Emerging Technologies for Food Processing

Hosahalli S. Ramaswamy

Professor

Department of Food Science

McGill University

International Workshop:

On food security through potato production and human nutrition

Bogota, Colombia, June 24-25, 2013

Presentation Outline

Food Security

Food Safety –Microbiological Issues

Food Processing Strategies
Thermal Processing, freezing, drying
Novel approaches in thermal processing
Non-Thermal Processing

Affordable technologies – Colombian context

Food Security

Multi-Component Concept Linked To

- Production adequacy
- Procurement (transport, distribution)
- Availability (storage, preservation)
- Food Safety (processing)
- Food Quality (processing, formulations)
- Food diversity (processing)

Food Processing Objectives
Primary: Preservation

- ✓**Prevent undesirable changes**
  - ✓**Wholesomeness**
  - ✓**Nutritive value**
  - ✓**Sensory qualities**
- ✓**Control activities**
  - ✓**Chemical**
  - ✓**Biochemical & Physiological**
  - ✓**Microbiological**

Food Processing
Other objectives

1. Product Diversification
2. Value addition
3. Convenience Foods
4. Marketing Needs
5. Ingredients Isolation/ Synthesis
6. Non-conventional Foods

Food Processing & Handling Objectives

Primary

- Safety & Stability (Preservation)

Safety Concern

- Eliminate or Disable Pathogens

Stability

- Eliminate or Disable Spoilage Organisms
- Inactivate enzymes
- Suppress chemical reactions

Micro-organisms & Food

- ***Food Pathogens*** *– public health concern because they enter the human system through food and cause various disease*
- ***Food Poisoning Micro-organisms*** *– these are not pathogens but produce toxins in foods which when ingested cause harm to public health*
- ***Food Spoilage Microorganisms*** *– these are not of public health concern, but they cause spoilage of foods*

Common Food Pathogens

- *Clostridium perfringens; Campylobacter jejuni,*
- *Salmonella* spp.; *Salmonella*
- *Escherichia coli O157:H7; Bacillus cereus*
- *Listeria monocytogenes* ; *Shigella* spp.
- *Staphylococcus aureus*
- *Streptococcus*
- *Vibrio; Yersinia*

Micro-organisms of Safety Concern

Exotoxins of concern

- ***Clostridium botulinum***
- ***Clostridium perfringens***
- ***Staphylococcus aureus***
- ***Bacillus cereus***

- **Mycotoxins: *Aflatoxin***
- ***Natural Toxins: Alkaloids***

Numerous Outbreaks (both fresh and inadequately processed foods, examples)

Lebanon Bologna - *E. coli* O157:H7, 2011
Hazelnuts – *E. coli* O157:H7, 2011
Cheese – *E. coli* O157:H7, 2010
Shredded Romaine Lettuce from a Single Processing Facility - *Escherichia coli* O145, 2010
Beef from National Steak and Poultry - *E coli* O157:H7, 2010

2011 United States **listeriosis** outbreak from cantaloupes

2011 United States salmonellosis outbreak in cantaloupe infected with **Salmonella** Panama from Guatemala.

2010 Louisiana Clostridium perfringens outbreak

2010 Multihospital Outbreak of ***C. difficile*** Infection, Ohio

Microbialogical Basis

Microbial safety and stability is achieved based on combination of factors that depends :

Sensitivity of microbial growth and activity to

- **Oxygen (aerobic, anaerobic)**
- **pH (*C. botulinum*)**
- **Temperature (thermo, meso, psychro)**
- **Water activity**
- **Spore vs vegetative bacteria**

Food Processing Strategies

Addition of Heat: Canning (thermal processing)

Removal of Heat: Refrigeration, Freezing

Removal of Moisture: Drying, Frying, Extrusion

Use of Radiation: Irradiation, UV, Pulsed Light

Addition of preservatives

Addition of salt and sugar

Fermentation

Alternative Heating Media: Microwave, Ohmic

Non-Thermal Processing: HPP, PEF, Ozone,, PL

Hurdle Technologies….. and many more

Thermal Processing Principles

Vacuum Sealed Cans/Pouches
(Prevents the growth of Obligate Aerobes

pH

pH < 4.5
High Acid Foods

pH ≥ 4.5
Low Acid Foods

Pasteurization: mild treatment < 100°C

Pasteurization: mild treatment < 100°C

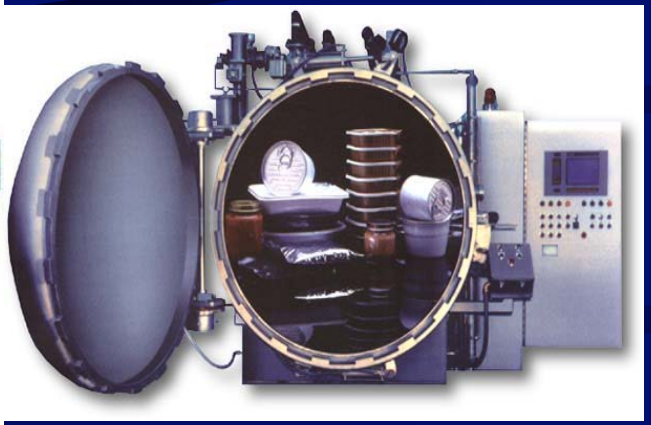
Sterilization: severe treatment >110°C

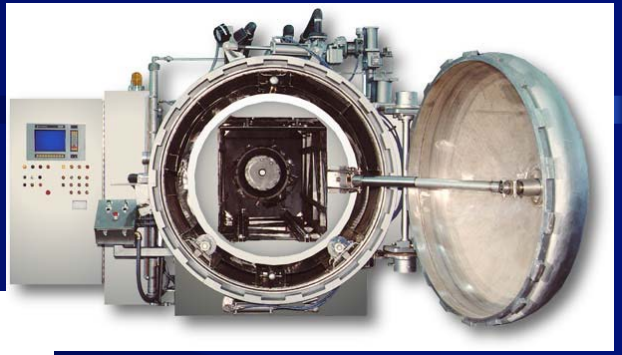
Controls pathogenic & Spooilage vegetative forn Spore formers in-active. Shelf-stable products for fruits & acidified foods

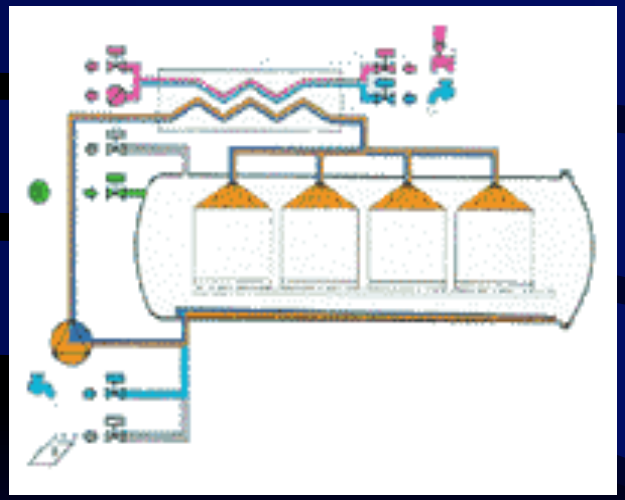
Only pathogens Controlled. Spores active; Only short-term storage at refrigerated conditions

