Teacher Professional Development Programme
Knowledge Enriching Series for
New Senior Secondary Technology and Living:
Food Science and Technology Strand

Item 1: Food Studies

Food Preservation I

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The Chinese University of Hong Kong
Outlines for Food Preservation I and II

- Purpose of food preservation
- Factors causing food deterioration
- Principles of food preservation
- Thermal and non-thermal methods of food preservation
- Emerging methods of preservation
What is Food Preservation?

- It is an action or a method of maintaining foods at a desired level of properties/characteristics or nature for as long as possible.
- Use of specific thermal and nonthermal processing techniques to minimize microbial spoilage and extending the shelf-life of foods.
Examples of food preservation throughout history

- Milling of cereal grains into flour [~10,000 BC]
- Baking unleavened bread [10,000 BC]
- Meat and fish smoking, salting and drying [~4,000 BC]
- Canning [1800s AD]
- Milk pasteurization [1800s AD]
- Freeze-drying [1900s AD]
- Modified atmosphere packaging [1900s AD]
- Food irradiation [1900s AD]
- Nonthermal preservation [2000 AD]
Fig. 28. Drawing of the relief from the Tomb of Eurysaces, in Rome. After Hans Lamer, *Römische Kulture im Bilde* (Leipzig: Quelle & Meyer, 1915), Fig. 145.

Source: Ancient Food Technology by Robert I. Curtis
Plate 27. Pompeian bakery at Reg. VII.i.22 (Casa dei Fornai), showing the oven (left) and four donkey-driven rotary grain mills made of basalt. Note the ancient repairs on the *catillus* of the first mill.

Source: Ancient Food Technology by Robert I. Curtis

Source: Ancient Food Technology by Robert I. Curtis
Fig. 11. Wall painting from the Eighteenth-Dynasty Tomb of Nakht at Thebes. At top, treading grapes to make wine; wine amphorae appear at upper right of treading vat. Note the spout placed high up on vat. At bottom, catching and processing of birds. From Davies, *Tomb of Nakht*, Pl. XXVI. Courtesy of the Hargrett Rare Book and Manuscript Library, University of Georgia Libraries.

Source: Ancient Food Technology by Robert I. Curtis
Figure 1. Various stages of food production, manufacture, storage, distribution, and sale.
What are foods?

- Foods are materials, raw, processed, or formulated, that are consumed orally by humans or animals for growth, health, satisfaction, pleasure, and satisfying social needs.
Different classes of foods include:

- Perishable and Nonperishable
- Harvested and Fresh
- Minimally Processed
- Preserved
- Manufactured and Formulated
- Primary and Secondary Derivatives
- Synthetic
Table 1. Storage Life of Some Fresh Foods at Normal Atmospheric Conditions

<table>
<thead>
<tr>
<th>Food</th>
<th>Terminology</th>
<th>Storage Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat, fish, and milk</td>
<td>Perishable</td>
<td>1-2 days</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>Semiperishable</td>
<td>1-2 weeks</td>
</tr>
<tr>
<td>Root crops</td>
<td>Semiperishable</td>
<td>3-4 weeks</td>
</tr>
<tr>
<td>Grains, pulses, seeds, and nuts</td>
<td>Nonperishable</td>
<td>12 months</td>
</tr>
</tbody>
</table>

Why food needs to be preserved?

- To preserve quality and nutritive values of foods
- To overcome inappropriate planning in agriculture,
- To prevent spoilage and eliminate waste
- To produce value-added products, and
- To provide variation in diet
Figure 1. Unit operations for fruit and vegetable canning

Harvesting
Receiving
Washing
Peeling, Husking, Pitting, Coring, etc.
Separating, Grading, Sorting for size, Color, Solids and Defective removal
Holding by Quality
Pumping
Blanching
Dewatering
Filling
Exhausting
Container Closing
To warehouse
How long to preserve?

