PACKAGING OF AGRICULTURAL PRODUCTS

Japan Food Packaging Association
ISHITANI Takasuke Ph.d
What is the genuine agricultural products? fresh produces?

What is the freshness?

We don’t use the word “freshness” for evaluation of fresh produces, we use the key words of food quality. “Freshness” is a general idea for newly harvested or newly produced foods.

Newly harvested fresh produces are not always good quality. Sorting is necessary for getting good products after harvest.

Living fish in the aquarium in a seafood restaurant is very fresh, but is not always good taste as Sashimi.
What is the genuine product?

- Safe and secure (reliable)
- Good taste of eating quality (includes good smell, good texture)
- Beautiful appearance
- Nutritious
- Good for health
- Good information
- But how do you know?
What is the genuine fresh produces?

- **Safe & secure** (reliability) by farm assurance
  ASEANGAP, QGAP, GLOBALG.A.P.

- **Good taste** of eating quality by **tasting**
  (good smell, good texture)

- **Beautiful appearance** (buying motivation)

- **Nutritious** (increase by using good manure etc.)
  (vitamins, minerals, protein, amino acids) check data

- **Good for health** (functional properties) check data
  (natural pigments, polyphenols, β-glucan, etc.)

- **Good information** (indication, website)
  (variety, production area, no using chemicals, etc.)
National Standard (Code) of Good Agricultural Practice
  • • • for example: England Code of GAP
  Japanese code of GAP
  for sustainable agriculture
Farm Inspection conducted by government and
direct payment to the farm by the result of inspection
(conducted by the government of
  Country or Province)

National Standard for Farm Assurance • • • QGAP
80% of farms were inspected by the government
Most of the super markets sell
  the agricultural products of QGAP
  or of GLOBALG.A.P. or of organic

Farm Assurance (Private, Association)
  • • • GLOBALG.A.P. ASEANGAP
Soil Code
Water Code
Green Code

Protecting our Water, Soil and Air
A Code of Good Agricultural Practice for farmers, growers and land managers

Japanese code of GAP
But this is not National
Private code of GAP by FGAP Assoc.

Japan doesn’t have national code of GAP
Quality factors for evaluation

《fundamental quality》 Nutrition and Safety

《functional quality》
1. Palatability
Appearance, Color, Taste, Smell or odor, Physical property
2. Functional components for biological health control
Polyphenol, $\beta$-glucan, carotenoid, anthocyanin, peptide, lipid, etc.
immunological competence, anti-cancer, anti-aging,
blood pressure control, etc.

《Secondary factors of quality》
1. Distribution stability of each factor
   (changing velocity – withering, color change, fragrance disappear,
   changes velocity in taste, texture, components, etc.)
2. Consumer’s sense of value
   (like or dislike, cultural, economical factors, good for pleasure,
   conveniency, etc.)
Evaluation of the good tasty (palatability) by scientific manners.

**Sensory analysis**

**Appearance** ・・・<observation>・・・ related with marketability or salability of commodity

**Color, Smell** ・・・<observation, smelling>・・・sensory, chemical, physical analysis ・・・ related with consumer judgment

**Taste** ・・・<tasting>・・・sensory, chemical, physical analysis ・・・

  - Brix ・・・ Handy Refractometer, ・・・ easy way
  - Organic acid, Sugar & acid ratio, Amino acid・・・
  - chemical and sensory analysis,
  - Astringency, off-taste ・・・<tasting>

**Texture** ・・・<tasting>・・・ sensory, physical analysis ・・・
Utilization of tomato and quality factors

Fresh use • • <higher price> • • salad, sandwich, hamburger, etc.
● sweetness, sugar acid ratio, color, texture, shelf life, etc.

Cooking use • • <medium price> • • Italian dish, ethnic dish in Japan, soup, as seasoning, etc.
● taste, carotenoid content, solid content, etc.

Rich in glutamic acid

Processing use • • <lower price> • •
• tomato ketchup, puree, tomato sauce etc.
● color density, total solid, brix, yield, etc.
Quality factors of food

Nutrition
- protein, enzyme, amino acid, fat & oil, carbohydrate, sugar, fiber, pectin, organic acid, vitamin, mineral, etc.
- residual pesticide, natural toxin, heavy metal, harmful microorganisms, etc.