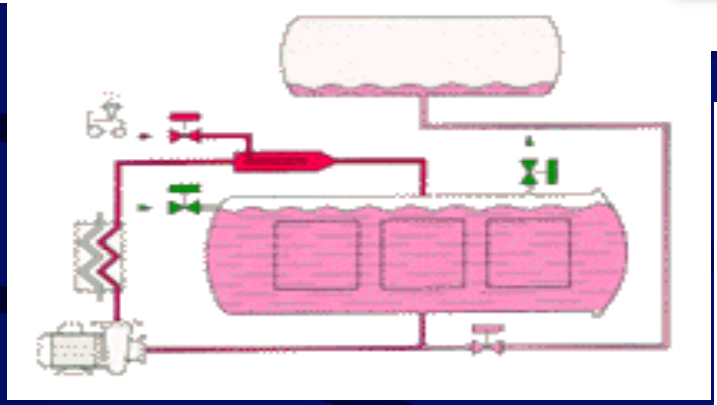
Spores killed: Public health concern: *Clostridium botulinum; Bot Cook*
- 12D Process is implemented.
Spoilage: Mesophiles are killed. Heat resistant thermophiles are not killed but controlled by storing the product below 30°C

Retort Systems









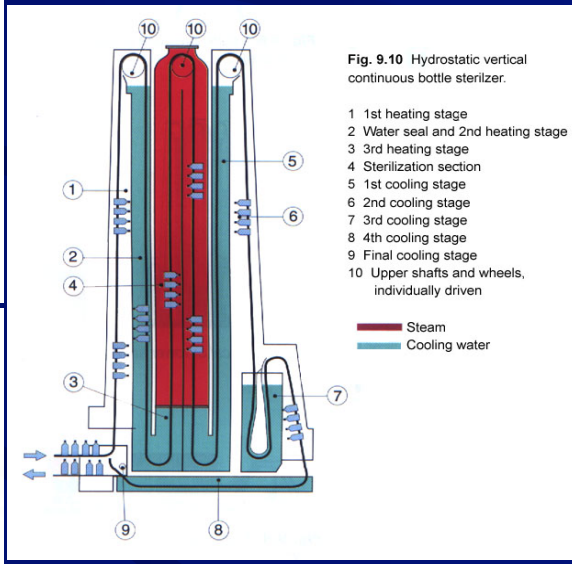
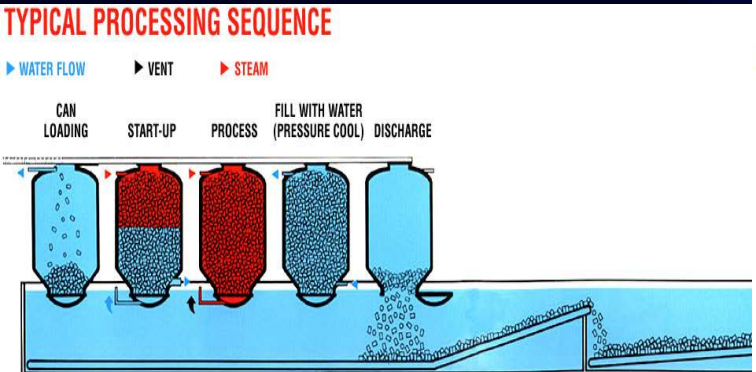
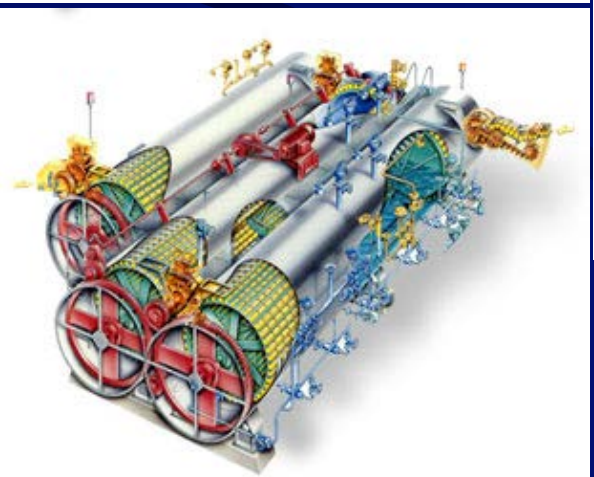


Fig. 9.10 Hydrostatic vertical continuous bottle sterilzer.

1 1st heating stage
2 Water seal and 2nd heating stage
3 3rd heating stage
4 Sterilization section
5 1st cooling stage
6 2nd cooling stage
7 3rd cooling stage
8 4th cooling stage
9 Final cooling stage
10 Upper shafts and wheels, individually driven