- When one or more quality attributes of a food has reached an undesirable state or level defined by manufacturer according to criteria when the product is saleable
- Unsuitable for consumption
- Shelf-life
- Best-before date or pack date
- Use-by date or expiration date
Figure 2. Factors affecting food quality, safety, and choice.
Factors causing food deterioration and spoilage

- Mechanical
- Physical
- Chemical
- Enzymatic
- Microbial effects
### Table 2. Major Quality-Loss Mechanisms

<table>
<thead>
<tr>
<th>Microbiological</th>
<th>Enzymatic</th>
<th>Chemical</th>
<th>Physical</th>
<th>Mechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microorganism growth</td>
<td>Browning</td>
<td>Color loss</td>
<td>Collapse</td>
<td>Bruising due to vibration</td>
</tr>
<tr>
<td>Off-flavor</td>
<td>Color change</td>
<td>Flavor loss</td>
<td>Controlled release</td>
<td>Cracking</td>
</tr>
<tr>
<td>Toxin production</td>
<td>Off-flavor</td>
<td>Nonenzymatic browning</td>
<td>Crystallization</td>
<td>Damage due to pressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nutrient loss</td>
<td>Flavor encapsulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oxidation-reduction</td>
<td>Phase changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rancidity</td>
<td>Recrystallization</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shrinkage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Transport of component</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Organisms That Spoil Foods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Microorganisms</strong></td>
</tr>
<tr>
<td>a. Fungi: mold and yeast</td>
</tr>
<tr>
<td>b. Bacteria</td>
</tr>
<tr>
<td>c. Phages</td>
</tr>
<tr>
<td>d. Protozoa</td>
</tr>
<tr>
<td><strong>2. Insects and mites</strong></td>
</tr>
<tr>
<td>a. Directly by eating (infestation)</td>
</tr>
<tr>
<td>b. Indirectly by spreading diseases (fruitfly, housefly)</td>
</tr>
<tr>
<td><strong>3. Rodents</strong></td>
</tr>
<tr>
<td>a. Directly by consuming food</td>
</tr>
<tr>
<td>b. Indirectly by spreading diseases</td>
</tr>
</tbody>
</table>

Categorization of Major Food Preservation Methods

- Inhibition of microbial growth
- Slowing down of chemical deterioration
- Direct inactivation of bacteria, yeasts, or enzymes
- Avoiding recontamination before and after processing
Inhibition
- Low-temperature storage
- Reduction of water activity
- Decrease of oxygen
- Increase of carbon dioxide
- Acidification
- Fermentation
- Adding preservatives
- Adding antioxidants
- Control pH
- Freezing
- Drying
- Concentration
- Surface coating
- Structural modifications
- Chemical modifications
- Gas removal
- Changes in phase transition
- Hurdle technology

Inactivation
- Sterilization
- Pasteurization
- Irradiation
- Electrifying
- Pressure treatment
- Blanching
- Cooking
- Frying
- Extrusion
- Light
- Sound
- Magnetic field

Avoid recontamination
- Packaging
- Hygienic processing
- Hygienic storage
- Aseptic processing
- HACCP
- GMP
- ISO 9000
- TQM
- Risk analysis and management

Food Preservation by Inhibition

- Control of external environment (temperature, atmosphere, humidity, etc.)
- Control of intrinsic properties of foods (water activity or pH value)
Preservation of dried fruits
Food Preservation by Use of Chemicals/Additives*

- To control pH
- As antimicrobes
- As antioxidants
- Synthetic and natural sources
- Risk-benefit analysis

* More details to be covered in Food Science and Technology Extended Studies under the topic of Industrial Food Production (Food Processing – Use of Food Additives)
Table 4. Types and properties of antimicrobial substances used in the food processing industry.

