Emerging Technologies for Food Processing

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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)

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

- **pH < 4.5**
  - High Acid Foods
  - Pasteurization: mild treatment < 100°C
  - Controls pathogenic & Spooilage vegetative forms.
  - Spore formers in-active.
  - Shelf-stable products for fruits & acidified foods

- **pH > 4.5**
  - Low Acid Foods
  - Sterilization: severe treatment >110°C
  - 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

- **pH**
  - Pasteurization: mild treatment < 100°C
  - Only pathogens Controlled.
  - Spores active; Only short-term storage at refrigerated conditions
Retort Systems

Typical Processing Sequence

1. Water Flow
2. Vent
3. Steam

- Can Loading
- Start-up
- Process
- Fill with Water (Pressure Cool)
- Discharge

Fig. 9.10 Hydrostatic vertical continuous bottle sterilizer:

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

- **Nutrient Destruction**
  - 90%
  - 50%
  - 10%
  - 5%
  - 3%

- **Temperature (C)**
  - T1
  - T2
  - T3
  - T4

- **Relative time**
  - t1
  - t2
  - t3
  - t4

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

\[ q = \frac{kA\Delta T}{x} \]

\[ q = hA\Delta T \]
Agitation Processing

Two common modes of agitation/rotation

Axial Rotation
(Continuous Operation)

End over end rotation
(Batch Operation)
Food Processing Optimization...

1) Agitation Processing

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

\[ q = h A \Delta T \]
Agitation Processing
ASEPTIC PROCESSING.

Aseptic Environment

Filling & Sealing

Aseptic Product

q = h A ΔT

Product

Container

Sterilization

Sterilization
• 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
Microwave Heating: Two Modes

**Ionic Polarization**

**Dipole Rotation**

**Sodium Ion**

**Chlorine Ion**

**Water Molecule**

**Ionic Interaction**

**Dipolar Interaction**

**Alternating Electric Field**
Ohmic heating

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
High Pressure Processing

- An emerging and Novel technology
- Derived from material sciences
- First application Hite (1899)
- Gaining tremendous popularity in recent years
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
Drying
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 driers
Low cost technologies for home/community based food products
Commercial Evaporative Coolers

[Diagram of evaporative cooling mechanism]

2-Stage or Indirect/Direct Evaporative Cooling

- Outdoors
  - Primary air to cooling living space
  - Fan for secondary air
  - Heat exchanger (water soaked material)

- Indoors
  - Conditioned air to house
  - Reservoir & pump of recirculated water
  - Secondary air for cooling heat exchanger
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)
Thank you for your patience
Gracias por la espera