Steam
Cooling water

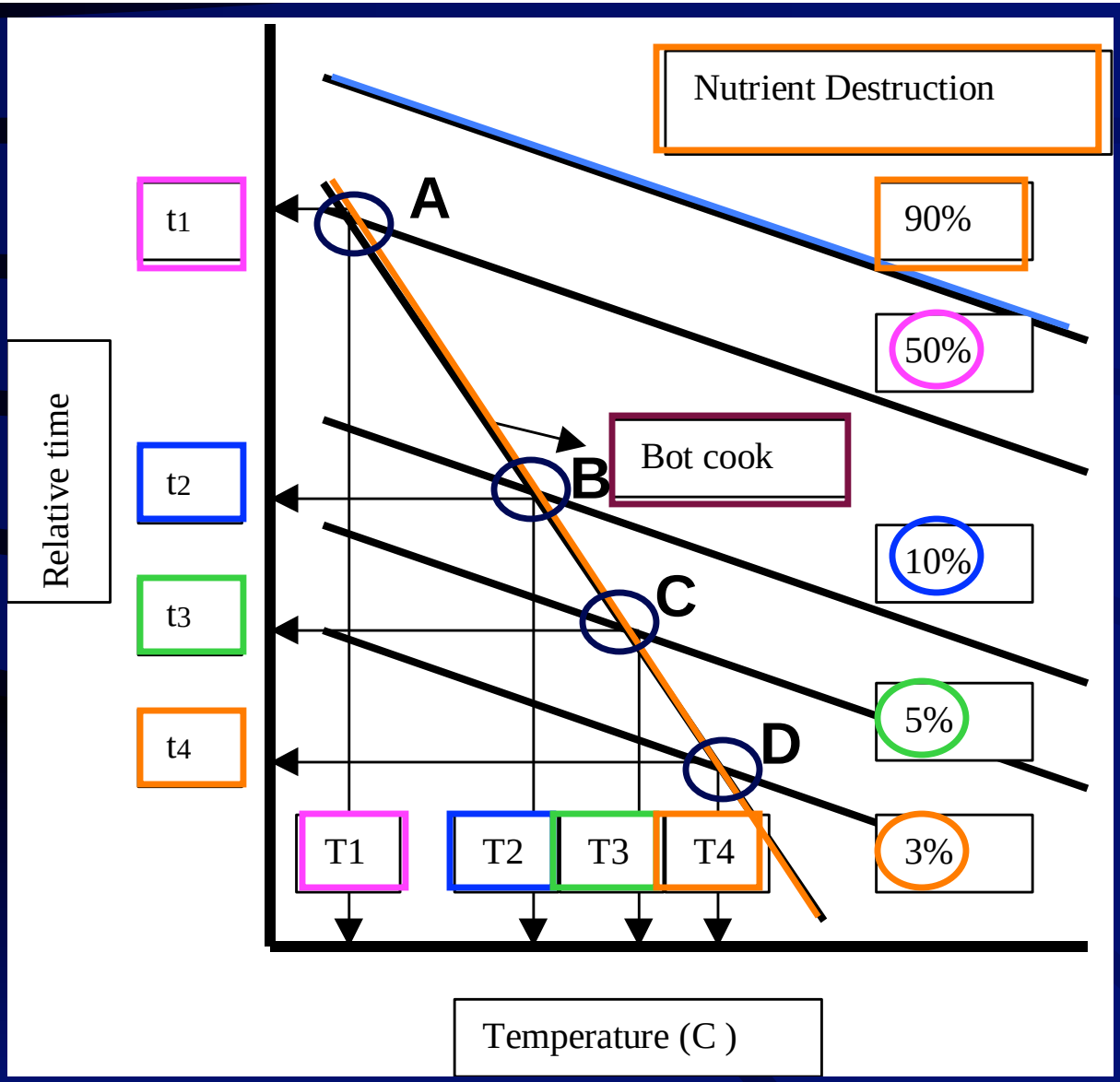




Quality Optimization in Thermal Processing

Today, consumers demand more than just safe foods!

Illustration of high temperature short time (HTST) heating principle



Quality Optimization in Thermal Processing

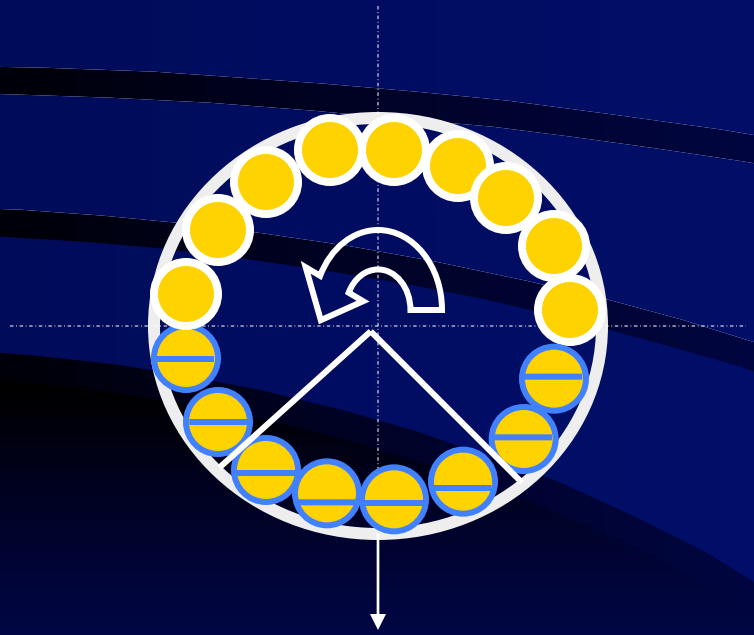
- **All techniques used improve the heat transfer to the product which reduces the cooking time and hence improve the quality in thermally processed foods**

$$q = \frac{kA\Delta T}{x}$$

$$\mathbf{q = h\,A\,\Delta T}$$

Agitation Processing

- Two common modes of agitation/rotation



Axial Rotation
(Continuous Operation)

End over end rotation
(Batch Operation)

