Introduction

Principle:

- Provide a brief overview of the major biochemical, chemical, physical, biological changes that occur in foods during processing & storage.
- How these combine to affect food quality.
Knowledge of such changes is essential before a sensible choice of packaging materials can be made.

The rate of such changes can be minimized by selection of the correct packaging materials.

How about the classification of Undesirable changes that occur in foods
Classification of Undesirable Changes that occur in foods

**Texture**
- Loss of solubility
- Loss of WHC
- Toughening
- Softening

**Flavor**
- Rancidity
- Other off flavors

**Color**
- Darkening
- Bleaching
- Off colors

**Appearance**
- Increase / decrease particle size
- Non uniformity

**Nutritive value**
- Loss of Vitamins, Minerals, Proteins, Lipids
OVERVIEW

Introduction

Deteriorative Reaction in Foods

Rates of Deteriorative Reactions (RDR)

Extrinsic Factors to control RDR

Conclusion
1. Enzymatic changes

Enzymes can act as:

- **Catalyst**: accelerating the rate of chemical reaction.
- **Specificity**: enabling the food processor to selectively modify individual food components.
- **Regulatory**: controlling biochemical processes.
1. Enzymatic Changes

Type:

- **Exogenous enzymes**: microbial enzymes during food spoilage changes sensory quality of foods.

- **Endogenous enzymes**:
  - Autolysis in fish postharvest
  - Glycolysis in postmortem
  - Senescence & spoilage of fruits & vegetables
  - Lipid and phenolic oxidation
Deteriorative Reaction in Foods

1. Enzymatic changes

Type:

- **Lipase & lipoxygenase in milk** → lipid oxidation → affecting the color, flavor, texture.
- **Lactase in milk**: formation of lactic acid → curd, sour taste
- **Phenolase** → leading to browning
- **Phospholipase** → leading to changes in texture
1. Enzymatic changes

How to control enzymatic changes?

- Temperature
- pH
- Aw
- Chemical substances which inhibit enzymes
- Alteration of substrate
- Alteration of products
- Preprocessing control
2. Chemical Changes

- **Sensory Quality:**
  1. Lipid oxidation
  2. Nonenzymic browning
  3. Color changes (Chlorophylls, Heme pigments, anthocyanins, carotenoid, natural pigment)
  4. Flavor changes

- **Nutritional Quality:**
  Vitamins, proteins, lipids
2. Chemical Changes

- The rates of these chemical reactions are dependent on a variety of factors amenable to control by packaging including:
  - light, oxygen concentration, temperature, Aw.
- The packaging also play a major role in controlling these factors.
2. Chemical Changes

Chemical reaction that can lead to deterioration of food quality or impairment of safety:

1. Non enzymic browning
2. Lipid hydrolysis & oxidation
3. Protein denaturation & cross linking
4. Oligo & polysaccharide hydrolysis
5. Protein hydrolysis
6. Polysaccharide synthesis
7. Degradation of specific natural pigments
8. Glycolytic changes
Deteriorative Reaction in Foods

2. Chemical Changes (Sensory Quality)

a. Lipid Oxidation (Autooxidation):

→ The reaction of molecular oxygen by a free radical mechanism with hydrocarbons and other compounds.

→ The reaction of free radical is extremely rapid.

→ Lipid which contain multiple double-bonded systems (ex: PUFA, phospholipids) are susceptible to autooxidation.

→ The mechanism of lipid oxidation (4 steps): initiation, propagation, branching and termination.
2. Chemical Changes (Sensory Quality)

a. **Lipid Oxidation (Autooxidation)**:

- **Initiation**: takes place by loss of hydrogen radical due to heat, light or trace metals.
- **Propagation**: lipid-free radical reacts with \( \text{O}_2 \) → **peroxy free radicals**, then react with more lipid → **hydroperoxides**.
- **Branching process**: increase in free radicals from decomposition of hydroperoxides.
- **Termination**: elimination of free radicals by addition of two free radicals → stable radical / unreactive.
2. Chemical Changes (Sensory Quality)

b. Nonenzymic browning:

- One of the major deteriorative chemical reactions which occurs during storage of dried & concentrated foods.