Basic quality

Safety

Quality

Functional quality

Palatability
- Appearance: shape, big, long, uniformity, luster, etc.
- Color: density, tint, natural pigments, etc.
- Taste: sugar, organic acid, amino acid, umami, bitterness, salt, etc.
- Smell: density, quality, alcohols, esters, acids, terpenes, aldehydes, floral, off-odor, etc.
- Texture: from tough to week, protein, fiber, etc.

Biological health control
- polyphenol, β-glucan, carotenoid, peptide, lipid, etc.
- immunologic competence, anti-cancer, anti-oxidation, control blood pressure, etc.
Structure of “quality”
Overall quality and individual quality of food
What is the most important factor affecting to the overall quality of food?
Depends on the food.

individual quality

- shape
- color
- texture
- smell
- shelf life
- nutrition
- taste
- function

overall quality acceptability
### Sensory analysis of food

#### Name

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#### Appearance, color

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#### Smell

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#### Taste

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#### Overall evaluation

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</table>
Factors of quality change of foods and environmental conditions

- **Biological factors**
  - bacteria, yeast, mold
  - enzyme
  - Insects, rats

- **Chemical factors**
  - fat oxidation
  - discoloration
  - Non-enzymatic browning

- **Physical factors**
  - oxygen
  - temperature
  - humidity, Aw
  - pH
  - fat absorption
  - moisture, Aw, pH
  - light, metal ion

- **Artificial factors**
  - needle
  - poison
  - flavor change
  - absorb moisture
  - drying
  - broken
  - crystallization
  - bad odor
  - moisture
  - vibration, shock
  - temperature

Product tampering / contamination of foreign objects: insects, plastics, foreign plants, hair (human, rat), mold.

Living frog in salad vegetable in UK

Chicken nugget of Mac in USA
Pest Control

- maize weevil
- Indian meal moth
- Kashmir flour beetle
Egg stage 4 days

30℃で
約34日

Larval stage 34 days (30°C)
Dry Foods  
Sorption isotherm

Intermediate Moisture Foods

High Moisture Foods

Quality stability

Relative Velocity

Oxidation of Fats & Oils

Non-enzymatic browning

Enzyme Activity

Mold

Yeast

Bacteria

Water activity

Relative Velocity

Dry Foods  
Sorption isotherm

Quality stability

Oxidation of Fats & Oils

Non-enzymatic browning

Enzyme Activity

Mold

Yeast

Bacteria

Water activity
Water activity or Aw is the partial pressure of water vapor in a substance divided by the standard state partial vapor pressure of water.

In the field of food science, the standard state is most often defined as the partial vapor pressure of pure water at the same temperature. Using this particular definition, pure distilled water has a water activity of exactly 1.00.

Higher Aw substances tend to support more microbes. Bacteria usually require at least 0.91, Fungi at least 0.70.

Water migrates from areas of high Aw to areas of low Aw. For example, if honey (Aw ≈ 0.6) is exposed to humid air (Aw ≈ 0.7), the honey absorbs water from the air. If salami (Aw ≈ 0.87) is exposed to dry air (Aw ≈ 0.5), the salami dries out, which could preserve it or spoil it.
What is free water?

<table>
<thead>
<tr>
<th>Water</th>
<th>occurrence</th>
<th>high temp.</th>
<th>low temp.</th>
<th>microorganism</th>
<th>solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free water</td>
<td>75-85%</td>
<td>easy</td>
<td>easy</td>
<td>can use</td>
<td>active</td>
</tr>
<tr>
<td>Bound water</td>
<td>15-25%</td>
<td>difficult</td>
<td>difficult</td>
<td>cannot use</td>
<td>not active</td>
</tr>
</tbody>
</table>
Types of Foods

- **High Moisture Foods (HMF)** Aw. 1.00-0.90
  - Fresh foods (Fruit, Vegetable, Meat, Milk, Egg)
    - (Fish, Shellfish, Sea weed)
  - Daily necessity foods (Noodle, Bread, Pickles, Tofu)
  - High moisture processed foods
    - (Ham & sausage, Fruit & vegetable juice, Cake)

- **Intermediate Moisture Foods (IMF)** Aw. 0.90-0.65
  - Processed IMF (Salty foods, High sugar foods)
  - Semi-dried traditional foods
    - (Dry fruits, Dried fish & shrimp, Confectionaries)
  - Traditional seasonings (Fish sauce, Soy sauce)
Dry Foods (DF) Aw. 0.65-0.00