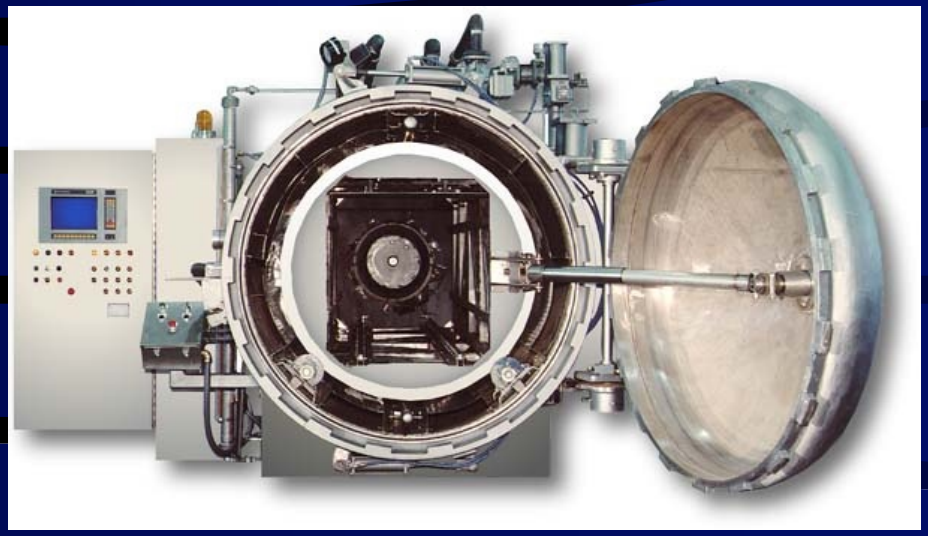
Food Processing Optimization…

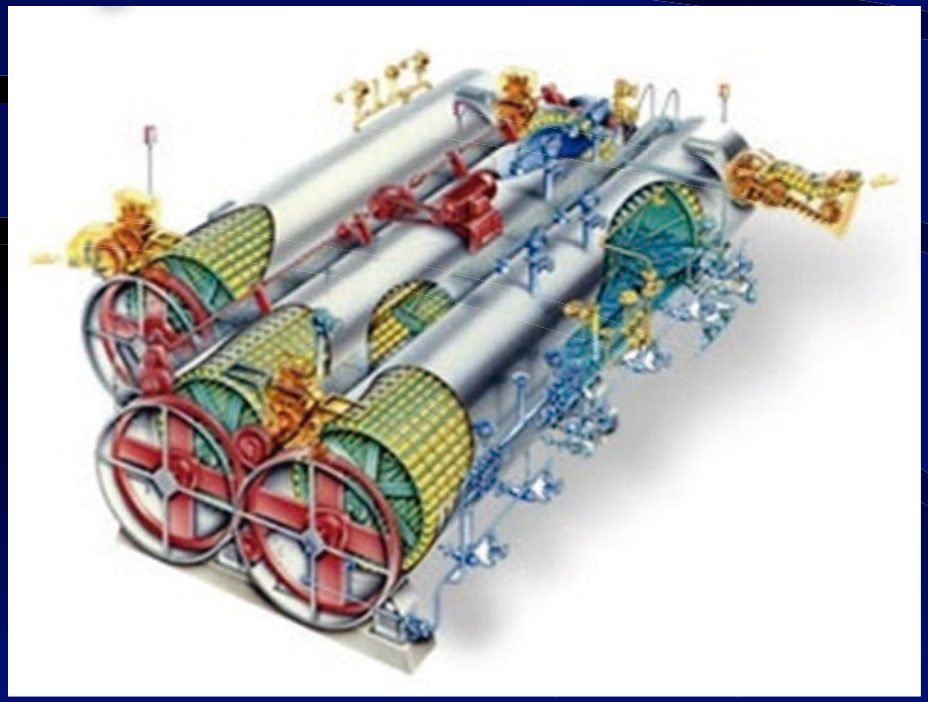
- **1) Agitation Processing**

$$q = h A \Delta T$$

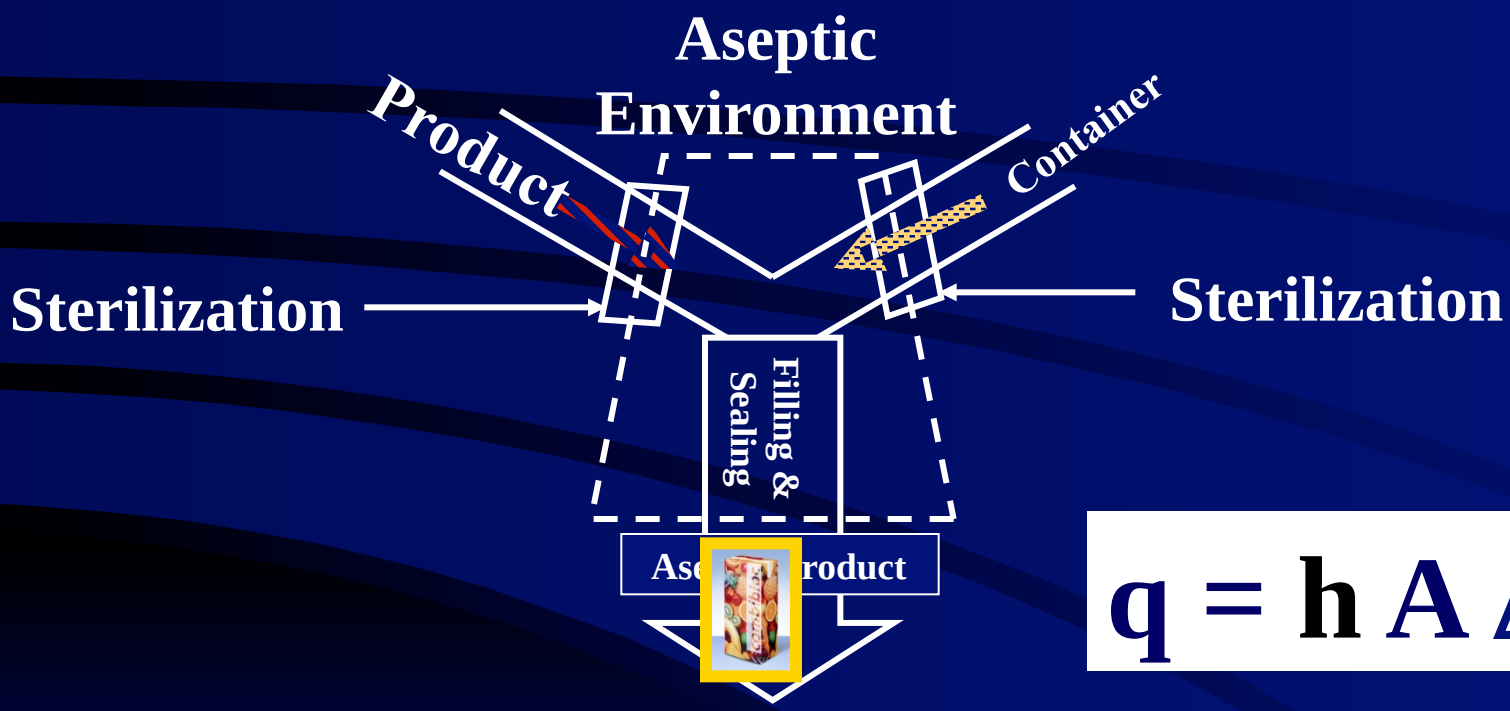
- **Improves heat transfer by agitation**
  - **Improves mixing and heat transfer coefficient**
  - **Two Types:**
    - **End-over-end and Axial Agitation**

Agitation Processing





ASEPTIC PROCESSING.



$$q = h A \Delta T$$

- **3) Thin Profile Processing**
- **For conduction heating foods**

$$q = \frac{kA\Delta T}{x}$$

  - **Increase surface area**
  - **Reduce thickness**

Semi-Rigid Plastic Containers

Future trends in food processing

Applications of novel advanced sterilization techniques

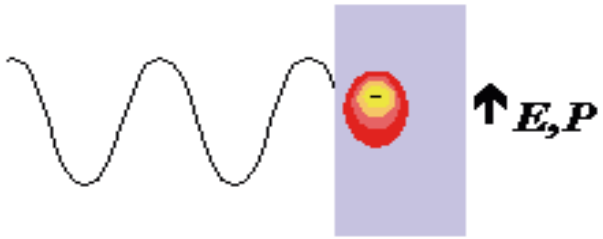
- Microwave heating
- Radio frequency heating
- Ohmic heating

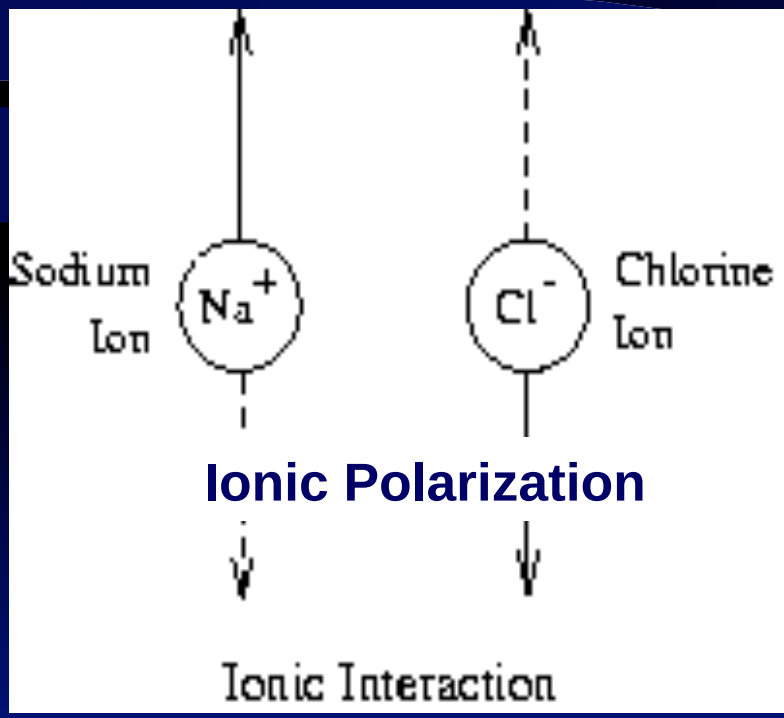
Applications of non-thermal processing techniques