- Maillard reactions (3 stages):
  1. Early Maillard \( \rightarrow \) chemically well-defined steps w/o browning
  2. Advanced Maillard \( \rightarrow \) lead the formation of volatile or soluble substances
  3. Final Maillard \( \rightarrow \) leading to insoluble polymers
b. Nonenzymic browning:

- The initial reaction involves a simple condensation between an aldehyde (usually reducing sugar) and an amine (usually protein or amino acids) to give a glycosylamine via Schiff’s base.
- The glycosylamine then undergoes an amadori and various flavor compound.
- Strecker degradation involves oxidative degradation of amino acids.
2. Chemical Changes (Sensory Quality)

b. Nonenzymic browning:

- Transamination of the Schiff base, substitution of amino-deoxy-ketose
- Formation of heterocyclic compounds such as pyrazines and pyrroles (brown melanoidin pigments)
2. Chemical Changes (Sensory Quality)

c. Color Changes:

- Acceptability of color in a given food is influenced by many diverse factors, including cultural, geographical, and sociological aspects of the population.
- The Nature changes of pigments:
  1. Chlorophylls
  2. Heme Pigments
  3. Anthocyanins
  4. Carotenoids
2. Chemical Changes

Color changes

1. Chlorophylls

Heat & Acid $\rightarrow$ **Pheophytinization** $\rightarrow$ Dark color (brown)

Ex: **photooxidation** of green peas & beans packed in clear glass containers $\rightarrow$ loss of desirable color.

2. Heme Pigments

Oxygen + myoglobin $\rightarrow$ oxymyoglobin or brown metmyoglobin

Ex: loss of desirable color in fresh meat.
3. Anthocyanins

- water soluble pigments in plants
- composed of an aglycone (anthocyanidin) esterified to one or more of five sugars (glucose, rhamnose, xylose, galactose, arabinose)
- Decolorization of the pigments is depend on pH.
- Stable in low pH
- Neutral pH (no color), acid pH (red-purple), basic pH (light blue)
2. Chemical Changes

Color Changes

4. Carotenoids:

- Lipid soluble
- Yellow and red colors of plant and animal products
- Include a class of hydrocarbons called carotenes & their oxygenated derivatives called xantophylls.
- Autooxidize by oxygen, light, heat and prooxidants
2. Chemical Changes

Flavor Changes

Oxidation

Lipids → Aldehydes, ketones (off-flavor)

\( O_2, \) light, \( pH, \) heat

The volatile flavors \( \rightarrow \) autooxidation \( \rightarrow \) cause: painty, fatty, metallic flavors
2. Nutritional Changes
   a. Vitamin
      Vitamin C destruction
      pH, metal, oxygen
### General Stability of Vitamins to Environmental Effects

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Oxygen</th>
<th>Light</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>S</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>U</td>
<td>U</td>
<td>S</td>
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<tr>
<td>Biotin</td>
<td>S</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Carotenes</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>S</td>
<td>U</td>
<td>S</td>
</tr>
<tr>
<td>Tocopherols</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
</tbody>
</table>

Source: Robertson (1993)
2. Chemical Changes

b. Protein

Protein degradation
- Oxidation
- Protein + lipid
- Maillard reaction

c. Lipids

Lipids degradation → Peroxide
- Oxygen
2. Chemical Changes

Maillard Reaction

- Reducing sugars & Amine $\rightarrow$ off color $\rightarrow$ brown color (melanoidin pigment)
- Rasemination in amino acids
- Changes amino acid configuration:
  - L-amino acid $\rightarrow$ D-amino acid
- Loss of nutritional properties, primarily from losses in the amino acid lysine.
3. Physical Changes

- Geometrical
- Thermal
- Optical
- Mechanical
- Rheological
- Electrical
- Hydrodynamic
3. Physical Changes

