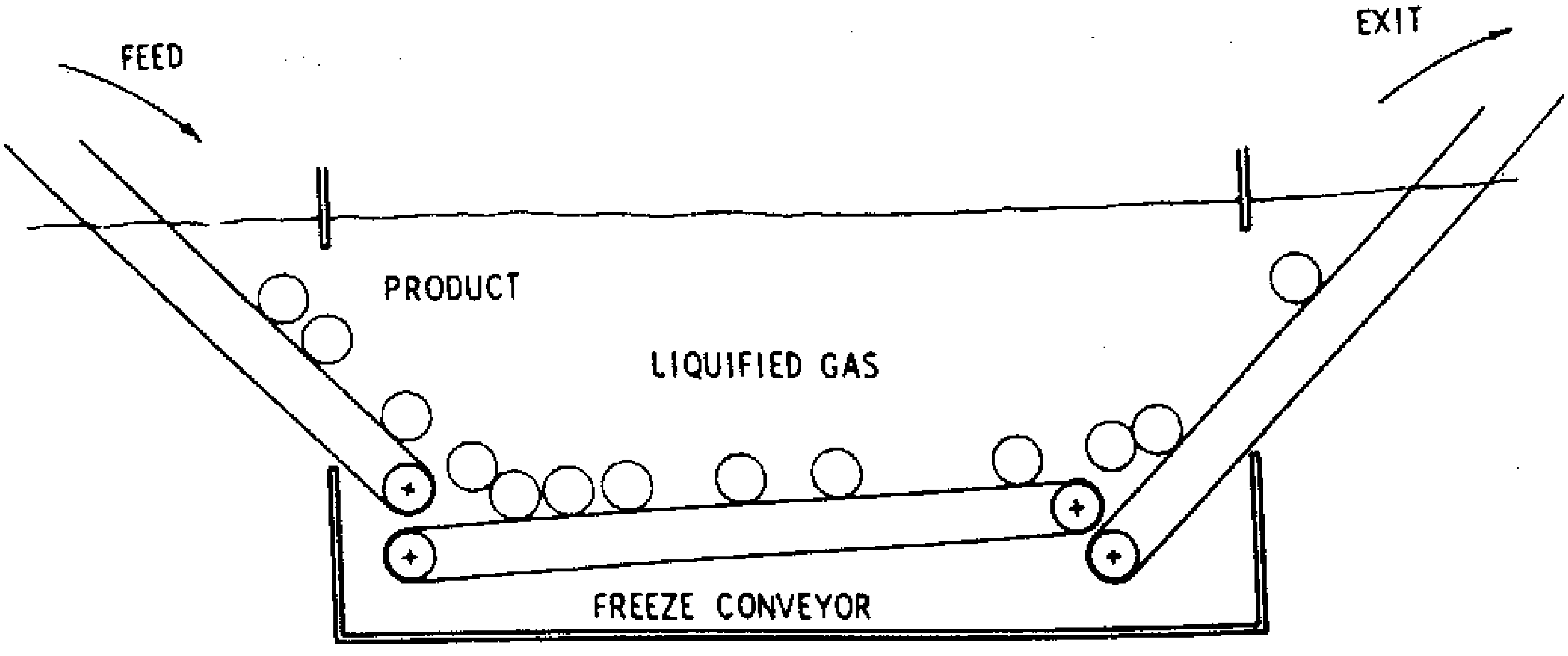
- In these types of freezing systems, the product moves on a conveyor into the cold environment in a manner similar to air blast systems. In a fluidized bed system, the cold air used as a freezing medium is directed upward through the mesh conveyor at velocities sufficient to cause vibration and movement of product on the conveying system. The vibration or movement of product while being conveyed, increases the contact between cold air and the product and reduces the time required for freezing.



6.10 figure A continuous fluidized-bed freezing system (courtesy of Frigoscandia).

Continuous Immersion Freezing System

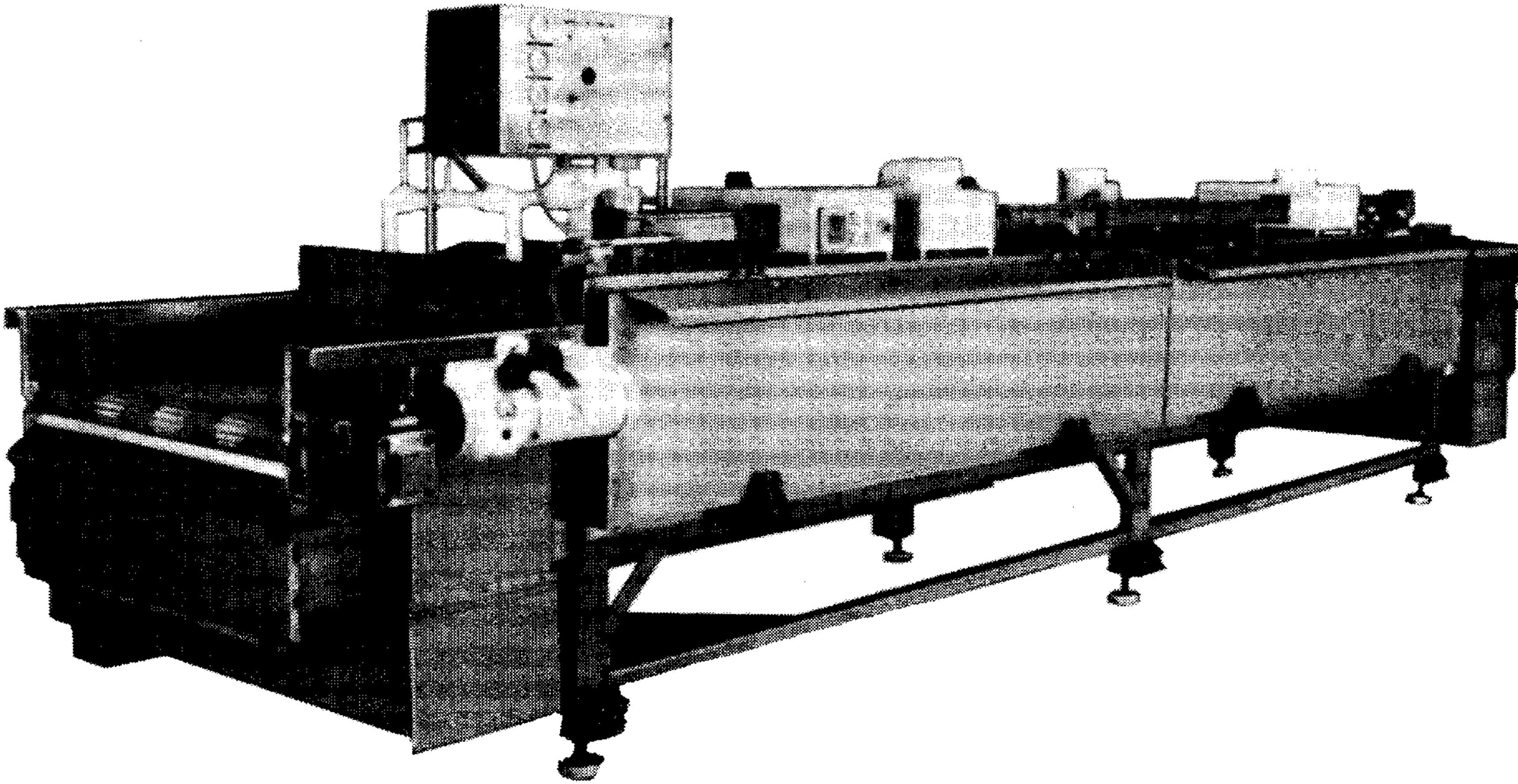
- For products where rapid freezing is appropriate, direct contact between a liquid refrigerant such as nitrogen or carbon dioxide may be used. The product is carried on a conveyor through a bath of liquid refrigerant to establish direct and intimate contact with the liquid refrigerant.



6.11 figure A continuous immersion freezing system.

Continuous Cryogenic Freezing Systems

- The product on a conveyor moves through a tunnel where it is exposed to a spray of liquid refrigerant as it changes phase to vapor state. The length of time for freezing is established by the rate of conveyor movement through the tunnel where the product is exposed to the cryogenic refrigerant.



6.12 figure A continuous cryogenic freezing system (courtesy of Liquid Carbonic).

Scraped surface, continuous system

- These types of freezing systems utilize a scraped surface heat exchanger as a primary component of the continuous system used to convert liquid product into a frozen slurry. In these systems, the outer wall of the heat exchanger barrel represents the barrier between the product and the low-temperature refrigerant used for product freezing.

Problem 1: Cooling of Apples

EXAMPLE 17–1 Cooling of Apples while Avoiding Freezing

Red Delicious apples of 70 mm diameter and 85 percent water content initially at a uniform temperature of 30°C are to be cooled by refrigerated air at −5°C flowing at a velocity of 1.5 m/s (Fig. 17–11). The average heat transfer coefficient between the apples and the air is given in Table 17–2 to be 21 W/m^2 · °C. Determine how long it will take for the center temperature of the apples to drop to 6°C. Also, determine if any part of the apples will freeze during this process.

SOLUTION The center temperature of apples drops to 6°C during cooling. The cooling time and if any part of the apples will freeze are to be determined.

Assumptions 1 The apples are spherical in shape with a radius of $r_0 = 3.5$ cm. 2 The thermal properties and the heat transfer coefficient are constant.

Properties The thermal conductivity and thermal diffusivity of apples are $k = 0.418$ W/m · °C and $\alpha = 0.13 \times 10^{-6}$ m^2/s (Table A–7).

Analysis Noting that the initial and the ambient temperatures are $T_i = 30$°C and $T_\infty = -5$°C, the time required to cool the midsection of the apples to $T_0 = 6$°C is determined from transient temperature charts for a sphere as follows:

Solution Example 1

$$\left.\begin{aligned} \frac{1}{\mathrm{Bi}} &= \frac{k}{hr_o} = \frac{0.418\ \mathrm{W/m\cdot{}^\circ C}}{(21\ \mathrm{W/m^2\cdot{}^\circ C})(0.035\ \mathrm{m})} = 0.57 \\ \frac{T_o - T_\infty}{T_i - T_\infty} &= \frac{6-(-5)}{30-(-5)} = 0.314 \end{aligned}\right\} \quad \tau = \frac{\alpha t}{r_o^2} = 0.46$$

Therefore,

$$t = \frac{\tau r_o^2}{\alpha} = \frac{(0.46)(0.035\ \mathrm{m})^2}{0.13 \times 10^{-6}\ \mathrm{m^2/s}} = 4335\ \mathrm{s} \cong \mathbf{1.20\ h}$$

The lowest temperature during cooling will occur on the surface ($r/r_o = 1$) of the apples that is in direct contact with refrigerated air and is determined from

$$\left.\begin{aligned} \frac{1}{\mathrm{Bi}} &= \frac{k}{hr_o} = 0.57 \\ \frac{r}{r_o} &= 1 \end{aligned}\right\} \quad \frac{T(r) - T_\infty}{T_o - T_\infty} = 0.50$$

It gives

$$T_{\text{surface}} = T(r) = T_\infty + 0.50(T_o - T_\infty) = -5 + 0.5[6 - (-5)] = 0.5^\circ\mathrm{C}$$

which is above -1.1°C, the highest freezing temperature of apples. Therefore, **no part of the apples will freeze** during this cooling process.

Problem 2 : Freezing of Beef

EXAMPLE 17–2 **Freezing of Beef**

A 50-kg box of beef at 8°C having a water content of 72 percent is to be frozen to a temperature of −30°C in 4 h. Using data from Fig. 17–13, determine (*a*) the total amount of heat that must be removed from the beef, (*b*) the amount of unfrozen water in beef at −30°C, and (*c*) the average rate of heat removal from the beef.

SOLUTION A box of beef is to be frozen. The amount of heat removed, the remaining amount of unfrozen water, and the average rate of heat removal are to be determined.

Assumptions The beef is at uniform temperatures at the beginning and at the end of the process.

Properties At a water content of 72 percent, the enthalpies of beef at 8 and −30°C are $h_1 = 312$ kJ/kg and $h_2 = 20$ kJ/kg (Fig. 17–13).

Solution : Problem 2

Analysis (*a*) The total heat transfer from the beef is determined from

$$Q = m(h_1 - h_2) = (50\,\text{kg})[(312 - 20)\,\text{kJ/kg}] = \mathbf{14{,}600\ kJ}$$

(*b*) The unfrozen water content at −30°C and 72 percent water content is determined from Figure 17–13 to be about 10 percent. Therefore, the total amount of unfrozen water in the beef at −30°C is

$$m_{\text{unfrozen}} = (m_{\text{total}})(\%\,\text{unfrozen}) = (50\,\text{kg})(0.1) = \mathbf{5\ kg}$$

(*c*) Noting that 14,600 kJ of heat are removed from the beef in 4 h, the average rate of heat removal (or refrigeration) is

$$\dot{Q} = \frac{Q}{\Delta t} = \frac{14{,}600\,\text{kJ}}{(4 \times 3600\,\text{s})} = \mathbf{1.01\ kW}$$

Therefore, this facility must have a refrigeration capacity of at least 1.01 kW per box of beef.

This problem could also be solved by assuming the beef to be frozen completely at −2°C by releasing its latent heat of 240 kJ/kg and using specific heat values of 3.25 kJ/kg · °C above freezing and 1.75 kJ/kg · °C below freezing. The total heat removal from the box of beef in this case would be 16,075 kJ. Note that the difference between the two results is 16,075 − 14,600 = 1475 kJ, which is nearly equal to the latent heat released by 6 kg of water as it freezes.