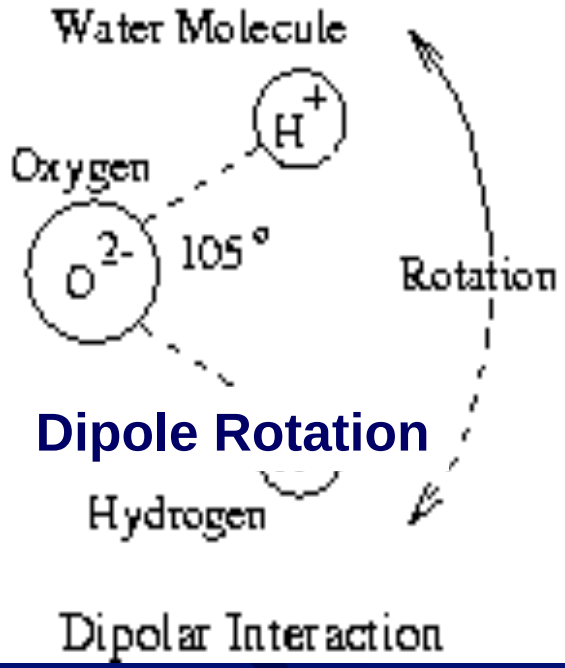
- High Pressure Processing
- Pulsed Electric Field Applications
- Pulsed Light, Irradiation