<table>
<thead>
<tr>
<th>Antimicrobial Compound</th>
<th>Effective Against</th>
<th>Some Food Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetic acid salt (sodium acetate)</td>
<td>bacteria, molds</td>
<td>bread; as vinegar in pickled products and mayonnaise</td>
</tr>
<tr>
<td>benzoic acid salt (sodium benzoate)</td>
<td>molds and yeasts</td>
<td>ketchup, jams, syrups, orange juice products, syrups</td>
</tr>
<tr>
<td>Na and Ca propionate</td>
<td>bacteria, molds</td>
<td>bread, cake, cheese foods</td>
</tr>
<tr>
<td>potassium sorbate</td>
<td>bacteria, molds</td>
<td>breads</td>
</tr>
<tr>
<td>salt (sodium chloride)</td>
<td>bacteria, yeast, molds</td>
<td>baked products, canned foods, meats</td>
</tr>
<tr>
<td>sodium nitrite</td>
<td>Clostridium</td>
<td>cured meat products</td>
</tr>
<tr>
<td>sodium benzoate</td>
<td>molds and yeasts</td>
<td>condiments, fruit juices</td>
</tr>
<tr>
<td>sugar (sucrose)</td>
<td>bacteria, yeast, mold</td>
<td>baked products, fruit preserves, meats</td>
</tr>
<tr>
<td>sulfite, sulfur dioxide (SO₂)</td>
<td>bacteria, yeast, mold</td>
<td>dried fruit, lemon juice, molasses, wines</td>
</tr>
</tbody>
</table>
Preservation of bakery products
Preservation of sausages
Sausage (Frankfurter) making

Preparation of the casing
Washing and trimming
Grinding
Prepare the meat emulsion
Emulsion stuffing
Cooking/Roasting
Storage

A comminuted meat emulsion, showing protein matrix of muscle fibers, collagen fibers, and emulsified fat droplets surrounded by a film of myofibrillar protein
Table 5 Formulation of a typical Frankfurter

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boneless beef (10-12% fat)</td>
<td>1100 gm</td>
</tr>
<tr>
<td>Pork trimmings (20-30% fat)</td>
<td>900 gm</td>
</tr>
<tr>
<td>Ice</td>
<td>400 gm</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>70 gm</td>
</tr>
<tr>
<td>Salt</td>
<td>45 gm</td>
</tr>
<tr>
<td>Sugar</td>
<td>30 gm</td>
</tr>
<tr>
<td>White pepper</td>
<td>6.2 gm</td>
</tr>
<tr>
<td>Coriander</td>
<td>3.7 gm</td>
</tr>
<tr>
<td>Nutmeg</td>
<td>2.5 gm</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>1.1 gm</td>
</tr>
<tr>
<td>Cardamom</td>
<td>0.6 gm</td>
</tr>
<tr>
<td>Sodium nitrite</td>
<td>0.25 gm</td>
</tr>
<tr>
<td>Liquid Smoke</td>
<td>5 ml</td>
</tr>
</tbody>
</table>
**Table 6 Functional ingredients in processed meat**

Several common processed meat ingredients and their functions.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate (NO$_3^-$)</td>
<td>Nitrite is the active form; antioxidant that slows rancidity</td>
</tr>
<tr>
<td>Nitrite (NO$_2^-$)</td>
<td>Inhibits spoilage and pathogenic organisms; contributes to flavor; prevents warmed-over-flavor; stabilizes color</td>
</tr>
<tr>
<td>Phosphates</td>
<td>Increase juiciness; inhibit rancidity; retain moisture; solubilizes proteins</td>
</tr>
<tr>
<td>Salt</td>
<td>Cure ingredient; extracts myofibrillar proteins; provides flavor; tenderizes</td>
</tr>
<tr>
<td>Spices</td>
<td>Contribute specific flavors; inhibit bacterial growth</td>
</tr>
<tr>
<td>Sugar</td>
<td>Binds to water; facilitates browning reactions; provides sweetness to counteract salt; acts as substrate for fermentation</td>
</tr>
<tr>
<td>Water</td>
<td>Provides calorie reduction (fat replacer); carries and distributes dry ingredients; contributes to juiciness and tenderness</td>
</tr>
<tr>
<td>Erythorbate</td>
<td>Acts as antioxidant</td>
</tr>
</tbody>
</table>
Preservation of pickled foods
Table 7. Some Chemical and Natural Antioxidants and Their Uses