Thanks

for

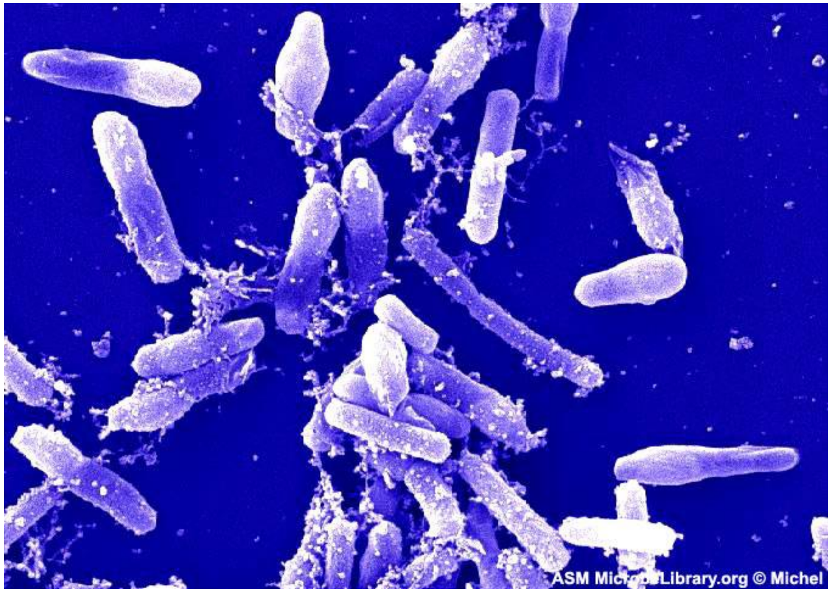
your attention

Is Pasteurization Effective?

How does pasteurization affect the activation of *Bacillus* spores in milk?

Bacillus is a family of bacterium that is characterized primarily for endospores, highly resistant, dormant forms of life. They also have the following characteristics:

- Gram-postive
- Rod shaped
- α-hemolysis
- Catalase positive
- Extreme Thermophiles



Background – Endospores

Endospores are extremely resistant to any environmental conditions and are the known source for species survival.

They are produced through sporulation usually triggered by poor growth conditions.

They remain dormant until conditions are right again for the live bacterium is able to survive.

Background – Pasteurization

Defined as: “The heating of every particle of milk or milk product to a specific temperature for a specified period of time without allowing recontamination of that milk or milk product during the heat treatment process.”

Background – Pasteurization

- Is used to improve the quality of dairy products
- To decrease health risks associated with bacterium normally found in dairy products

Experiment

- The extreme heat associated with pasteurization could be responsible for the activation of bacterial endospores derived from *Bacillus,* and therefore an increase in reproduction and concentration of cells.
- We plan on isolating *Bacillus* from both spoiled and non-spoiled milk and comparing the concentrations of *Bacillus* in each.
- If our hypothesis is true, then there should be a higher concentration of *Bacillus* in the spoiled milk.

Experiment – Protocol

1. Make Dextrose-Tryptone Agar :

    -minimal media, selective for *Bacillus*

    -Bromcresol Purple is a pH indicator that turn yellow when the pH becomes very low due to the fermentation of sugars such as dextrose

2. Plate both spoiled and non-spoiled milk (whole and regular) onto dextrose-tryptone agar and TSA plates in serial dilutions to obtain concentrations.

3. Perform a series of tests to be sure that we have obtained *Bacillus*

Methods

Our protocol will test our hypothesis by finding the concentrations of *Bacillus* using serial dilutions and confirm the presence of *Bacillus* by performing tests that the results would be characteristic of *Bacillus*. These tests include:

- Catalase
- MacConkey's Media
- Blood Agar
- Endospore stain

Results

(TSA)	Regular Whole Milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
Dilution	$1*10^{-4}$	$1*10^{-5}$	$1*10^{-1}$	$1*10^{-5}$
# of Colonies	191	205	363	198
Concentration (CFU/ml)	$1.91*10^{7}$	$2.05*10^{8}$	$3.63*10^{4}$	$1.98*10^{8}$

Results

(Dextrose-Tryptone)	Regular Whole Milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
Dilution	Unable to Count (Too tiny)	$1*10^{-5}$	$1*10^{-1}$	$1*10^{-5}$
# of Colonies	N/A	227	207	169
Concentration (CFU/ml)	N/A	$2.27*10^{8}$	$2.07*10^{4}$	$1.69*10^{8}$

Result

	Regular whole milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
Blood Agar	Alpha	Alpha	Alpha	Gamma

Regular Skim Milk

Sour Skim Milk

Result

	Regular whole milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
MacConkey	White Colonies	No Growth	No Growth	No Growth

Whole Regular Milk, the only Gram-negative species

Result

	Regular Whole Milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
Catalase	Positive	Negative	Negative	Negative

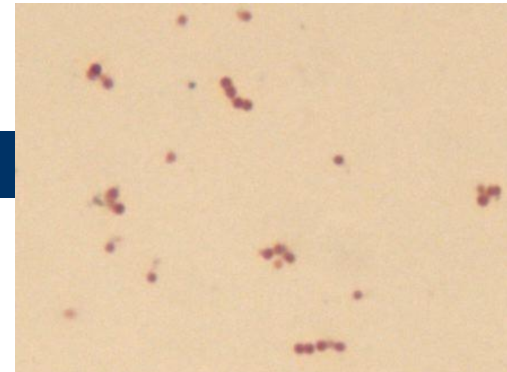
Results

Bacillus cerus, control

	Regular Whole Milk	Sour Whole Milk	Regular Skim Milk	Sour Skim Milk
Endospores	Negative	Negative	Negative	Negative

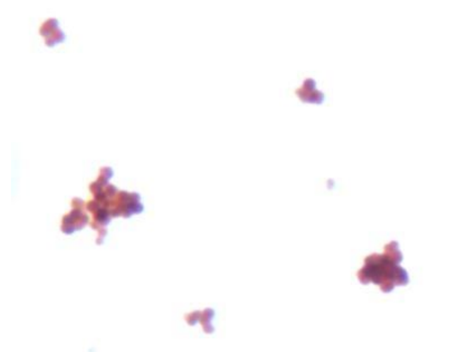
Results

Whole Regular Milk



Whole Sour Milk

Skim Regular Milk

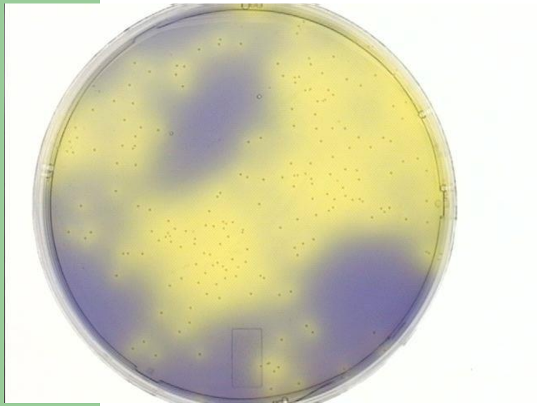


Skim Sour Milk

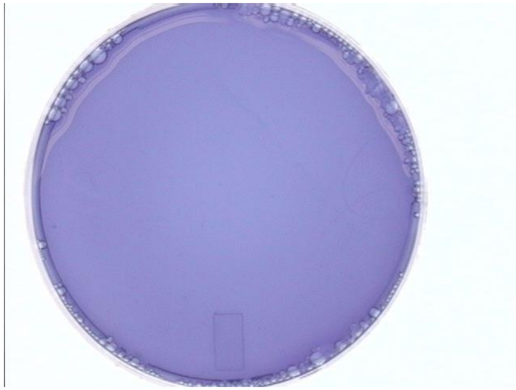
Rods

Cocci

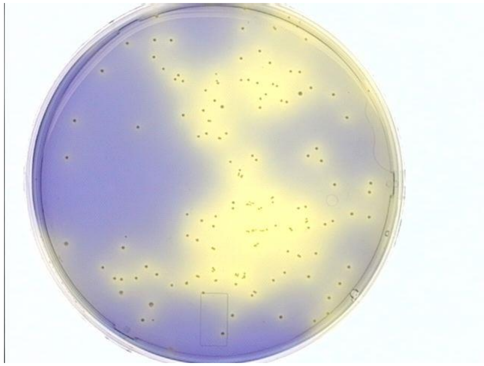
Results



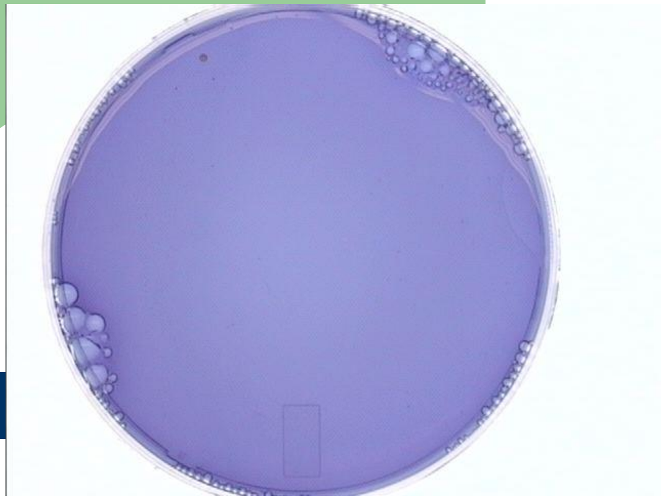
Skim Regular 10^{-1}



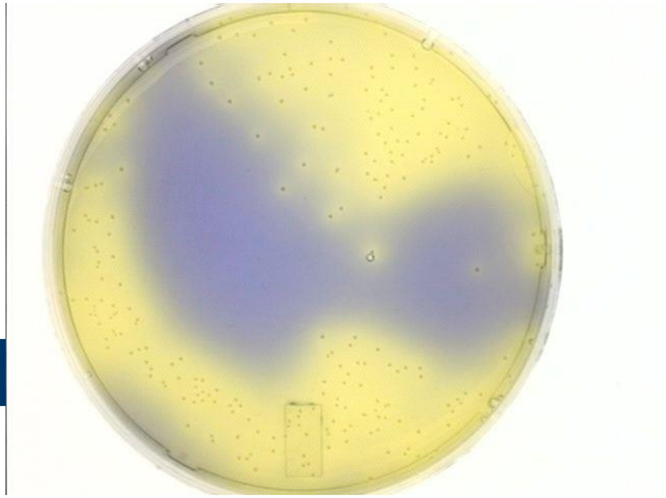
Skim Regular 10^{-5}



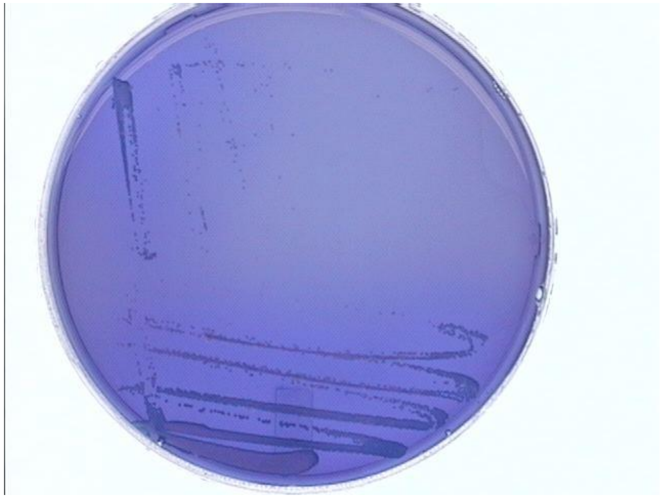
Skim Sour 10^{-5}



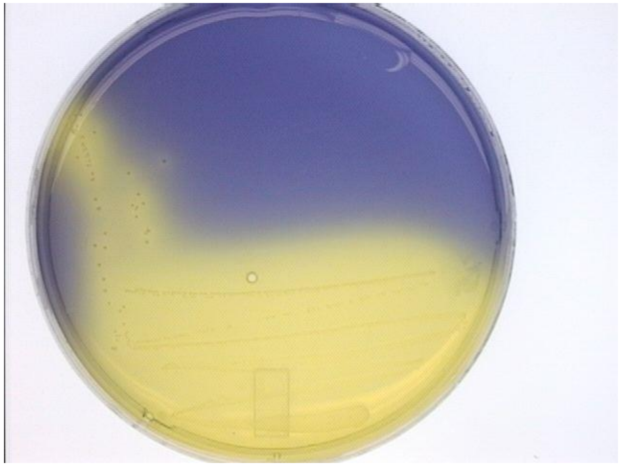
Whole Regular Milk 10^{-5}



Whole Sour Milk 10^{-5}



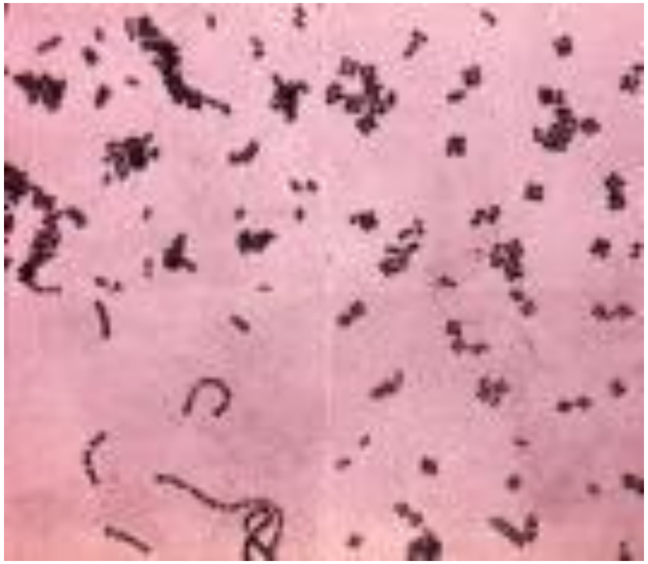
Whole Regular Milk Streak Plate



Whole Sour Milk Streak Plate

Discussion

Stretococcus is a common cause of Mastitis in cows. It is a non-endospore forming, catalase postive cocci shaped bacterium. Mastitis is easily seen by an inflamed udder in the cow and is caused by a bacterial infection. This is what we think we recovered in the sour milk.



Diseases

- ***B. cereus*** **causes food-poisoning syndromes (found in milk):**

  1. Rapid-onset emetic syndrome

  -nausea, vomiting

  2. Slower onset diarrheal syndrome

- ***Drink water and eat garlic if extremely sever then antibiotics may be necessary such as: erythromycin, ciprofloxacin and chloramphenical. These antibiotics break down the cell wall or prevent synthesis of proteins.***
- **B. anthracis*, causes anthrax under skin, in the lungs (pneumonia) and intestine.***
- **These diseases are rare and can be treated by antibiotic therapy such as: penicillin, doxycycline and flouroquinolones (especially in inhaled *Bacillus*.**

What if we found *Bacillus*?