Characteristics:

- Defect on packaging
- *Over heat sealing* → Nicked packaging → Microbial growth → product is unsafety
- Off Smell, taste, and flavor
- Density changes
- Viscosity changes
3. Physical Changes

Geometrical

- **Include**: size, shape, volume, density, surface area
- **Related to**: homogenous food units, texture characteristics
- **Texture can be divided into 2 classes**:
  1. Particle size & shape: gritty, grainy
  2. Particle size & orientation: fibrous, cellular
- **Ex of physical changes**: Hygroscopic, Caking, agglomeration in food powders (starchy powders, proteinaceous, crystalline sugar, amorphous sugar, fatty)
Deteriorative Reaction in Foods

3. Physical Changes

Powders Type
- Starchy powders (wheat flour)
- Proteinaceous (soy isolate)
- Crystalline sugar (sucrose)
- Amorphous sugar (dehydrated fruit juices)
- Fatty (soup mix)

How to control physical changes (caking)??
Using antcaking agents, control Aw
4. Biological Changes

- **Microorganisms**
  1. Bacteria
  2. Fungi
  3. Yeast

- **Macroorganisms**
  1. Insect
  2. Rodentia
4. Biological Changes

A. Microorganisms:
- Acid formation $\rightarrow$ decrease pH
- Protein denaturation $\rightarrow$ floculation
- Slime formation
- Viscosity changes
- Lipolysis
- H2S, amoniak, amine, indole formation
4. Biological Changes

How to Control Microorganisms growth ???

a. Intrinsic Factors

* pH
* Aw
* Nutrient
* Eh
* Antimicrobial substances
* Biological structures
4. Biological Changes

b. **Extrinsic Factors**

* **Temperature**
Most pathogens are mesophilic

* **RH**
influence $Aw$ of food

* **Gas concentration**
MAP (Modified Atmosphere Packaging) $\rightarrow$ preventing the growth of aerobic m.o
C. **Packaging materials**

- Microorganisms (mold, yeast, bacteria) cannot penetrate material of **plastic film and metal foils**
- **Heat resistant plastic/aluminium foil** → microbial growth test
4. Biological Changes

Approximate Minimum Aw Values for the Growth of Microorganisms in Foods

- Most spoilage bacteria: 0.91
- Most spoilage yeasts: 0.88
- Most spoilage molds: 0.80
- Halophilic bacteria: 0.75
- Xerophilic bacteria: 0.65
- Osmophilic yeast: 0.60
4. Biological Changes

B. Macroorganisms

a. Insects

Temp growth: 10 - 35°C
Water content > 11%
Product: cereal, milk and its derivates, fruits, dried meat

b. Rodentia: Mouse

Control sanitation
# 4. Biological Changes

## Resistance of Materials to Insect Penetration

<table>
<thead>
<tr>
<th>Type</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycarbonate, Polyethylene terephthalate</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellulose acetate, polyamide, PE (0,254 mm), PP, PVC (unplasticized)</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
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<tr>
<td>Acrylonitrile, PE (0,12 mm)</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Kraft paper, paper, PE (0,025-0,1 mm)</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
4. Biological Changes

Methods for Obtaining Insect Resistance of Packaging Materials

- Select a film thickness
- Use a film adhesive containing approved insecticide
- Add an insecticide directly to the packaging material
- Use shrink film overwraps
- Seal carton flaps completely
OVERVIEW

- Introduction
- Deteriorative Reaction in Foods
- Rates of Deteriorative Reactions (RDR)
- Extrinsic Factors to control RDR
- Conclusion
Rates of Deteriorative Reactions

- Zero order reactions
- First order reactions
- Microbial Growth and Destruction
Extrinsic Factors Controlling RDR

We should control temperature, Aw, Gas Atmosphere and light to protect agricultural and food products.

- Effect of Temperature
- Effect of Aw
- Effect of Gas Atmosphere
- Effect of Light
OVERVIEW

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Thank You