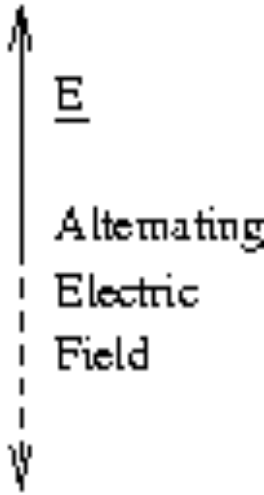
Novel Methods of Heating

Microwave Heating: Two Modes

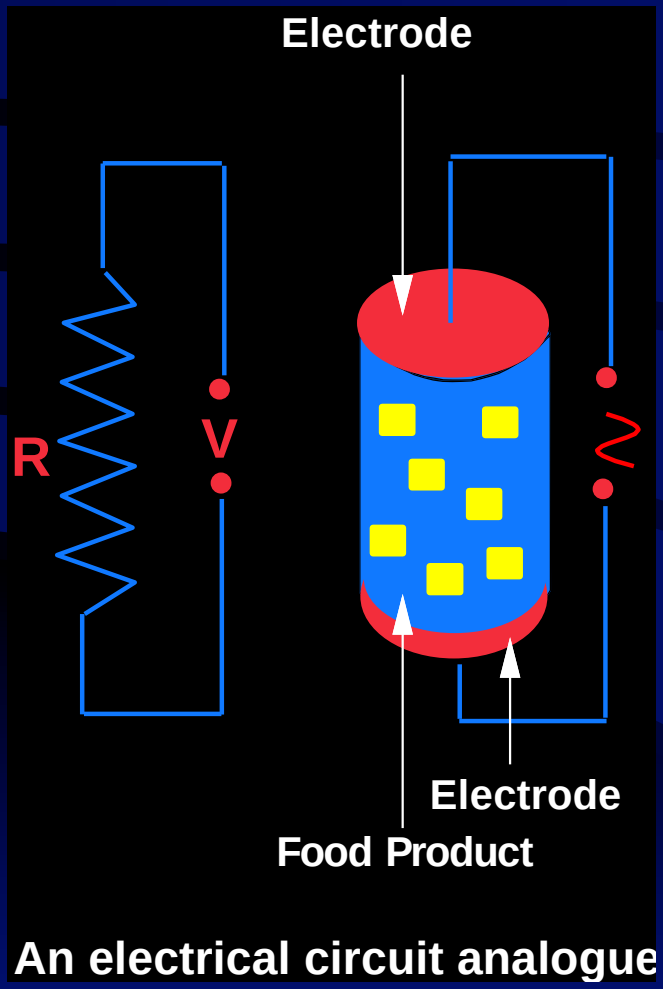








Ohmic heating



An electrical circuit analogue

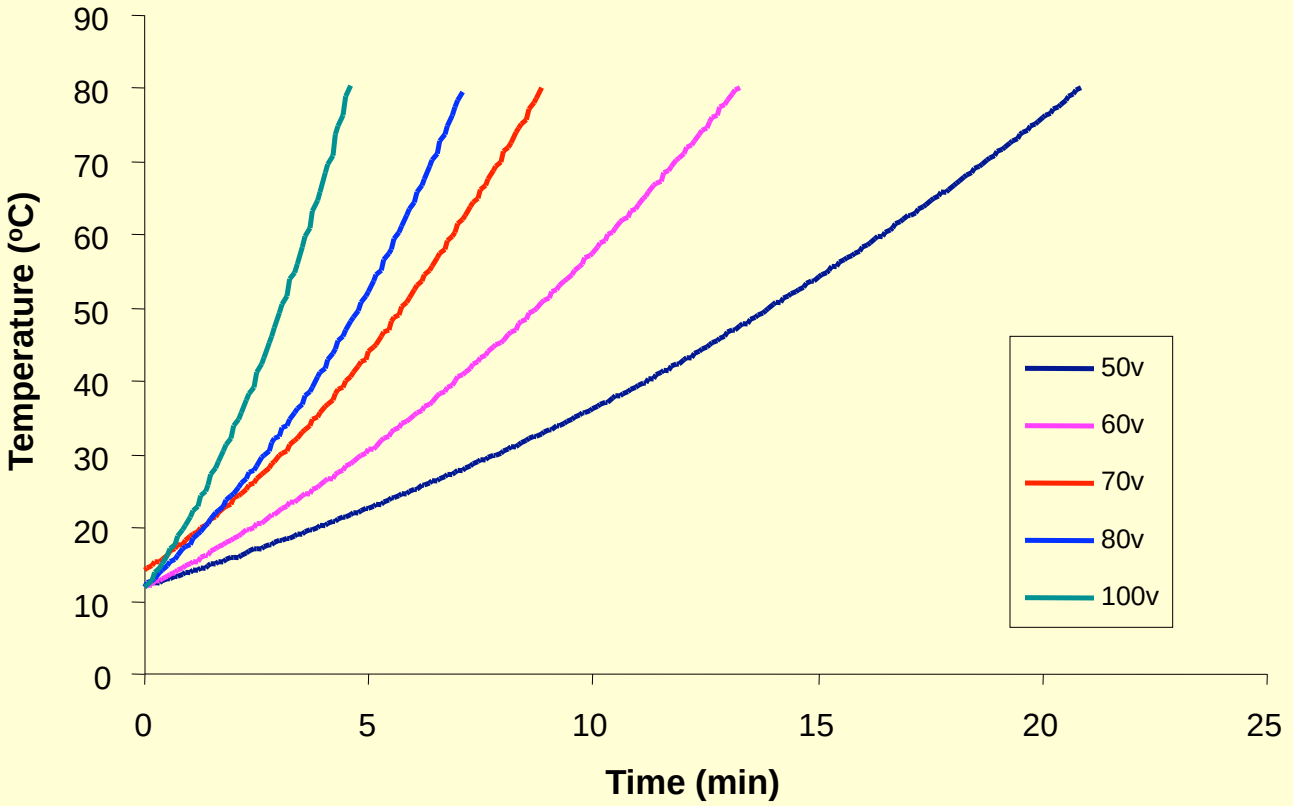
Also called

- ✓Direct resistance heating
- ✓Joule effect heating
- ✓Electro-conductive heating
- ✓Electro-resistive heating

Principle

Heat generation occurs when an electric current is passed through an electrically conducting food product.

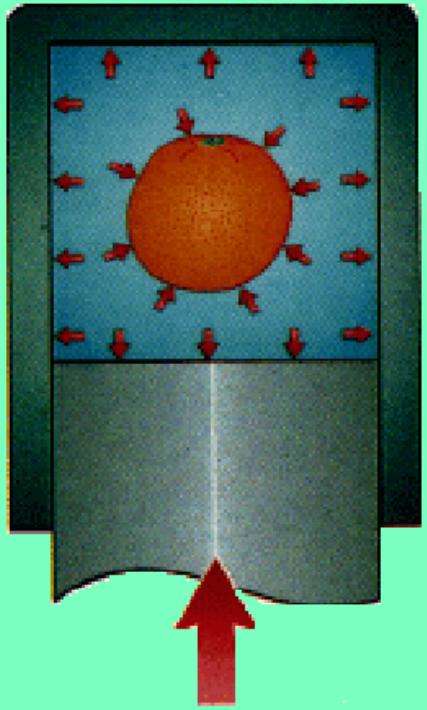
Typical Time Temperature Profiles under Ohmic Heating Conditions



Quality Optimization: Non-thermal Processing

High Pressure Processing

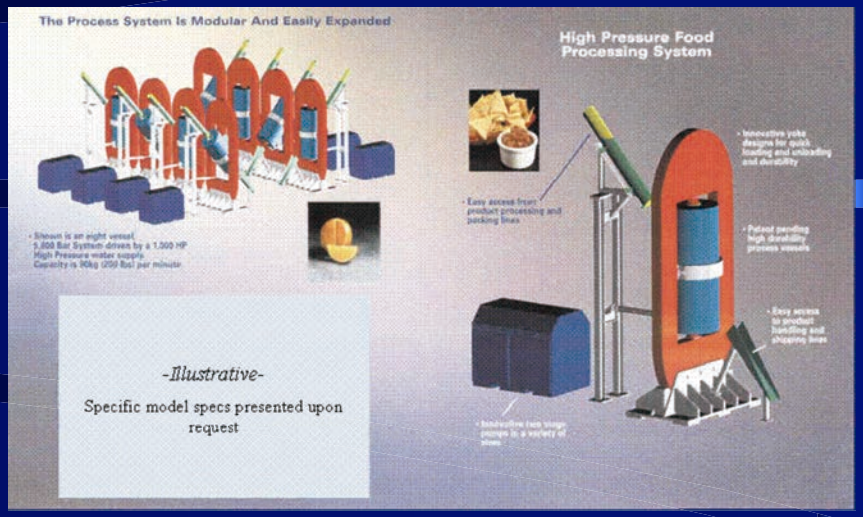
- An emerging and Novel technology
- Derived from material sciences
- First application Hite (1899)
- Gaining tremendous popularity in recent years



Equipment

Avure

HP Dynamics Inc



NC Hyperbaric

STANSTED

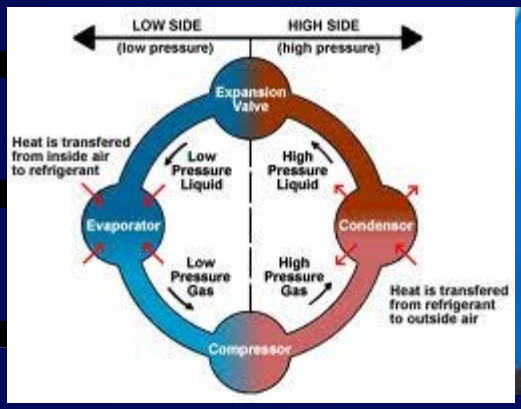
ACB

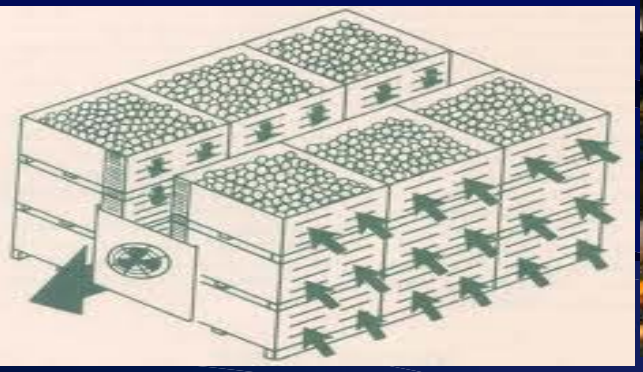
HPP Pilot Plant at McGill

High Pressure Application Areas

- **Pasteurization:** Juices, milk
- **Sterilization:** High and low acid foods
- **Texture modification:** Fish, egg, proteins, starches
- **Functional changes:** Cheese, yogurt , surimi
- **Specialty processes:** Freezing, thawing, fat crystallization, enhancing reaction kinetics

Refrigeration, Cooling, Freezing





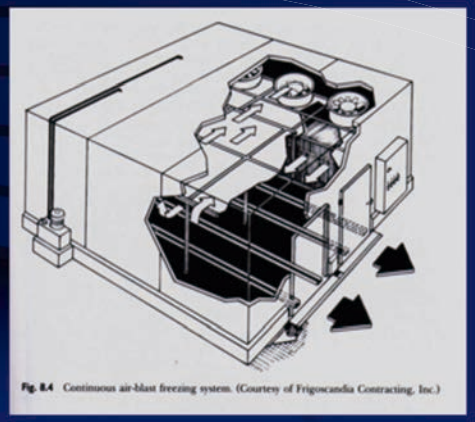
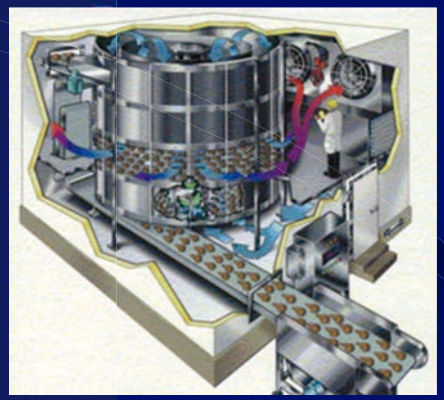


Fig. 8.4 Continuous air-blast freezing system. (Courtesy of Frigoscandia Contracting, Inc.)