- Finding an increased concentration of *Bacillus* in the sour milk would mean that Pasteurization would in fact activate the spores and *Bacillus* would be present in sour milk. This would lead to possible food-poisoning caused by *B. cereus.*
- Pasteurization is not as effective in preventing health risks associated with contaminated food as thought.

Conclusions

- We didn't actually find *Bacillus* in the sour milk, which disproves our hypothesis that the endospores were activated due to the extreme heat.
- This experiment makes sense and it could only have been human errors that caused us to deem our hypothesis as false.

LECTURE 5

DRYING TECHNOLOGY IN FOOD PROCESSING AND PRESERVATION

Contents

Introduction to food processing; drying - Fundamentals

- Classification-general ideas
  - Why so many dryer types?
- Key criteria for classification
- Criteria for dryer selection
- Different dryer types
  - Energy related issues in drying
- Special/Innovative dryers
  - Closure

Food Processing

- Need of food processing - to avoid the spoilage of foods due to various reasons; to increase shelf life; to make food products available through out the year
- The spoilage could be due to physical damage, chemical damage, microbial attack
- Various food processing methods – Freezing, canning, preserving in syrup, food irradiation, salting, vacuum packaging, **dehydration**
- canning and freezing – best way to retain the taste, appearance, and nutritive value of fresh food (Cost involvement)
- Drying/Dehydration – very much cost-effective; product takes much less storage space than canned or frozen foods; Some dehydrated products have very good rehydration properties

Drying - Fundamentals

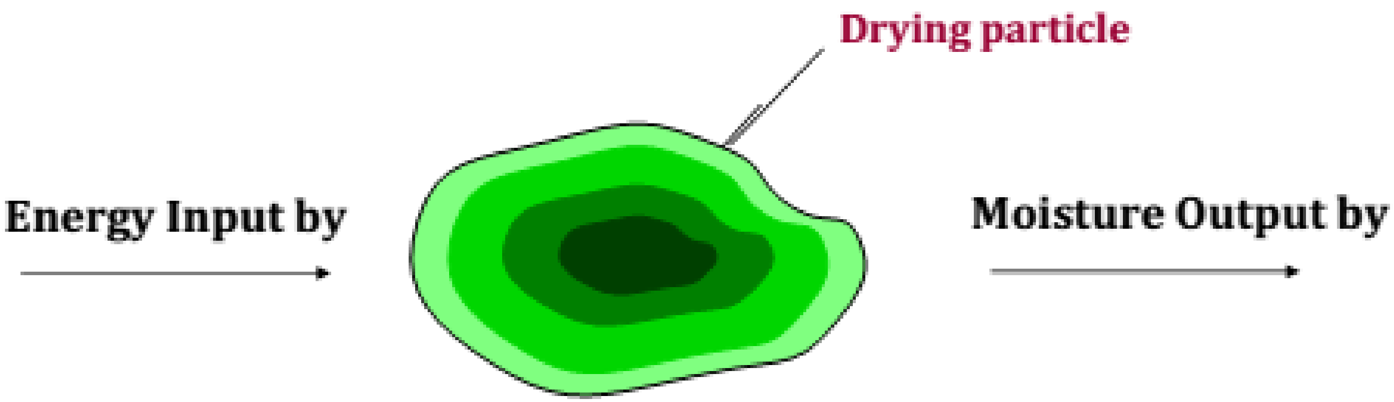
- Removal of a liquid from a solid/semi-solid/liquid to produce solid product by thermal energy input causing phase change (Sometimes converts solid moisture into vapor by sublimation eg. Freeze drying with application of heat.)

- Needed for the purposes of preservation and storage, reduction in cost of transportation, etc.

- Most common and diverse operation with over 100 types of dryers in industrial use

- Competes with distillation as the most energy-intensive operation

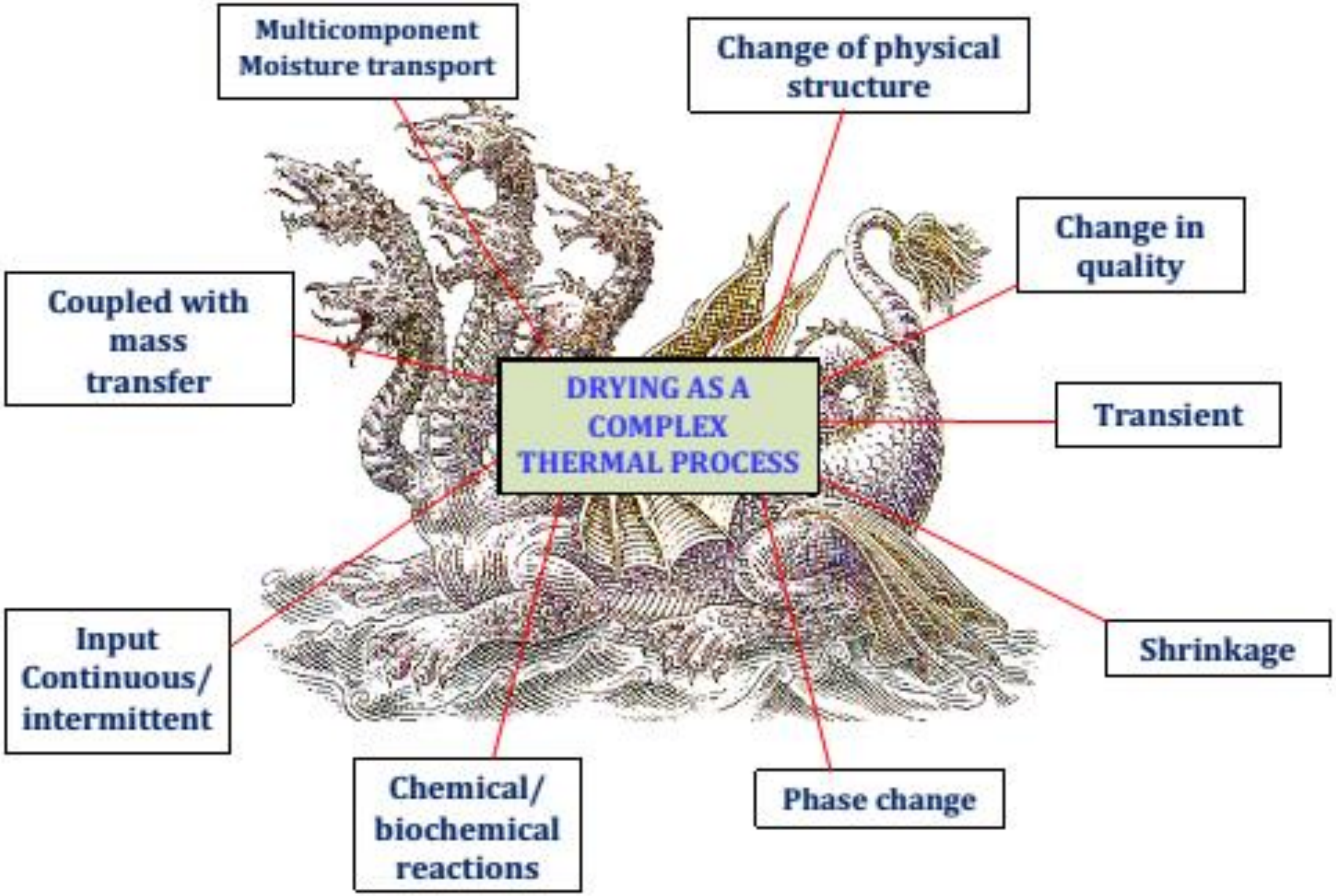
Drying - Fundamentals



- Conduction
- Convection
- Radiation
- Microwave and Radio Frequency Fields
- Combined mode

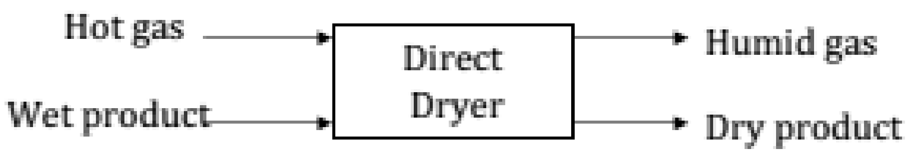
- Liquid diffusion
- Vapor diffusion
- Capillary flow (Permeability)
- Knudsen diffusion (Mean free path < pore dia.)
- Surface diffusion
- Poiseuille flow
- Combination of above

Drying a Complex Process



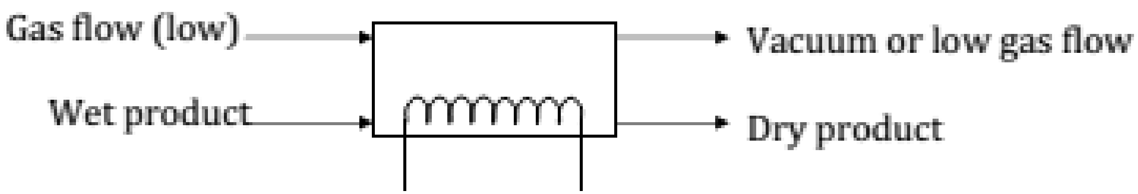
Drying based on heat input

I. Direct (Convective)



Drying medium directly contacts material to be dried and carries evaporated moisture.

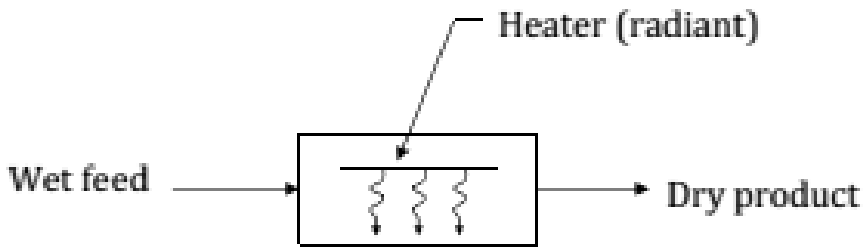
II. Indirect (Contact, Conduction)



Heat supplied
by heat exchanger
(through metal wall)

Drying based on heat input

III. Radiant



Vacuum or low gas flow to carry evaporated moisture away.

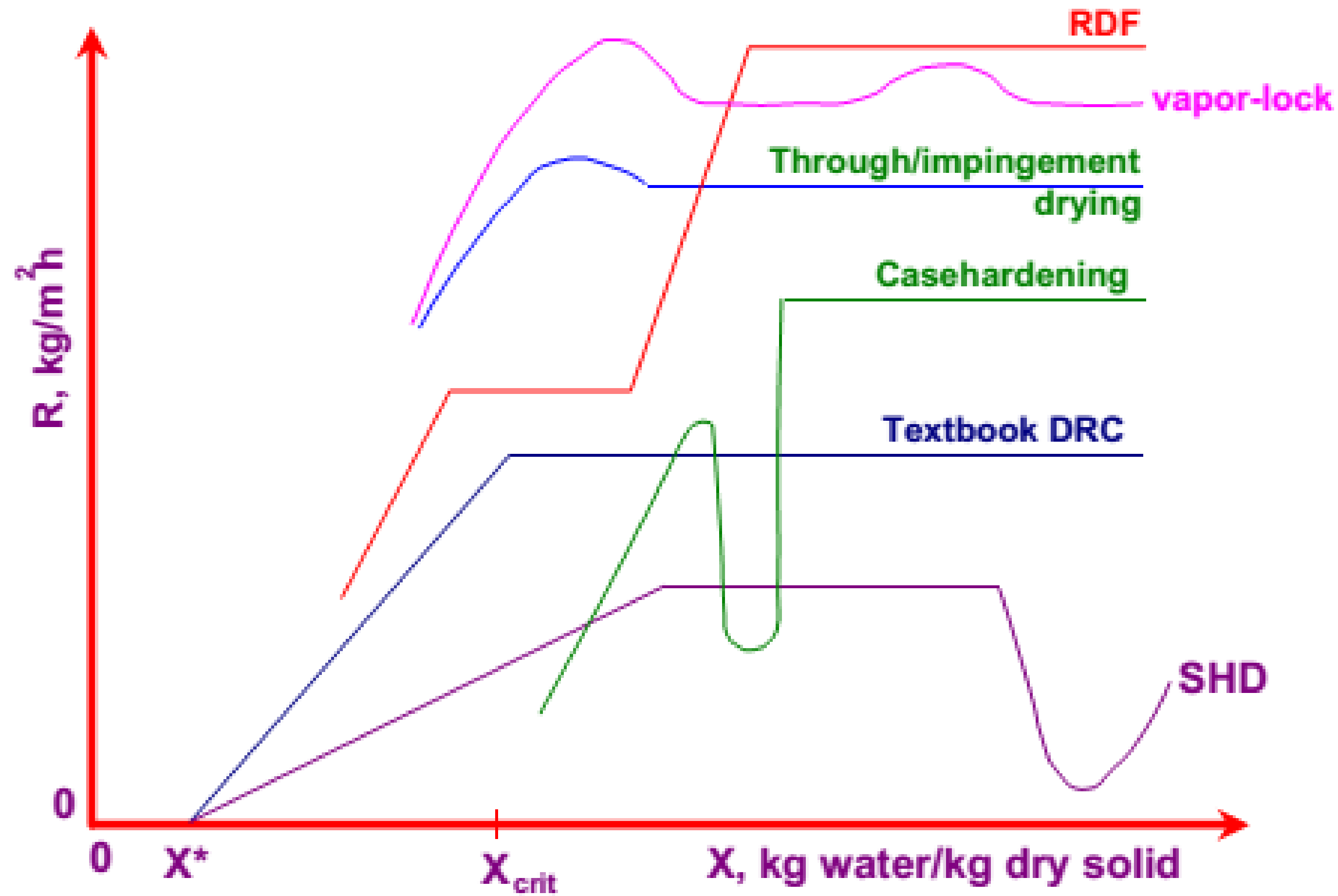
IV. Microwave or RF

Electromagnetic energy absorbed selectively by water (volumetric heating)

