Modified Atmosphere Packing (MAP) SEMINAR

Recent Issues and Development in Modified Atmosphere Packaging (MAP) Technology

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Factors affecting shelf life of foods

Storage conditions, temperature, light, sanitation

Type of packaging material, internal atmosphere; [O₂], [CO₂], [H₂O]

Handling practices

Food Packaging

Food Product

Properties of Foods
• Physiological condition
• Nutrition composition
• Water activity (a_w)
  • pH
• Product sanitation
• Other components? (antioxidants, preservatives, etc)

External Atmospheree condition, [O₂], [CO₂], [H₂O]
Factors affecting shelf life of foods

In the food industry the role of packaging is significant in increasing a product's shelf life by
- Ensuring food safety
- Delaying food value degradation
- Shelf life is closely related to packaging.

Factors affecting shelf life of foods

In the food industry the role of packaging is significant in increasing a product's shelf life by "regulating":
- $O_2$ and $CO_2$
- light
- water vapour
- aroma
- mechanical impact.
Factors affecting shelf life of foods

Purwiyatno Hariyadi/MAP Seminar, Jakarta 4 Maret 2010
Factors affecting shelf life of foods

In the food industry, the role of packaging is significant in increasing a product's shelf life by "regulating":

- $O_2$ and $CO_2$
- light
- water vapour
- aroma
- mechanical impact.
Fruits and Nuts are Living

- **Consume**
  - O₂
  - Substrates
- **Evolve**
  - CO₂
  - Heat
  - Ethylene
  - Lose H₂O through epidermis

- **Metabolically active**
  - Tissue softening
  - Starch to sugars
  - Sorbitol to fructose
  - Organic acids decreasing
  - Flavor volatiles increasing
  - Color changes

Factors Affecting Storage Life of Fruit and Vegetables

*Post Harvest Physiology*

**Pre-Harvest Conditions**
- Top quality damage-free produce
- Minerals

**Temperature**
- Pre-cooling
- Correct storage temperature

**Controlled Atmosphere**
- Physiology
- Relative humidity Oxygen
- Carbon dioxide
- Ethylene
- Dealing
Factors Affecting Storage Life of Fruit and Vegetables

Post Harvest Physiology

Types of Fruit

- **Climacteric**
  - Apples
  - Pears
  - Apricot
  - Peach
  - Plum
  - Fig
  - Persimmon

- **Non-climacteric**
  - Blueberries
  - Grapes
  - Cherries
  - Strawberries
  - Sweet oranges
  - Lemons

- Respiration increases during ripening
Factors Affecting Storage Life of Fruit and Vegetables

Post Harvest Physiology

- Ethylene content higher and increases more during ripening

![Diagram showing the stages of ripening: Bloom, Cell division, Cell enlargement, Maturation, Ripening, Senescence.](attachment:diagram.jpg)

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Factors Affecting Storage Life of Fruit and Vegetables

Oxygen Concentration vs Respiration

Factors that affect the storage life of fruits and vegetables include oxygen concentration and respiration rate. A diagram shows the relationship between relative respiration rate and oxygen concentration (0% to 16%) on the x-axis and respiration rate on the y-axis. The graph illustrates that as oxygen concentration increases, the respiration rate also increases, with a notable peak at aerobic conditions.

Relative Respiration Rate

- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2

Oxygen (%)

- 0
- 4
- 8
- 12
- 16

Aerobic
Factors Affecting Storage Life of Fruit and Vegetables

Oxygen Concentration vs Respiration

At low \([O_2]\)

Fermenting carbohydrates in fruits or grains anaerobically, produce ethyl alcohol

\[C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2\]
Factors Affecting Storage Life of Fruit and Vegetables

Oxygen Concentration vs Respiration

- **Anaerobic**
- **Aerobic**
- **Total**

Factors Affecting Storage Life of Fruit and Vegetables

**CO₂ Concentration?**

Raising the level of carbon dioxide to levels of 2 % or more can also be beneficial:

- reduce the products sensitivity to ethylene
- slow the loss of chlorophyll which is the green colour of fruit and vegetables
- High CO₂ can also slow the growth of many of the postharvest fungi that cause rots.
Methods of Storage

Storage of Apples

- **Oxygen Level**
  - Lower to 3% from 21%
    - Reduce respiration
    - Reduce ethylene production
  - If too low
    - Anaerobic metabolism
    - Off flavors

- **Carbon dioxide Level**
  - Increase to 5% from 0.03%
    - Reduce respiration
    - Reduce ethylene production
    - Inhibit the breakdown of pectic substances
  - If too high
    - Anaerobic metabolism
    - Off flavors

Some examples of products that benefit from Controlled Atmosphere or Modified Atmosphere storage*.