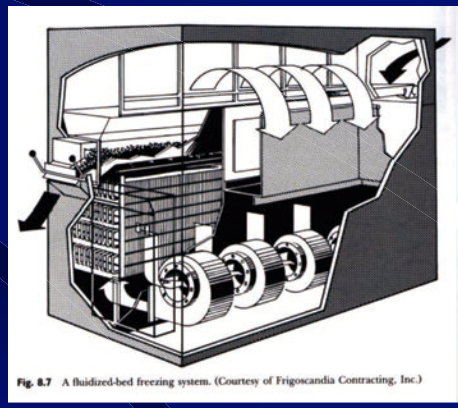
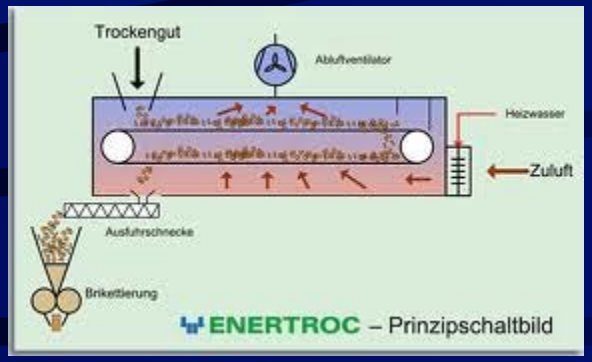


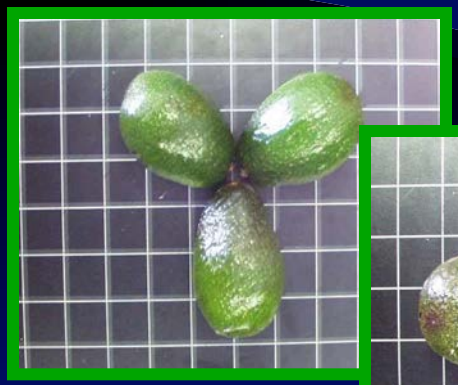
Fig. 8.7 A fluidized-bed freezing system. (Courtesy of Frigoscandia Contracting, Inc.)

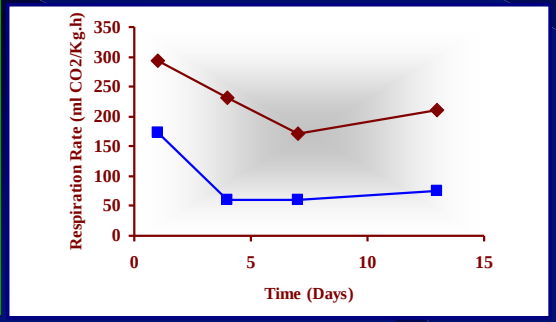
Drying

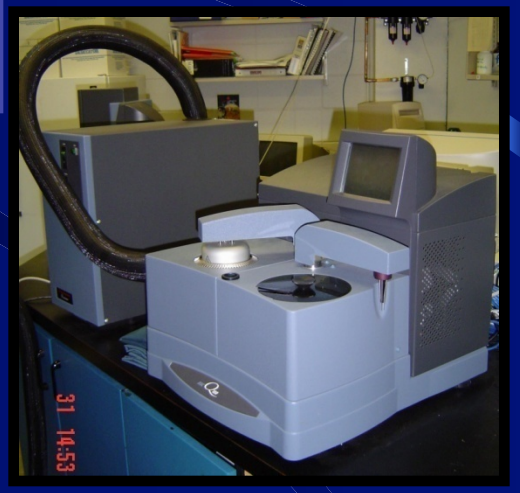

Trockengut
Abluftventilator
Heizwasser
Zuluft
Austrahrschnecke
Brikettierung
ENERTROC – Prinzipschaltbild

Edible Films for Shelf life Extension

- Biodegradable & Edible Films or shelf-life extension of fresh and cut fruits and vegetables



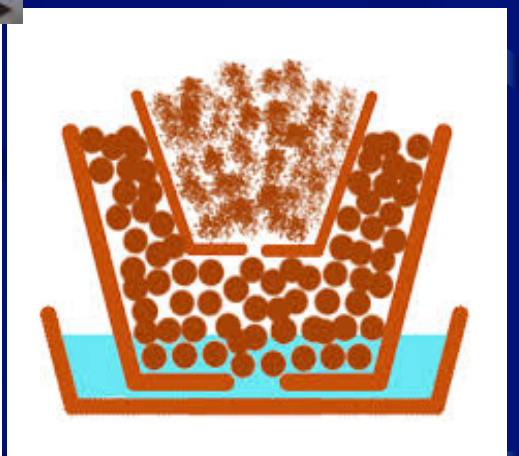




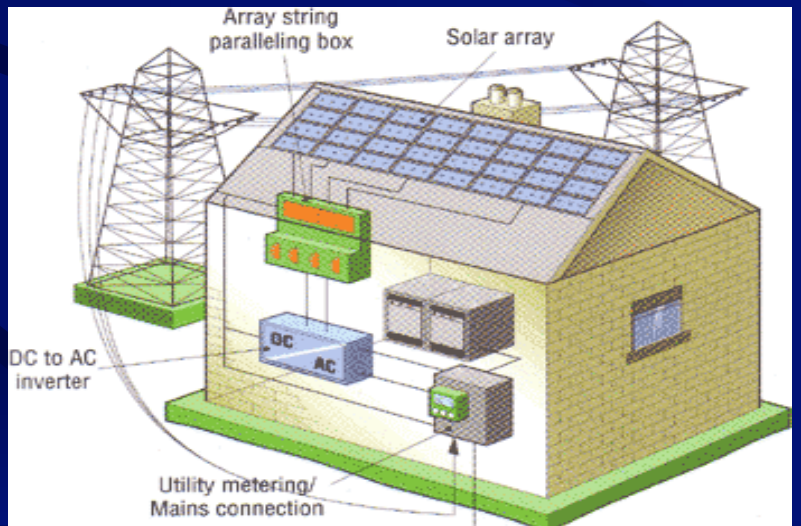
Affordable Technologies

Conventional thermal processing
Thin profile processing
Acidified thermal processing
Ohmic heating
Use of edible coating
Extrusion Technology
Many drying concepts – solar, osmotic
Many cooling and storage concepts
Formulation - blending