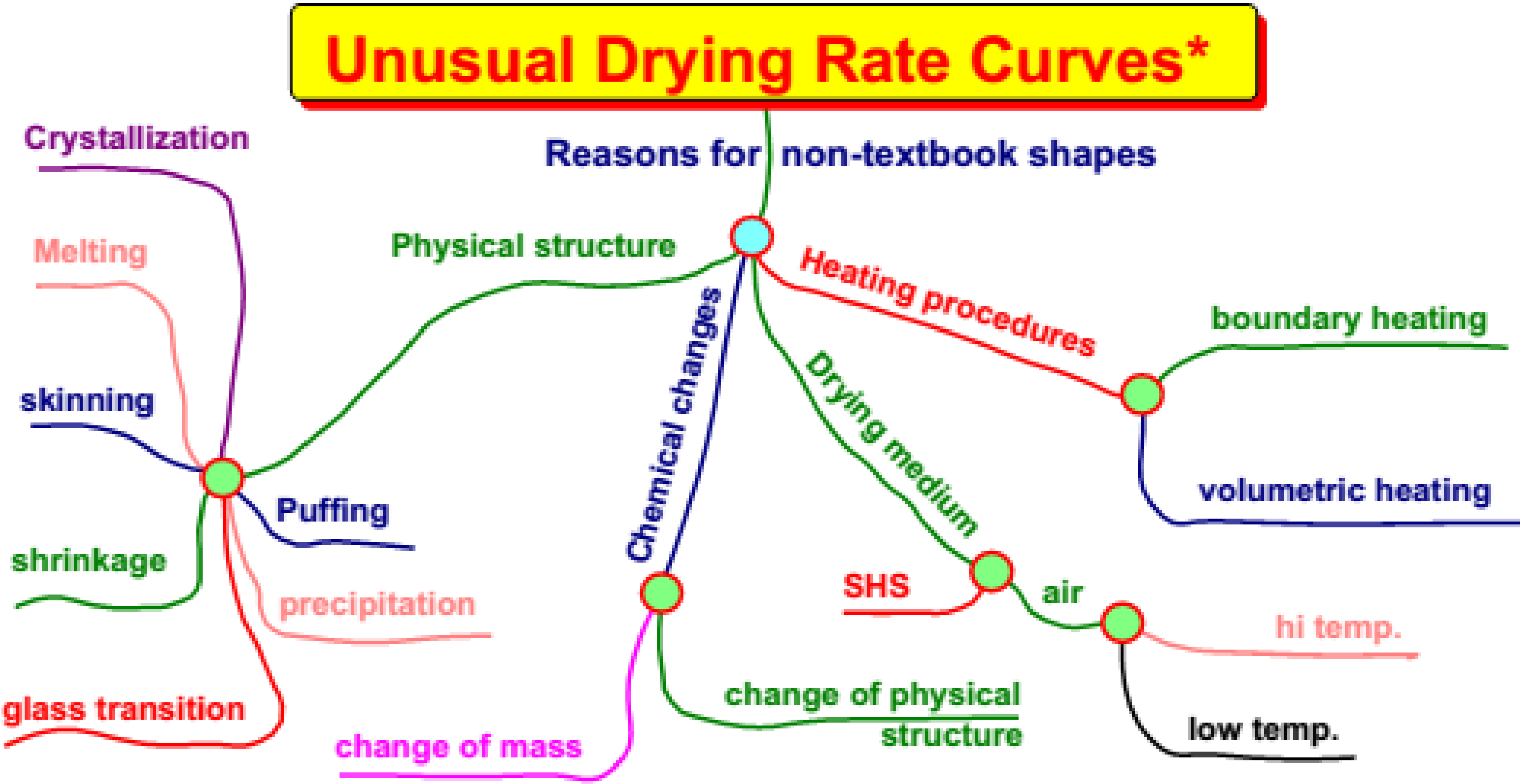
Typically less than 50% of total heat supplied in most direct dryers is used for evaporation. Water is the most common solvent removed in dryers.

Basic terms

Unusual Drying Rate Curves



Basic terms



* Constant drying conditions

Basic terms (water activity)

WATER ACTIVITY (a_w):

$$a_w = \frac{\text{Partial pressure of water over wet solid}}{\text{Equilibrium vapor pressure of water at same temp.}}$$

State of water in bio-product:

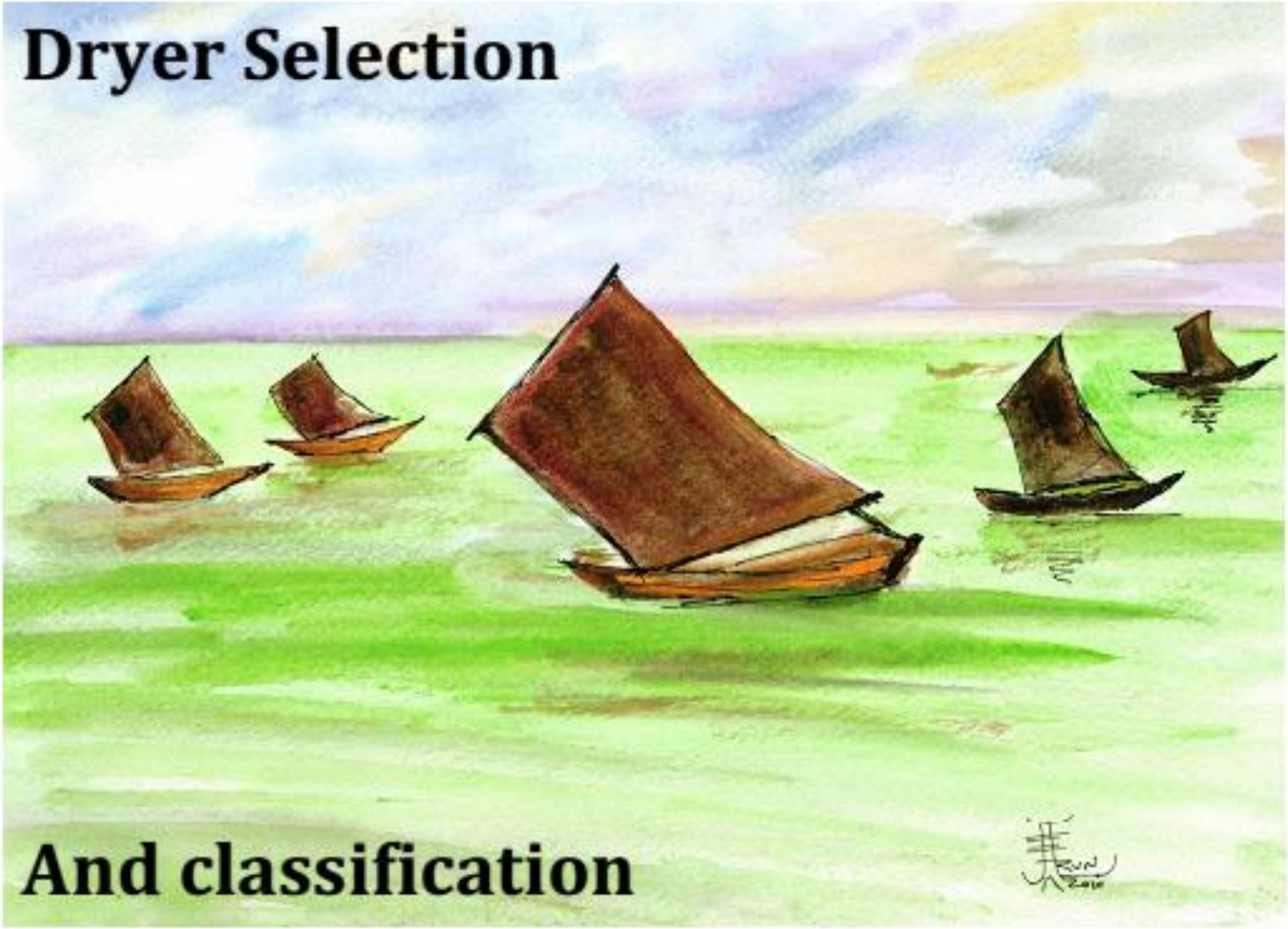
- **Free water - intra-cellular water; nutrients and dissolved solids needed for living cells**

- **Bound water - water built into cells or biopolymer structures Needs additional energy to break "bonds" with solid. Bound water also resists freezing**

For safe storage, bio-products must be dried to appropriate levels and stored under appropriate conditions

Why so many dryer types?

- Over 500 reported in literature studies; over 100 commercially available
- Over 50,000 materials are dried commercially at rates of a few kg/hr to 30 T/hr or more
- Drying times (residence times within drying chamber) can range from 1/3 sec. to months
- Temperature and pressure range from below triple point to super-critical
- Numerous constraints on physical/chemical properties of feed as well as dried product require a bewildering array of dryer designs
- Wide range of feeds (liquid, solid, semi-solid, particulate, pasty; sludge-like; sticky etc); wide specs on dried product


Dryer Selection
And classification

Why select dryer carefully?

- Can affect bottom-line..
- Product quality , energy usage affected by choice
- Choose right drying system-not jut dryer
- Weakest link decides ultimate goodness of system choice
- Survey of 10 largest pharma and chemical companies in Europe in 1990's identified dryer selection as main problem facing industry!
- Expert systems exist for selection. Different expert systems give different selections
- Know product and process well before choosing drying system; **imitation can cause problems!**

Some notes for dryer selection

- Must examine drying system cost rather than dryer cost for final selection.
- Largely untested in industrial practice – trend is to "repeat history"
- Do not copy dryer or dryer system used elsewhere without critical evaluation from square 1!
- Nickel ore concentrate is dried in different places using spray, fluid bed, rotary and flash dryers/ Which one do you COPY?
- Local fuel availability and relative costs of different energy sources, environmental requirements as well as legislation can change selection of dryer for same application

Main dryer classification criteria

Criterion	Types
Mode of operation	• Batch • Continuous*
Heat input-type	• Convection*, conduction, radiation, electromagnetic fields, combination of heat transfer modes • Intermittent or continuous* • Adiabatic or non-adiabatic
State of material in dryer	• Stationary • Moving, agitated, dispersed
Operating pressure	• Vacuum* • Atmospheric
Drying medium (convection)	• Air* • Superheated steam • Flue gases

Main dryer classification criteria

Criterion	Types
Drying temperature	• Below boiling temperature* • Above boiling temperature • Below freezing point
Relative motion between drying medium and drying solids	• Co-current • Counter-current • Mixed flow
Number of stages	• Single* • Multi-stage
Residence time	• Short (< 1 minute) • Medium (1 – 60 minutes) • Long (> 60 minutes)

Basic Choice: Form of Feed

Feed and product can be in one of these main basic forms:

•Particulate solids (bed/layer/or dispersed)

•Sheet or film

•Block or slab

•Slurry or solution (feed only) or paste

•Mostly require completely different types of dryer

•Widest choice available for particulate solids

•Specification of final product also critical in selection

Basic Choice: Batch or Continuous

Batch dryers favored by :

- Low throughput (under 50 kg/h)
- Long residence time (i.e. mainly falling rate drying)
- Batch equipment upstream and downstream
- Requirement for batch integrity

Continuous dryers favored by

- opposite conditions

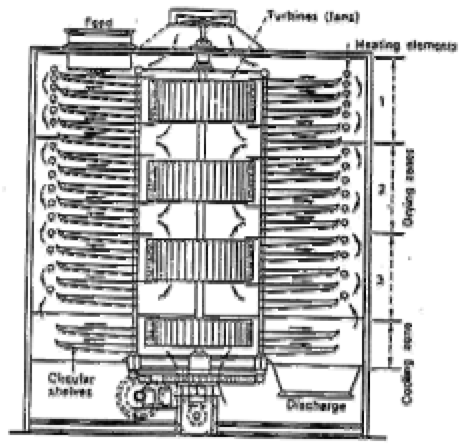
Dryers: Solid Exposure to Heat Conditions

Dryers	Typical residence time within dryer				
	0- 10 sec	10- 30 sec	5- 10 min	10- 60 min	1- 6 hr
Convection					
Belt conveyor dryer				X	
Flash dryer	X				
Fluid bed dryer				X	
Rotary dryer				X	
Spray dryer		X			
Tray dryer (batch)					X
Tray dryer (continuous)				X	
Conduction					
Drum dryer		X			
Steam jacket rotary dryer				X	
Steam tube rotary dryer				X	
Tray dryer (batch)					X
Tray dryer (continuous)				X	

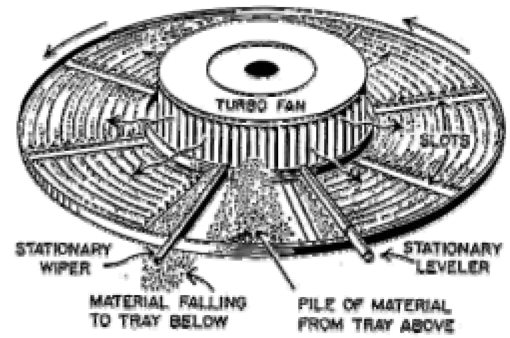
Product Classification and Dryer Types

Dryers	Evap. Rate ($kg/m^2/hr$)	Fluid, liquid suspension	Pastes	Powders	Granules, pellets	Operation
Forced Convection (through flow)	7.5	-	-	-	Good	Batch
Double Cone	10	-	Poor	Fair	Poor	Batch
FBD	130	-	-	Good	Good	Continuous
Band	30	-	Fair	-	Good	Continuous
Film Drum	22	Good	Fair	-	-	Continuous
Flash	750	-	Fair	Good	Fair	Continuous
Rotary (indirect)	33	-	Poor	Good	Fair	Continuous
Spin Flash	185	-	Good	Good	Fair	Continuous
Spray	15	Good	-	-	-	Continuous