<table>
<thead>
<tr>
<th>Product</th>
<th>Temperature °C</th>
<th>Oxygen (%)</th>
<th>CO₂ (%)</th>
<th>Storage life in air (days)</th>
<th>Storage life in CA /MAP (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple, Gala</td>
<td>0 - 2</td>
<td>1.5 - 2.5</td>
<td>1 - 5</td>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>Avocado</td>
<td>5 - 13</td>
<td>2 - 5</td>
<td>3 - 10</td>
<td>42</td>
<td>84</td>
</tr>
<tr>
<td>Banana</td>
<td>13 - 16</td>
<td>2 - 5</td>
<td>2 - 5</td>
<td>28</td>
<td>49</td>
</tr>
<tr>
<td>Bean, snap</td>
<td>4 - 8</td>
<td>2 - 3</td>
<td>4 - 7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Broccoli</td>
<td>0 - 1</td>
<td>1 - 3</td>
<td>5 - 15</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>Lettuce</td>
<td>0 - 1</td>
<td>2 - 5</td>
<td>&lt; 1%</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>P. ca</td>
<td>- 1 - 1</td>
<td>2 - 3</td>
<td>0 - 1</td>
<td>90</td>
<td>180</td>
</tr>
<tr>
<td>Pepper, Bell</td>
<td>7 - 12</td>
<td>2 - 5</td>
<td>2 - 5</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>Strawberry</td>
<td>- 0.5 - 0</td>
<td>5 - 10</td>
<td>15 - 20</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>

MAP for Fresh Cut

Low O₂ and/or elevated CO₂ environment within a fresh-cut MAP extend fresh-cut product shelf-life by:

• slowing browning reactions
• reducing the rate of product respiration and
• reducing C₂H₄ biosynthesis and action
• Elevated CO₂ environments within MAP bring an additional benefit of being fungistatic → are commercially used in both the whole and fresh-cut strawberry industry to reduce the growth of *Botrytis cinerea*. 
FISH product and MAP

Lower O₂:
✓ Reduced oxidation
✓ Reduced microbial activity

Higher CO₂
✓ Antimicrobial effect – Gram-negative organisms with aerobic metabolisms

Comparison of MAP, air and vacuum packaging:
Shelf life (sensory evaluation)

<table>
<thead>
<tr>
<th>Product</th>
<th>MAP</th>
<th>Air</th>
<th>Vacuum</th>
<th>Storage temp</th>
<th>CO₂/N₂/O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod (G. morhua) fillets</td>
<td>17</td>
<td>6</td>
<td>16</td>
<td>8</td>
<td>0/100/0</td>
</tr>
<tr>
<td>Catfish (filets)</td>
<td>13</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>75/25/0</td>
</tr>
<tr>
<td>Salmon (S. salar)</td>
<td>17</td>
<td>11</td>
<td>17</td>
<td>2</td>
<td>60/40/0</td>
</tr>
<tr>
<td>Shrimp, spotted (Pandalus platyceros)</td>
<td>14</td>
<td>7</td>
<td>0</td>
<td>100/0/0</td>
<td></td>
</tr>
<tr>
<td>Swordfish (Xiphias gladius) steaks</td>
<td>22</td>
<td>6</td>
<td>2</td>
<td>100/0/0</td>
<td></td>
</tr>
</tbody>
</table>
MEAT & Poultry product and MAP

Modified Atmospheres Used in Fresh Meat in USA

- 80% oxygen + 20% carbon dioxide
- 0.4% carbon monoxide + 60% carbon dioxide + 39.6% nitrogen (approved for bulk packages during transport, February, 2002, and for retail packages in January, 2004.

Pros/Cons of 80% oxygen MAP

- Advantages
  - 10-14 day redness, vs 3-5 days in PVC
- Disadvantages
  - Premature Browning during cooking
  - Oxidized (rancid) flavor
  - Bone darkening
MEAT & Poultry product and MAP

Pros/Cons of 0.4% CO-MAP

• Advantages
  – 28 days redness of ground beef, 35 days for steaks or roasts.
  – No oxidized flavor, no bone darkening

• Disadvantages
  – CO safety concerns
  – Can spoiled meat appear fresh?
  – Persistent pinking after cooking?
**ROP Pathogens of Concern**

- *Clostridium botulinum* – spore former, obligate anaerobe, is a concern with ROP foods.
  - Minimal growth requirement for *C. botulinum*

<table>
<thead>
<tr>
<th>Property</th>
<th>Group I</th>
<th></th>
<th>Group II</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proteolytic</td>
<td>Type A, B, F</td>
<td>Non-Proteolytic</td>
<td>Type B, F, E</td>
</tr>
<tr>
<td>Inhibitory pH</td>
<td>4.6</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibitory NaCl</td>
<td>10%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum $a_w$</td>
<td>0.94</td>
<td>0.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. optimum</td>
<td>98°F</td>
<td>86°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. range</td>
<td>50 -118°F</td>
<td>38 -113°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxin production</td>
<td>≥ 50°F</td>
<td>≥ 38°F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ROP Pathogens of Concern**

- *Listeria monocytogenes*
  - Conditions for LM growth:
    - ≤ 10 % salt
    - 5-10 % $O_2$
    - pH 4.1 – 9.6
    - $a_w$ 0.90 - 0.93
    - 28°F - 122°F
  - LM can survive months in a moist environment - steam from cooking, dishwashing machines, pressure sprayers.
  - LM competes well with other organisms, especially at refrigeration temperatures
  - LM is more heat resistant than most vegetative pathogens – a concern with lightly cooked foods
Product
- Raw material
- Process
- Hygiene.

Packaging-material and -machine
- Barrier
- Runability
- Sealability
- Design
- Hygiene.

Distribution:
- Time
- Temperature
- Light
- Mechanical impact
- Logistics
- Environment
- Consumer.

Packaged product

Terimakasih