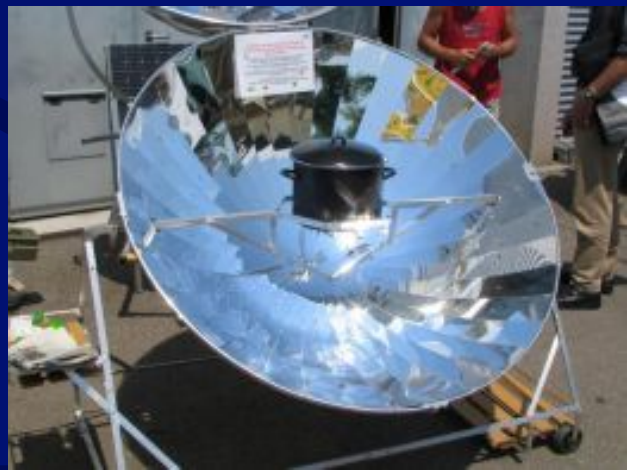
Pot in pot cooling

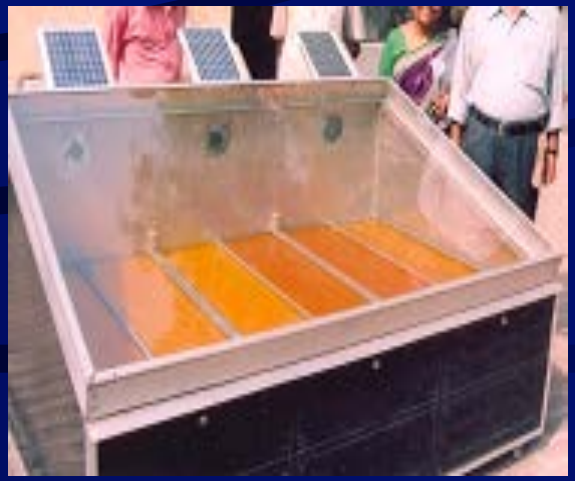


Solar water heaters & power generators

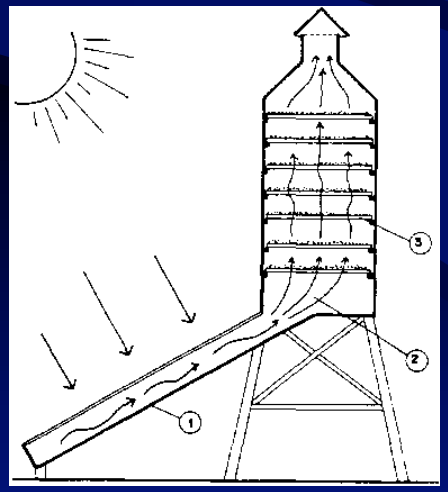


Solar cookers



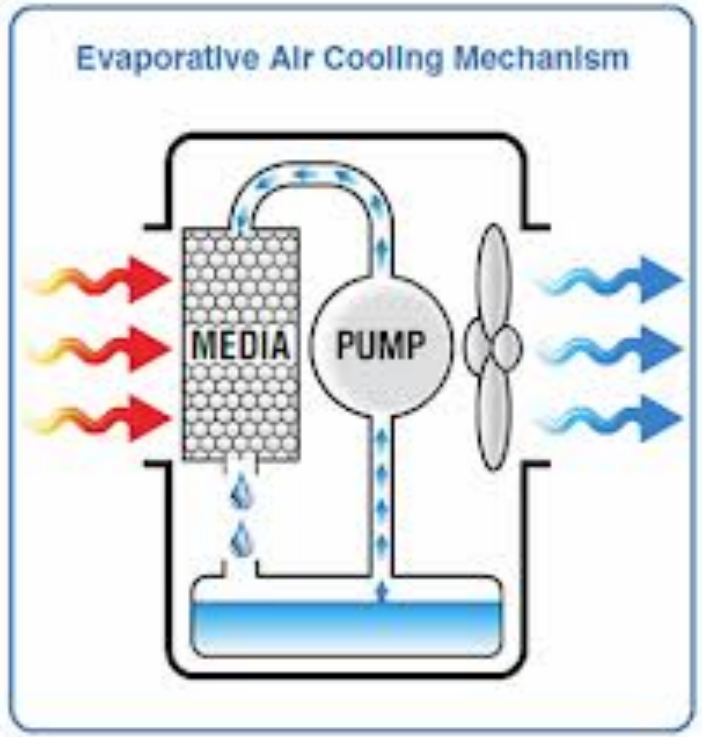


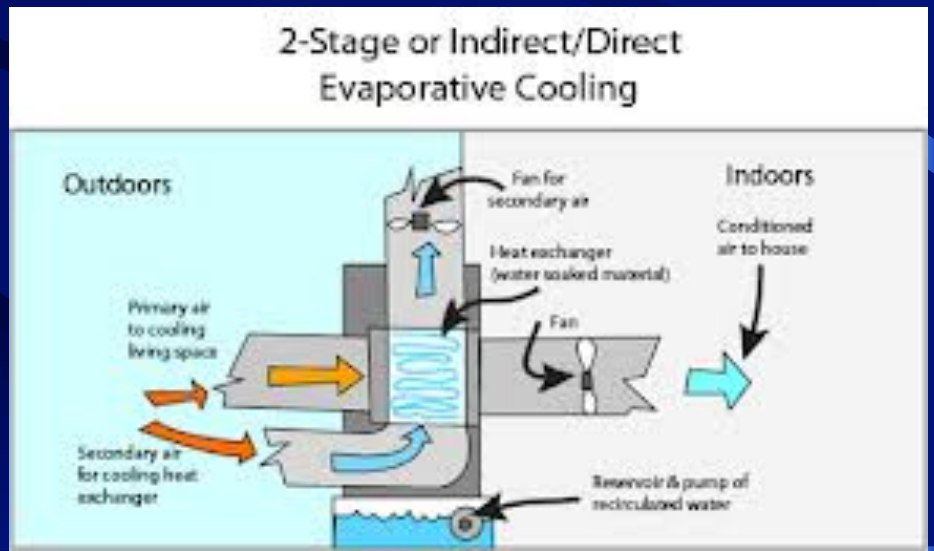
Solar driers



Low cost technologies for home/ community based food products

Commercial Evaporative Coolers





Potato Processing

Cooking - consumption
Cold Storage, curing
Drying – potato flakes
Frying – chips, French fries, patties
Baking
Mashed Potato
Potato flour (replacement for cereal flours)
Extraction – starch
Potato fiber - Resistant Starch (currently under review to be included as fiber)

Potato Potato!

Thank you for your patience

Gracias por la espera