Turbo Tray Dryers



(a) Turbo-tray tower dryer

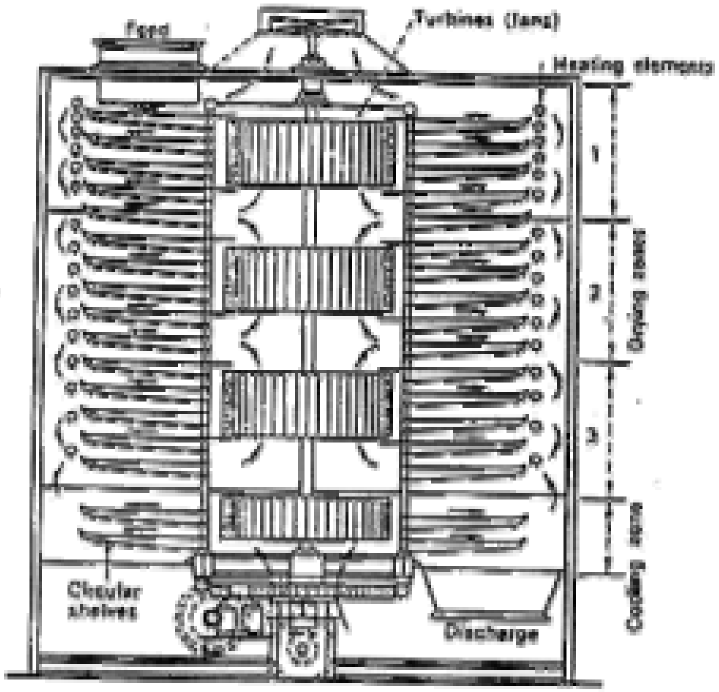


(b) Detail of annular shelf

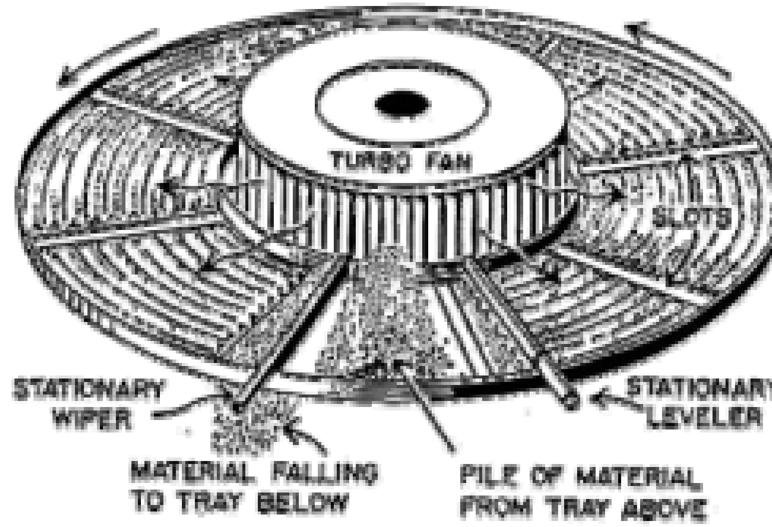
Rotating-shelf dryers

- Suitable for granular feeds, operate with rotating shelves and force convection of air above the shelves.
- The Dryer can have 30+ trays and provide large residence time.
- Hermetic sealing is possible for solvent recovery.

Turbo Tray Dryers



(a) Turbo-tray tower dryer



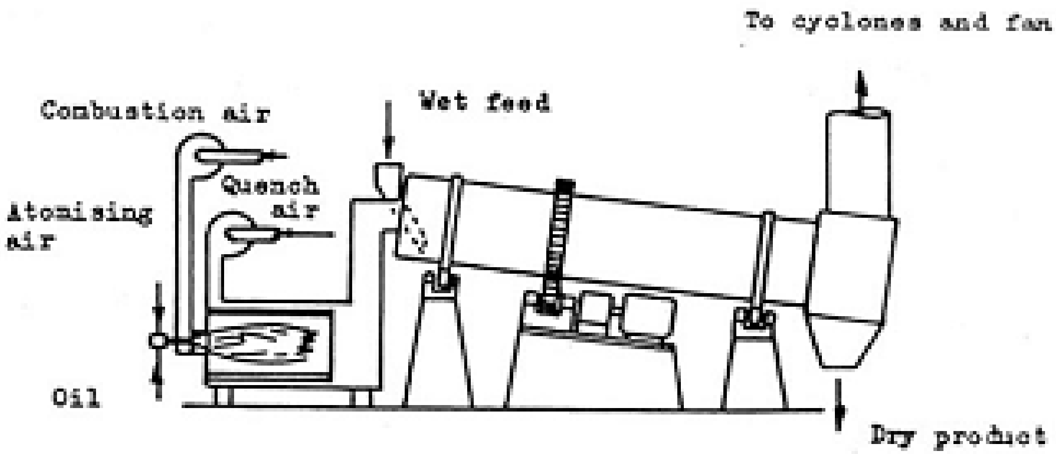
(b) Detail of annular shelf

Rotating-shelf dryers

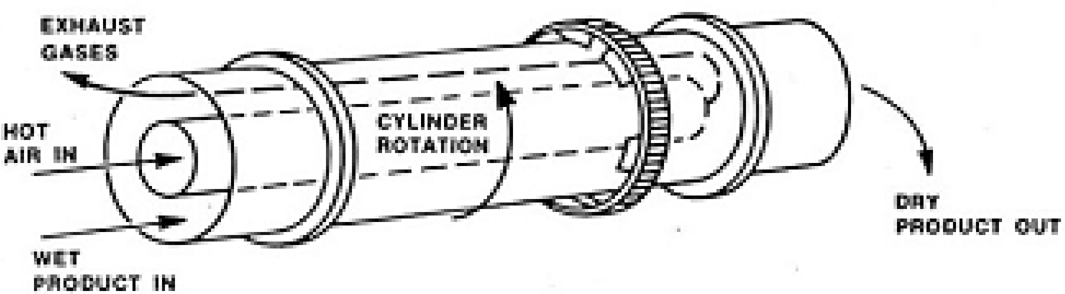
- Suitable for granular feeds, operate with rotating shelves and force convection of air above the shelves.
- The Dryer can have 30+ trays and provide large residence time.
- Hermetic sealing is possible for solvent recovery.

Rotary Dryer

Direct-Heat Rotary Drying



Typical cascading direct rotary dryer arranged for cocurrent operation. (From Nonhebel and Moss, 1971.)



Indirect-direct rotary dryer. (Courtesy of C-E Raymond, Combustion Engineering, Inc., Chicago, Illinois.)

- Combined cascade motion with heat & mass transfer.
- Large capital & operating cost.
- Used in fertilizers, pharmaceutical, lead & zinc concentrate for smelting, cement.

- Size 0.3 to 5 m diameter & 2 to 90 m length.

Microwave Dryers

Used in ceramics industries, foods & pharmaceuticals to drive off final traces of moisture.

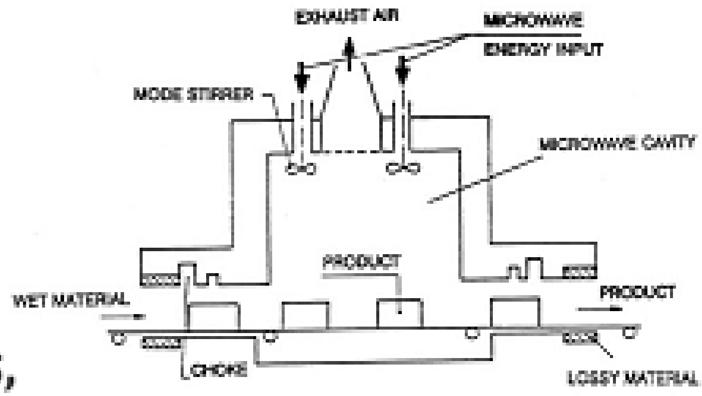


Fig. Band-type microwave dryer

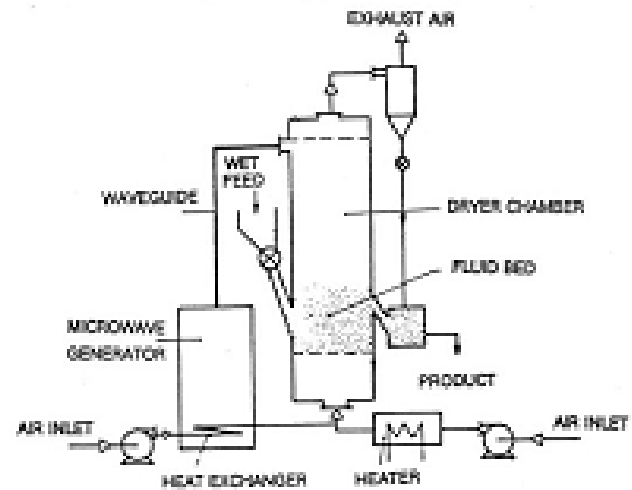
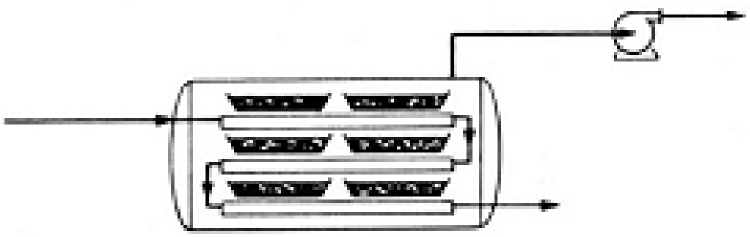
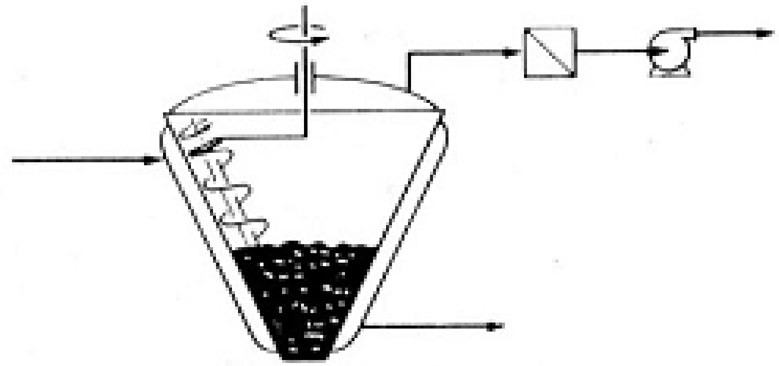


Fig. Microwave dryer for particulate materials

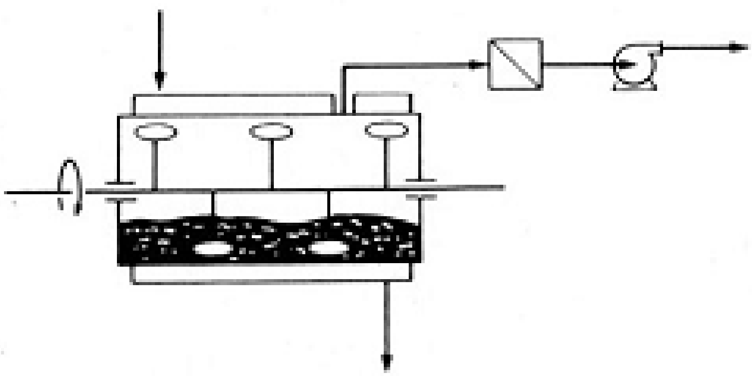
Vacuum Dryers – Heat Sensitive Materials



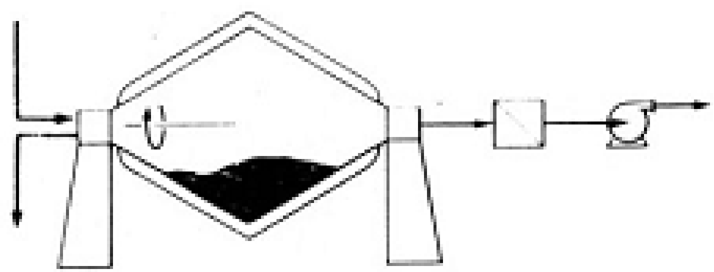
d. Vacuum tray dryer



f. Agitated vacuum dryer
(About 10 min^{-1})

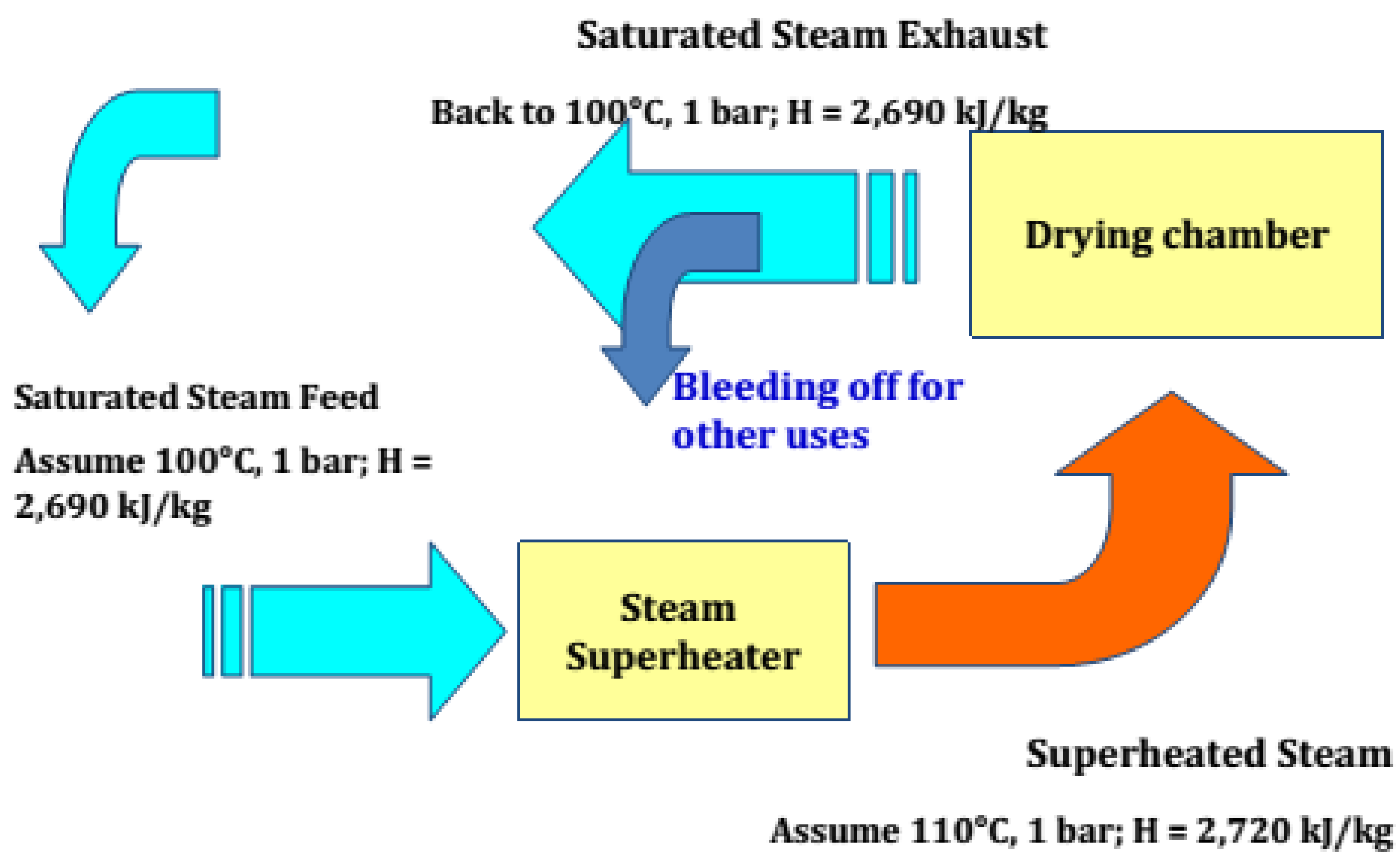


e. Agitated vacuum dryer
(About 75 min^{-1})