<table>
<thead>
<tr>
<th>Antioxidant</th>
<th>Action/Characteristics</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDTA&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Slow oxidation by metals</td>
<td>Vegetable oil-containing foods</td>
</tr>
<tr>
<td>Citric acid</td>
<td>Chelate metals in meat</td>
<td>Meats</td>
</tr>
<tr>
<td>Phosphates</td>
<td>Complexes with metal ions</td>
<td>Meats</td>
</tr>
<tr>
<td>BHA&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Survives baking and frying</td>
<td>Foods containing animal fats</td>
</tr>
<tr>
<td>BHT&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Survives baking and frying</td>
<td>Foods containing animal fats</td>
</tr>
<tr>
<td>TBHQ&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Survives frying temperature</td>
<td>Vegetable oil-containing foods</td>
</tr>
<tr>
<td>Propyl gallate</td>
<td>Heat sensitive</td>
<td>Vegetable oil-containing foods</td>
</tr>
<tr>
<td>Tocopherols</td>
<td>Can add with vitamin C, etc.</td>
<td>Foods containing animal fats</td>
</tr>
<tr>
<td>Rosemary</td>
<td>Delay free radical formation</td>
<td>Meats, irradiated ground beef</td>
</tr>
<tr>
<td>Thyme, oregano</td>
<td>Avoid warmed over-flavor</td>
<td>Comminuted poultry, meat, fish</td>
</tr>
<tr>
<td>Dried plums</td>
<td>Retard lipid oxidation</td>
<td>Sausage and other ground meat</td>
</tr>
<tr>
<td>Honey</td>
<td>Darker is more effective</td>
<td>Ground turkey</td>
</tr>
</tbody>
</table>

<sup>a</sup>Ethylenediaminetetraacetic acid  <sup>b</sup>Butylated hydroxyanisole  
<sup>c</sup>Butylated hydroxytoluene  <sup>d</sup>Tertiary-butylhydroquinone
Food Preservation by Control of Water

- Water content and water activity
- Removal of water by drying and concentration
- Freezing
Preservation of pasta
Food Preservation by Control of Atmosphere (Packaging Techniques)

- Modified atmosphere packaging
- Controlled atmosphere packaging
- Active packaging
- Vacuum packaging
- Asceptic packaging (avoid recontamination)
Preservation of packaged cakes
Preservation of rice cake

亞媽糖年糕

將糯米磨成米漿，加入黃糖，蒸製出別具傳統風味的亞媽糖年糕。口感軟滑香甜，味道老少咸宜。
奇華亞媽糖年糕最宜切成厚約一厘米小方片，然後沾滿蛋漿慢火煎香，特別香軟濃郁。
成份：糯米、片糖、水、瓜子、色素(E102, E110)
淨重：1000克

此日期前最佳 BEST BEFORE：見包裝底部
製造商：奇華餅家 香港九龍長沙灣青山道666號
請存放於陰涼乾爽處。
生產此食品的廠房有處理含有麩質的穀類、蛋類、花生、大豆、奶類、木本堅果及堅果製品。
香港製造

開封後必須冷藏 確保新鮮
Preservation of potato chips
Food Preservation by Inactivation

- Use of heat energy
- Use of radiation
- Use of high pressure and ultrasound*
- Use of electricity*
- Use of magnetic field*

* Emerging technologies
Preservation of dairy products
Preservation of cooked foods
Preservation of canned foods
Food Preservation by Food Safety Concepts/Systems

- Hazard Analysis and Critical Control Point (HACCP)
- ISO 9000 and 22000
- Good Manufacturing Practices (GMP)
- Standard Operating Procedures (SOP)
- Total Quality Management (TQM)
- Hurdle Technology/Combined Preservation Techniques
Example of application of hurdle technology in food preservation

Figure 5  Sequence of hurdles occurring during the ripening and drying of fermented sausages (salami). Symbols have the following meaning: pres., addition of nitrite-curing-salt; Eh, decrease of redox potential; c.f., growth of competitive flora; pH, acidification; $a_w$, decrease of water activity during the drying process. (After L. Leistner, Food Design by Hurdle Technology and HACCP, Adalbert-Raps-Foundation, Kulmbach, 1994, p. 62; L. Leistner, in Water Activity: Theory and Applications to Food Marcel Dekker, Inc., New York, 1987, p. 295.)
Suggested basic reading

- Food Preservation Techniques by P. Zeuthen and L. Bogh-Sorensen (2003), Woodhead Publishing
- Understanding Food Science and Technology by Peter S. Murano (2003), Thompson