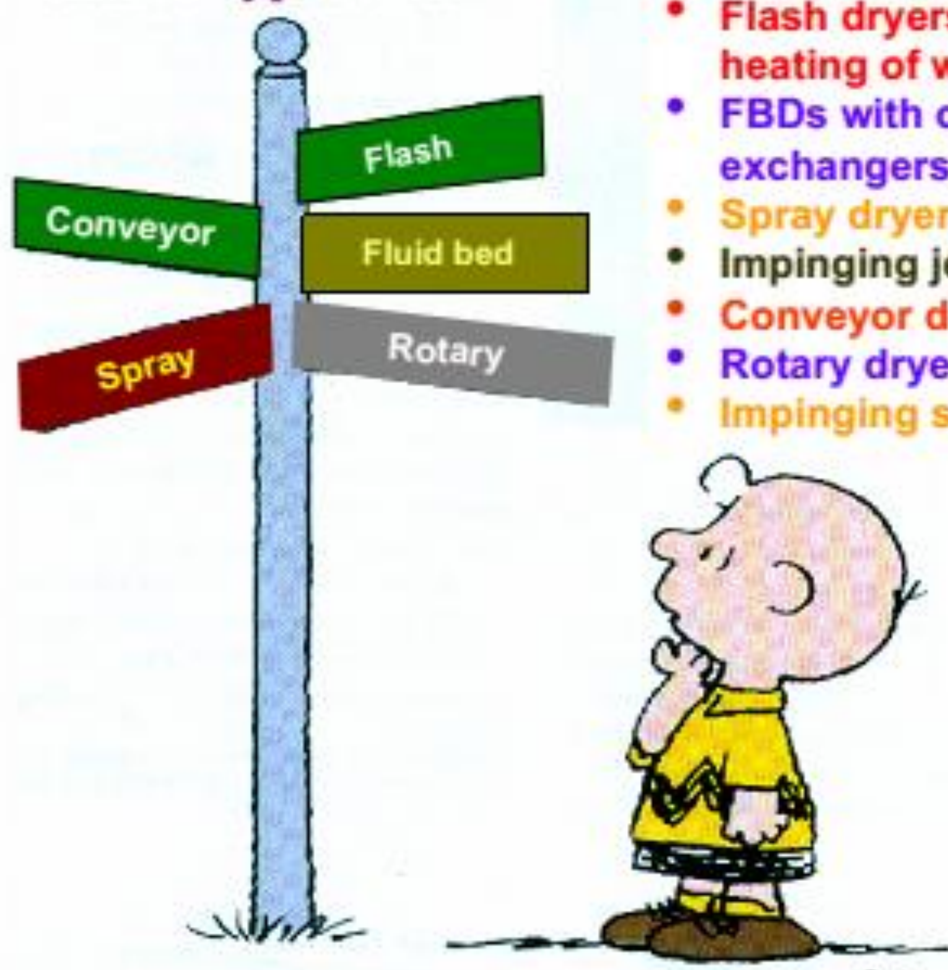
g. Tumbler

Superheated Steam Drying



Superheated Steam Drying

Possible Types of SSD



- Flash dryers with or without indirect heating of walls
- FBDs with or without immersed heat exchangers
- Spray dryers
- Impinging jet dryers
- Conveyor dryers
- Rotary dryers
- Impinging stream dryers

Advanced Drying Methods

- Atmospheric freeze drying
- Heat pump drying
- Hybrid drying
- Intermittent drying
- Spray freeze drying
- Pulse combustion dryers
- Multi-stage dryers
- Multi-processing dryers

Thank You for your Attention !!!

LECTURE 6

Freeze Drying Technology

Freeze Drying Applications

- Food preservation method
  - Lowers water activity
  - Reduces potential for microbial growth
  - Prevent Browning/Degradation
    - Maillard and Carmelization
  - Heat sensitive products
- Long Shelf Life

Freeze Dried Products

- Fruits/Vegetables
  - Peas
  - Tomatoes
  - Cherries
  - Berries
- Other food products
  - Ice Cream
  - Spaghetti
  - Coffee
- Pharmaceuticals
- Pets
  - Dogs
  - Squirrels

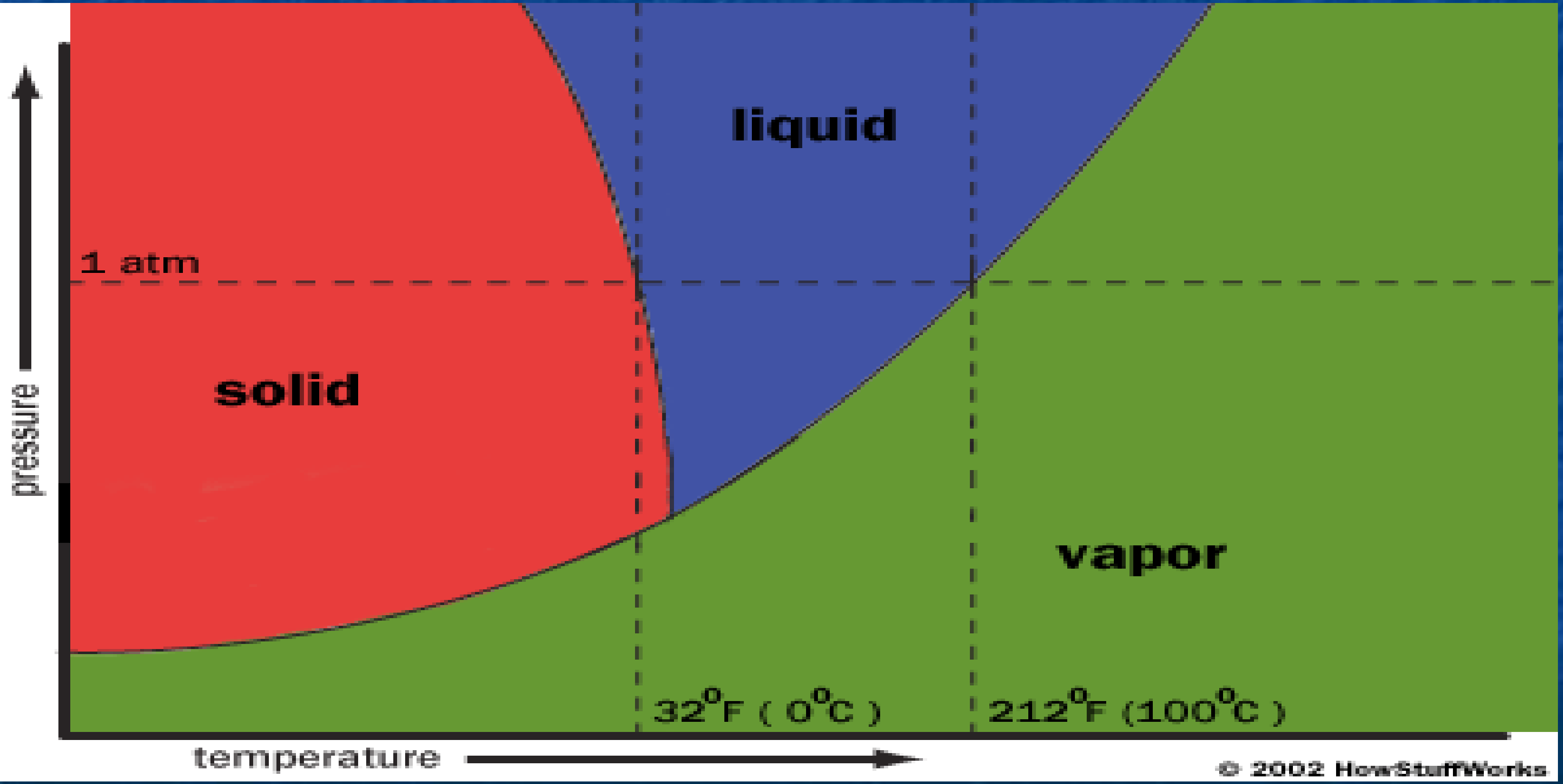
Effective Method Characteristics

- Factors for efficiency of drying processes
  - Heat and Mass transfer considerations
  - Maximum P_{vap} gradient
  - Maximum ΔT between air and interior of product
  - High convective coefficients at surface

Lyophilization : How it works

- Reducing product temp
  - Majority of product moisture in solid state
- Decrease ambient pressure
  - Sublimation (H_2O evaporation from solid to gas)
  - Carried out over vacuum
  - maintain P_{vap} gradient between the ice front in the material and the surrounding environment
- Apply heat to aid sublimation

State Diagram for H_2O



Heat Transfer

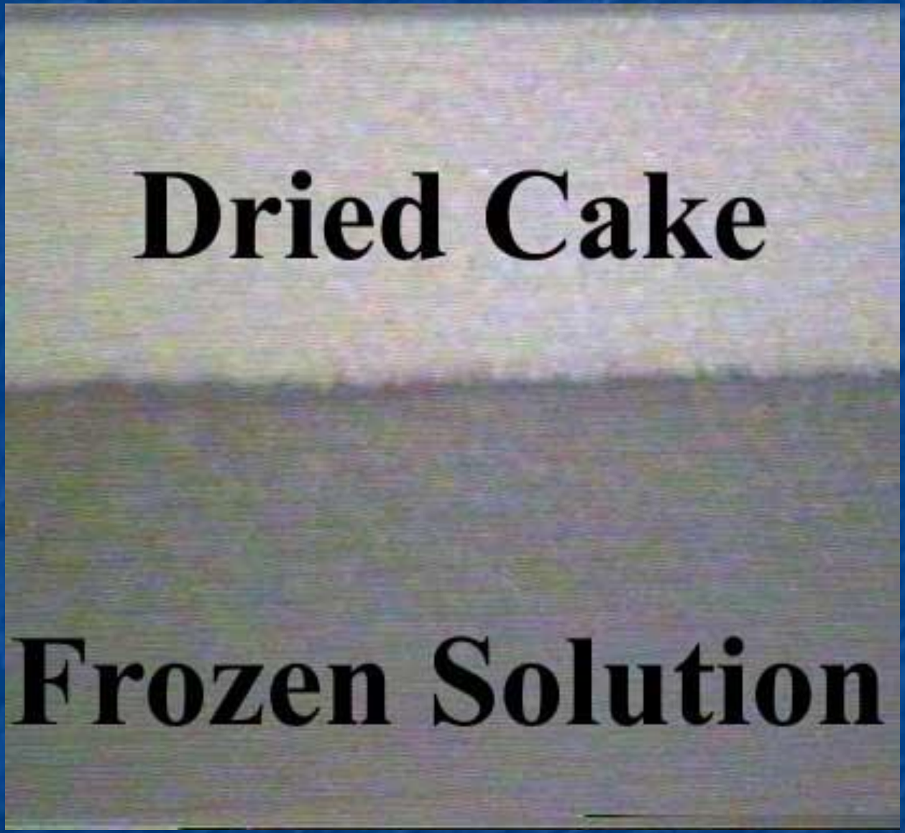
- Two possibilities:
  - Through frozen product layer
    - H.T. Rapid, not limiting
  - Through dry product layer
    - Slow
      - Low thermal conductivity of highly porous structure

Mass Transfer

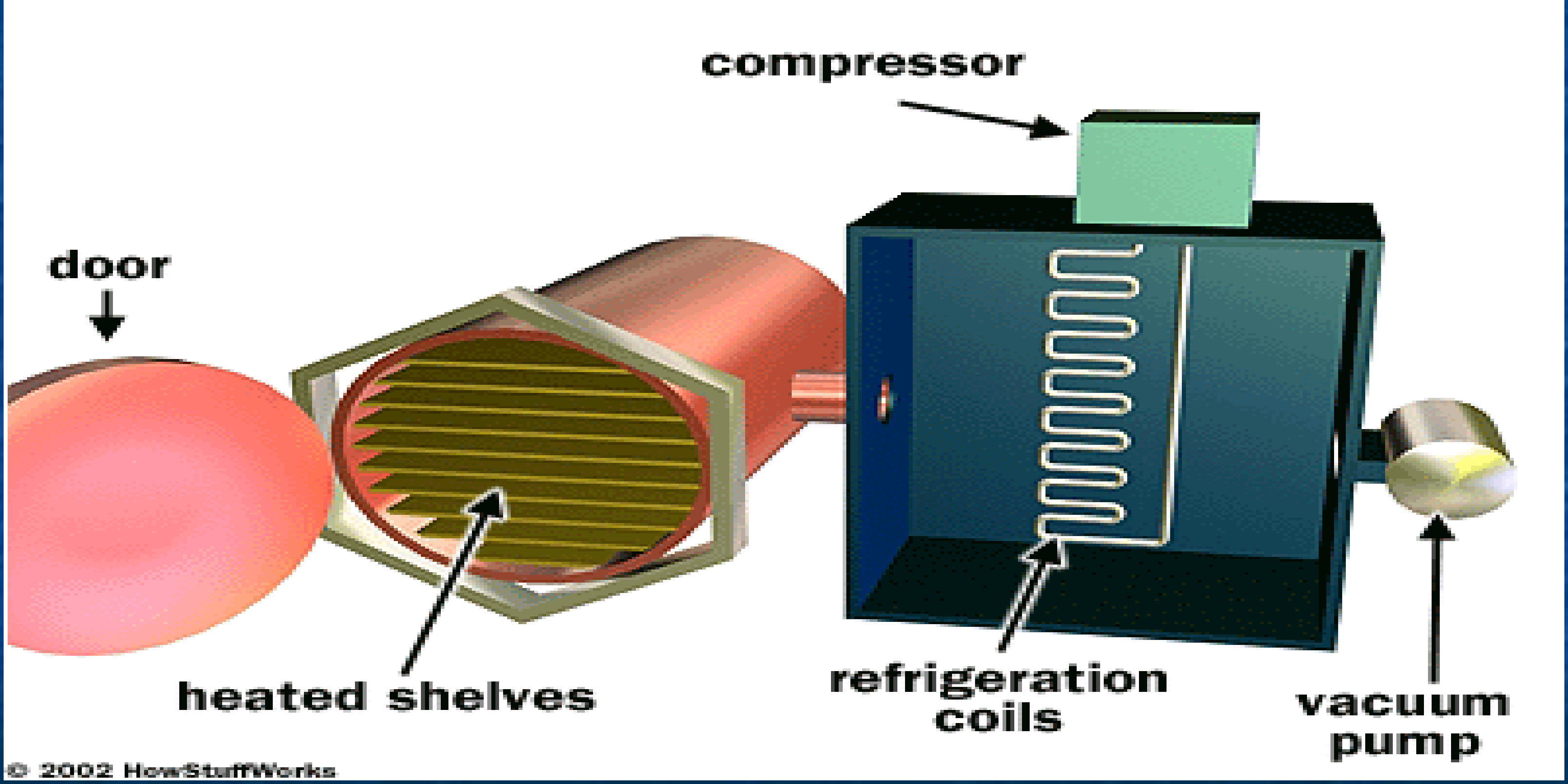
- Occurs in dry product layer
- Diffusion of water vapor is rate-limiting
  - Low molecular diffusion in vacuum

Drying Rate

- Drying time equation for moisture diffusion limited cases:
- $t = [(RT_A L^2)/(8DMV_W P_i - P_a)]*(1+4D/k_m L)$
  - L = thickness
  - T_A = absolute Temp
  - M = molecular weight
  - V_W = specific volume
  - $P_i = P_{vap}$ of ice
  - $P_a = P_{vap}$ of air at condenser surface
  - k_m = mass transfer coefficient
  - D = diffusivity [=] L^2/t
  - R = universal gas constant


Dried Cake
Frozen Solution

The Process


compressor
door
heated shelves
refrigeration coils
vacuum pump
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Primary Considerations

- Advantages
  - Higher quality product
  - Does not form ice crystals that disrupt the food matrix of the product.
    - I.e. freezing fruit
      - When crystals grow, cell wall breakage
      - Result? Higher quality product
- Disadvantages
  - High cost of product/process
  - Energy intensive in comparison to other drying methods

References

- http://home.howstuffworks.com/freeze-drying1.htm
- Singh, R. Paul and Dennis Heldman. Introduction to Food Engineering. Academic Press, Boston. 2001. pp567-8.
- http://www.foodsci.wisc.edu/courses/fs532/12freezedrying.php
- http://www.cheng.cam.ac.uk/research/groups/biosci/lyophilisation/images/fdstatic.jpg

LECTURE 7

The Past, Present and Future of

Food Biotechnology

What is Food Biotechnology?

Food biotechnology is the evolution of traditional agricultural techniques such as crossbreeding and fermentation.

It is an extension of the type of food development that has provided nectarines, tangerines and similar advancements.

Food Biotechnology

Technically Speaking...

Food biotechnology employs the tools of modern genetics to enhance beneficial traits of plants, animals, and microorganisms for food production. It involves adding or extracting select genes to achieve desired traits.

Evolution of Food Biotechnology

Food Biotechnology

Food Biotechnology: From Farm to Fork

- Farming & the environment
- Food quality & processing
- Health & nutrition
- Developing nations

Food Biotechnology

Farming & the Environment

- Reduces the use of pesticides
- Decreases soil erosion
- Helps protect water
- Conserves land & fossil fuels

Food Biotechnology

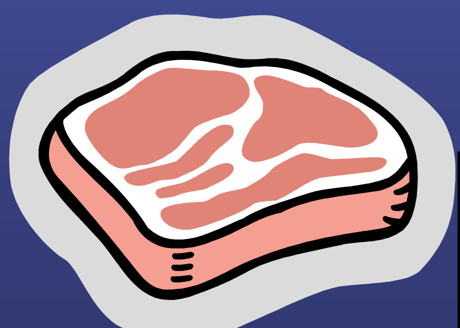
Farmers

- Increases crop yields
- Reduces farmer production costs
- Decreases farmer exposure to pesticides
- Improves farming efficiency

Preventable plant diseases

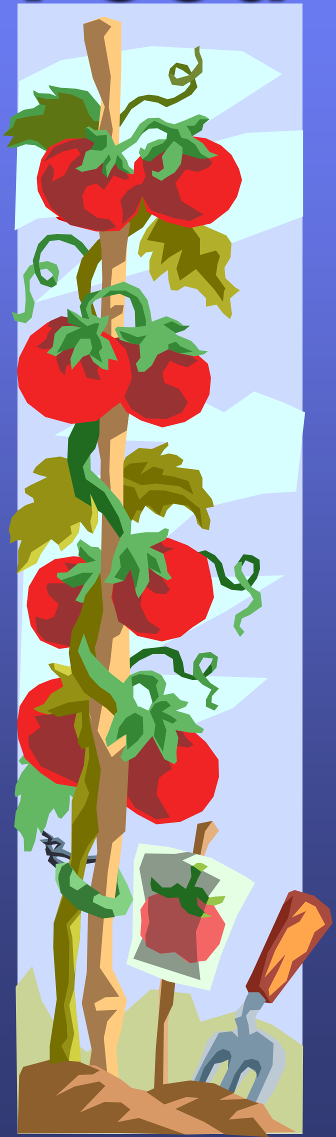
Farming & Animal Biotechnology

- Animal feed: biotechnology vs. traditional variety
- Animal products: milk, meat & eggs
- May improve feed supplies



Food Biotechnology

Food Quality & Processing



- Many processed foods use biotech crops
- Improved fat profile in oils - more stable for frying
- Delayed ripening = fresher produce

Food Biotechnology

Health & Nutrition

- More nutritious products to meet consumer demands
- Some oils may not require hydrogenation, and therefore be low or free of trans fatty acids
- Potatoes with higher solid content

Developing Nations: Biotechnology's Impact on Food Security

Food Biotechnology

Combating Hunger

- Food biotechnology will allow more food to be produced on less land
- Economic benefits will allow food biotechnology to contribute to combating global hunger

Food Biotechnology

Combating Hunger & Malnutrition

- Vitamin A deficiency and iron-deficiency afflict millions worldwide
- Potential solution: “golden rice”

Food Biotechnology

Consumers benefit from food biotechnology

- Better environment
- Better food processing & quality
- Improved nutritional profile

Food Biotechnology

Current Products of Food Biotechnology

Food Biotechnology

Consumers Support Food Biotechnology

- Nearly two-thirds believe food biotechnology will benefit their family in the next five years
- More than half would choose products modified to taste better or fresher
- Nearly three-quarters of consumers would likely buy produce protected against insect damage

Source: IFIC/Cogent, April 2003

Food Biotechnology

Food Biotechnology Is Safe

FDA

USDA

AMA

IFT

EC

FAO/
WHO

ADA

- Food biotechnology is one of the most extensively reviewed agricultural advancements to date
- Studies to date show no evidence of harmful effects

Food Biotechnology

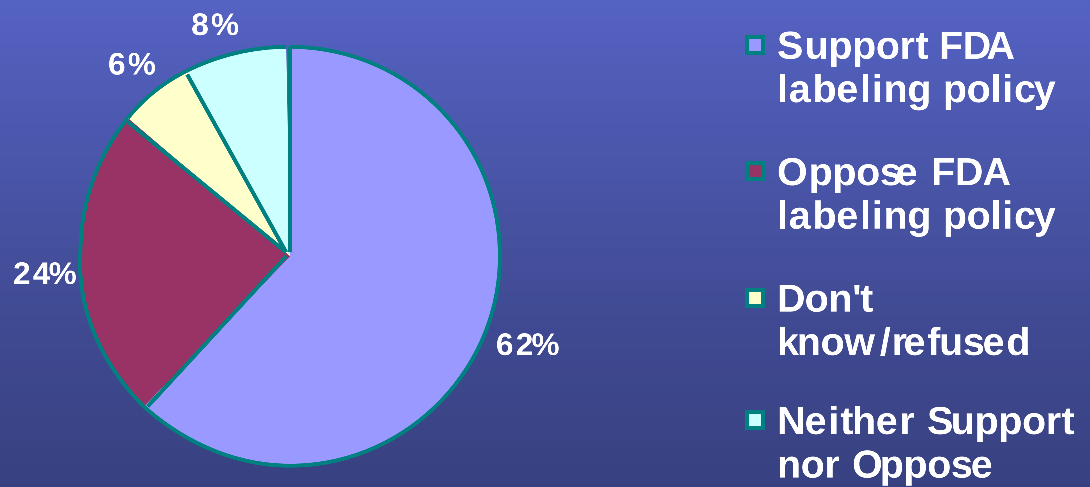
U.S. Labeling Policy for Food Biotechnology

- **FDA safety standards are consistent for all foods.**
- **A label disclosure would be required if . . .**
  - Allergens were present in the food
  - Levels of naturally occurring toxins had increased.
  - Nutrient composition or profile had been changed from its traditional counterpart

Consumers Support Labeling Policy

- **Nearly two-thirds of consumers support the FDA labeling policy**

  Source: IFIC/Cogent, April 2003



Food Biotechnology

FDA & Labeling Guidelines

- Jan 2001 FDA draft voluntary labeling guidelines released for public comment
  - "GM" or "GMO" would not be allowed on labels
    - Consumers found confusing
    - Misleading because inaccurate

Food Biotechnology

What Does the Future Hold?

Food biotechnology has the potential to:

- Reduce natural toxins in plants
- Provide simpler and faster ways to detect pathogens
- Extend freshness
- Increase farming efficiency

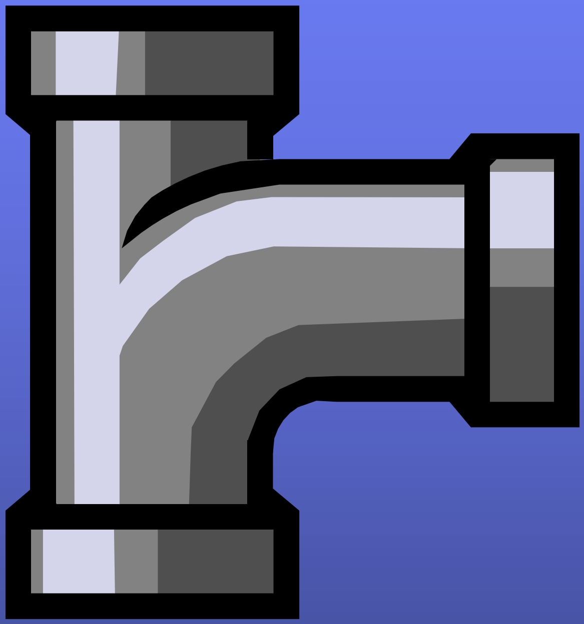
Food Biotechnology

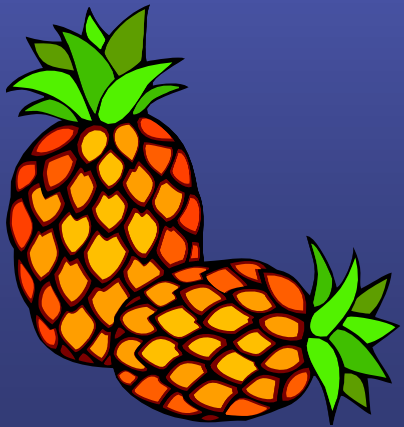
Future Health Benefits

- “Golden rice”
- Reduced allergens in food
- Improved nutritional content

Food Biotechnology

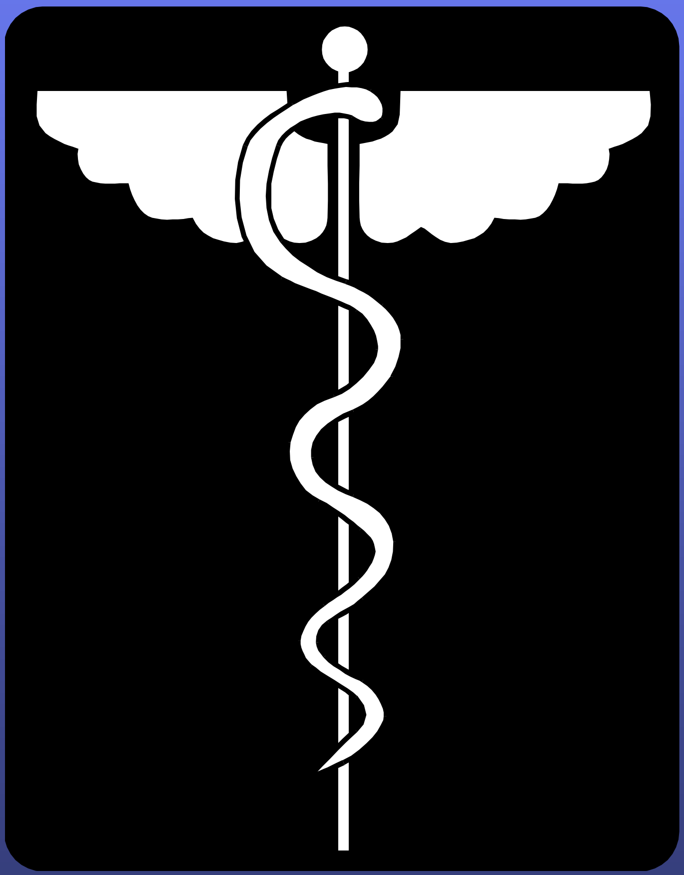
Products in the pipeline





Food Biotechnology

The Future: Beyond Food



- Plant-made Pharmaceuticals – growing medicines in plants
- Edible vaccines
- “No mow” grass

Food Biotechnology

LECTURE 8

DRYING AND DEHYDRATION

Drying and Dehydration

- Removes water
- Occurs under natural conditions in the field and during cooking
- Makes foods
  - Lighter
  - Take up less space
  - Cost less to ship

Dehydration

- Almost the complete removal of water
- Results in
  - Decreased weight
  - Increased amount of product per container
  - Decreased shipping costs

Purpose

- Remove enough moisture to prevent microbial growth
- Sun drying may be too slow and organisms may cause spoilage before the product can be thoroughly dried
  - In these cases salt or smoke may be added to the product prior to drying

Factors that Affect Heat and Liquid Transfer in Food Products

- Surface area
  - The greater the faster the product dries
- Temperature
  - The greater the difference between the product and drying medium, the greater the rate of drying
- Humidity
  - The higher, the slower the drying
- Atmospheric pressure
  - The lower, the lower the temperature required to remove water

Solute Concentration

- Foods high in sugar and other solutes dry more slowly
- As drying progresses the concentration of solutes becomes greater in the water remains causing the drying rate to slow

Binding of Water

- As a product dries, its free water is removed
- This water evaporates first
- Water in colloidal gels, such as starch, pectin or other gums is more difficult to remove
- Water that is most difficult to remove is that chemically bound in the form of hydrates

Chemical Changes

- Caramelization
  - Occurs if the temperature is too high
- Enzymatic browning
  - Caused by enzymes
  - Prevented by inactivating the enzymes before drying
- Nonenzymatic browning
  - Controlled by drying the foods rapidly
- Loss of ease of rehydration
- Loss of flavor

Food Concentration

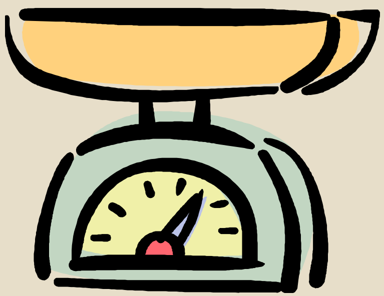
- Food concentrates by evaporation removing 1/3 to 2/3 of the water present
- Some preservative effects but mostly reduces volume
- May (depending on the food) make the food
  - take on a cooked flavor
  - Darken
  - Change in nutritional value
  - Microbial destruction

Methods of Concentration

- Solar
- Open kettles
- Flash evaporators
- Thin film evaporators
- Vacuum evaporators
- Freeze concentration
- Ultrafiltration and reverse osmosis

Reduced Weight and Volume

- Saves money
- Commonly concentrated foods
  - Evaporated and sweetened condensed milks
  - Fruit and vegetable juices
  - Sugar syrups
  - Jams and jellies
  - Tomato paste
  - Other types of purees, buttermilk, whey and yeast
  - Some food byproducts used as animal feeds

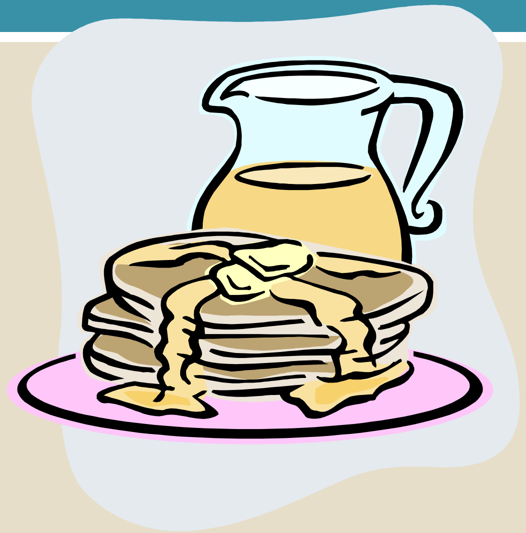


Solar Evaporation

- Oldest
- Slow
- Only used to concentrate salt solutions in human made lagoons

Open Kettles

- Used for
  - Jellies
  - Jams
  - Some soups
  - Maple syrup
- High temps and long concentration damage many foods



Flash Evaporators

- Subdivide the food and bring it in direct contact with steam
- Concentrated food is drawn off the bottom of the evaporator

Thin Film Evaporators

- Food is pumped onto a rotating cylinder and spread into a thin layer
- Steam removes water from the thin layer—quickly
- Concentrated food is wiped from the cylinder wall
- Concentrated food and water vapor are continuously removed to an external separator

Vacuum Evaporators

- Used for heat sensitive foods
- Lower temperatures can be used
- Vacuum chambers are often in a series allowing the food to become more concentrated as it moves through the chambers

Ultrafiltration

- Membrane filtration process
- Allows molecules the size of salts and sugars to pass through while rejecting molecules the size of proteins
- Applied to
  - Milk for protein standardization
  - Cheeses
  - Yogurts
  - Whey
  - Buttermilk
  - Eggs
  - Gelatin
  - Fruit juice

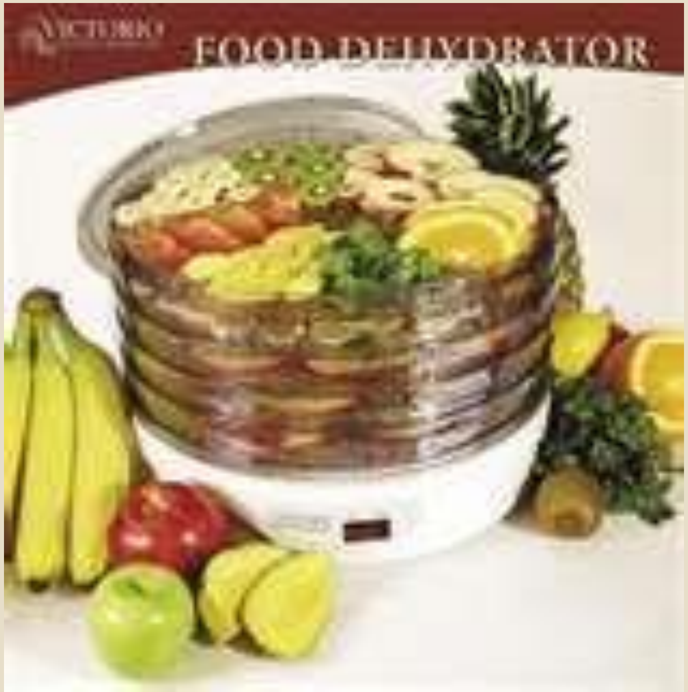
The following are titles of the courses.

Reverse Osmosis

- Uses the tightest membranes
- Allows only water to pass through the membranes
- Used to
  - concentrate whey
  - Reduce milk transportation cost by removing water
  - Recover rinsing water for recovery of milk solids
  - Concentration of eggs, blood, gelatin, fruit juices
- Ultrafiltration and reverse osmosis also decrease the potential for pollution from discharge water because both discharge water low in organic mater

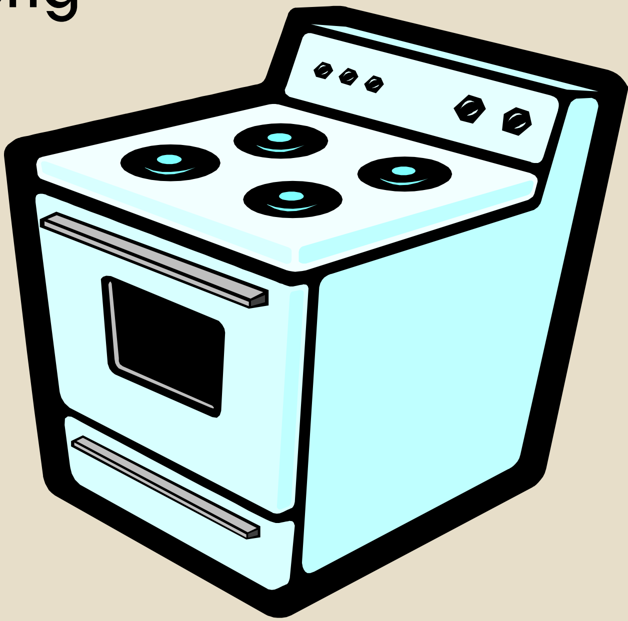
Food Dehydrators

- Efficiently designed to dry foods at 140°F
- Major disadvantage is limited capacity



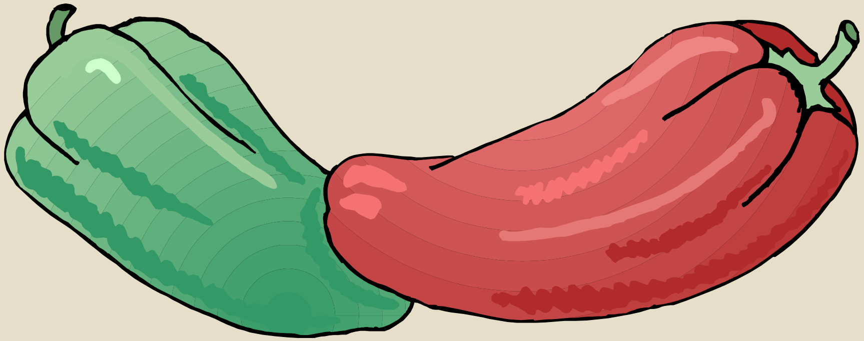
Oven Drying

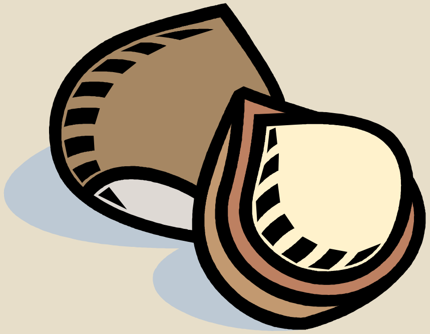
- Combines heat, low humidity and air current
- Ideal for drying
  - Meat jerkies, fruit leathers, banana chips & preserving excess produce like celery or mushrooms
- Slower than dehydrator, twice as long



Room Drying

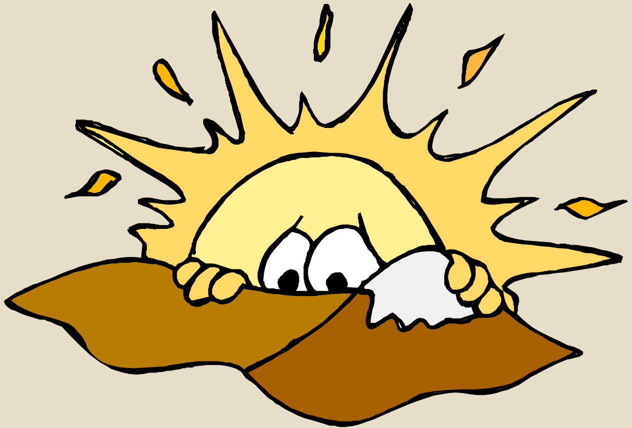
- Well ventilated attics, room, car, camper or screened in porch
- Most common for
  - Herbs
    - Hung in bunches
  - Hot peppers
    - Hung in bunches
  - Nuts in the shell
    - Laid out on paper in a single layer
  - Partially dried, sun dried fruits
    - Left on their drying racks





Sun Drying

- Fruits are safe to dry outdoors due to their high sugar and acid content when conditions are favorable for drying
- Not recommended for vegetables or meats
- Conditions needed for outdoor drying
  - Hot, dry, breezy days
  - Minimum temperature of 85°F, with higher temperatures being better
  - Humidity below 60%
  - Several days



Sun Drying (X)

- Racks or screens placed on blocks allow for better air movement—2 screens are best to keep animals, birds and insects out
- Best placed on a concrete driveway or over a sheet of aluminum or tin
- Screens may need to be turned to capture, full direct sun
- Foods need to be turned or stirred several times a day

Summary

- Drying and dehydration
  - Preserve
  - Decrease weight and volume
- Drying is affected by
  - Surface area
  - Temperature
  - Humidity
  - Atmospheric pressure
- Chemical changes occur during dehydration
- Foods can be dried by air convection, drum vacuum & freeze drying
- Food concentration removes 1/3-2/3 of the water
- Methods of concentration- solar, open-kettle, flash evaporators, thin-film evaporators, freeze concentration, Ultrafiltration or reverse osmosis
- Home drying allows the same general principles as commercial
- Home drying can be accomplished with small home dehydrators, oven, microwave or outdoors

Teaching Plan

Title: Food Processing and Preservation Technology

Lecturer : Dr Khairul Faezah Md Yunos

Date	Time	Title of Lecture / Practical
19	10am-1pm	History of Food Preservation
20	10am-1pm	Food Processing Technique and Preservation
21	10am-1pm	Thermal Processing/ Blanching experiments
22	10am-1pm	Pasteurization and Sterilization/ Eggs Pasteurization
23	10am-1pm	Low Temperature Processing / Freeze Drying
24	10am-1pm	Drying Technology of Food Preservation/Sun Drying of fruits
26	10am-1pm	Heat and Mass Transfer in Food Processing
27	10am-1pm	Food Processing and Biotechnology
28	10am-1pm	Drying and Dehydration/ Evaporation of Milk
29	10am-1pm	Microbiology of Food Processing/ Canning of Foods

Course Syllabus

Title: Food Processing and Preservation Technology

Lecturer : Dr Khairul Faezah Md Yunos

Summary of courses:

The course covered topics on food processing and preservation technology which includes the history on food processing and preservation technology, the various processing technique in order to increase the shelf life of food products. The technology of thermal processing techniques taught in the class is pasteurization, sterilization, canning, and dehydration and blanching. The lower temperature processing technology includes refrigeration and freezing. The drying technique of preservation discus in the lecture includes, freeze drying, spray drying, rotary drying, fluidized bed drying, drum drying and tray dryer. The students also learn the heat and mass transfer mechanism involved in the processing technology of food. This concept is important for the fundamental understanding of the processing technology. The lecture also covered the importance of processing technology on biotechnology aspect of food production and preservation.

Lecture Topics.

1. History of Food Preservation
2. Food Processing Technique and Preservation
3. Thermal Processing
4. Pasteurization and Sterilization
5. Low Temperature Processing
6. Drying Technology of Food Preservation
7. Heat and Mass Transfer in Food Processing
8. Food Processing and Biotechnology
9. Drying Technology and Dehydration
10. Microbiology of Food Processing

Laboratory Topics:

1. Blanching experiments
2. Eggs pasteurization
3. Sun drying of fruits
4. Evaporation of milk
5. Sterilization methods
6. Canning of fruits
7. Low temperature process

References.

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3. ASHRAE Handbook, Refrigeration Systems and Applications, American Society of Heating, Refrigerating, and Air-conditioning Engineers, Atlanta, GA, 1994.
4. O. R. Fennema and W. D. Powrie, Fundamentals of low temperature food preservation, Adv. Food Res. 13: 220 (1964)
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