- Dried fruits & vegetables, Dried meat & fishes
- Deep-fried, vacuum-dried fruits & vegetables (Potato chips, Popcorn, Snack foods)
- Instant dried foods (Instant noodle & soup)
- (Breakfast cereal, Dry fruit, fruit granola)
- Dried milk, Powdered foods (Instant soup, Skimmed milk)
- Green tea, Black tea, Regular & instant coffee
- Wheat flour, Rice flour, Starch, Nuts, Spices
Natural dry of cherry shrimp in Shizuoka
Drying of persimmon
Food, Water Activity, Factors Affecting Food Quality, Quality-preservation Technologies, and Functional Property of Packaging Materials (Ishitani, June 1993)
Package is the contact point between food and packaging material.

There is no food distributed without package.
Package of fresh produces

Vegetable ⇒ Measure respiration
⇒ Suitable packaging material
⇒ Packaging machine
Daily necessities, delicatessen
Shelf life is at least 5 days under low temp.
Tofu, fried tofu, konnyaku, fish cakes, pickles, potato salad, natto, raw and boiled noodles (Japanese, Chinese noodles), cooked beans, tsukudani, kanroni (IMF), etc.
Packed in plastic tray and wrapped
Fermented noodles in Thailand
Factors affecting to the quality change of foods

1.00 0.90 0.80 0.70 0.60 0.00

High moisture Foods

Intermediate moisture foods

Dried foods

Fruit & vegetable
Fish & meat, Milk & egg
Daily necessities

Sterilization, HTST, UHT
Bacteria elimination by filtration
Pasteurization, hot & cold, physical & chemical
Cold distribution, chilling or freezing
Gas control, low O2, high CO2
Water activity control 0.94, 0.90, 0.85
pH control < 4.6
Preservatives, Natural & artificial

Vacuum packaging
Nitrogen exchange packaging
Oxygen absorber packaging
Food additives

Cushioning packaging
Flavor-keeping packaging
Moisture-proof packaging

Bacteria (spoilage)
Yeast (fermentation)
Mold (growth)
Halophilic bacteria
Halo-tolerant yeasts
Sugar-tolerant yeasts
Xerophilic molds

Oxidation
Browning
Discoloration

Mechanical damage
Moisture absorption
Off-odor
Methods of quality preservation of High Moisture Food(1) for controlling bacteria, yeast and mold

(1) Heat sterilization: Retort package, Aseptic package (HTST, UHT sterilization)

(2) Elimination of microbes: Micro-filtration and aseptic package, Clean package in clean room

(3) Pasteurization: Low temperature or boil pasteurization, Infra red heating, Ultra violet light past., Irradiation (γ-, β-), Microwave heating Ohmic heating, Ultra high pressure,

(4) Low temperature distribution: Cooling, Chilling with sanitary control, Frozen
Methods of quality preservation of High Moisture Food

(5) Gas control : CO2 exchange package, Oxygen absorber with high gas barrier pouch, container
(6) Control of water activity : salt, sugar
  Food additives (sugar alcohols), Partial drying
(7) pH control : Addition of organic acids
  (Vinegar, Food additives)
(8) Addition of food additives : Artificial & natural preservatives, Anti-microbial agents
The level of addition for controlling the growth of *Bacillus subtilis*
Major poisoning bacteria and level of poisoning

- *Bacillus cereus* (soil) 100,000 <
- *Clostridium perfringens* (anaerobic) 100,000 <
- *Clostridium botulinum* (anaerobic) 100,000 < *
- *Staphylococcus aureus* (pyogenic) 100,000 < *
- *Listeria monocytogenes* (zoonosis) 100,000 < *
- *Vibrio parahaemolyticus* (halophilic) 10,000 < *

Growth under low temperature  *

<table>
<thead>
<tr>
<th><em>Salmonella (enterica)</em></th>
<th>100～1,000</th>
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<tbody>
<tr>
<td><em>Campylobacter jejuni</em> (zoonosis)</td>
<td>&lt;100</td>
</tr>
<tr>
<td><em>Escherichia coli</em> (enterohemorrhagic)</td>
<td>&lt;100</td>
</tr>
<tr>
<td><em>Norovirus</em> (oral infection) <strong>vomit</strong></td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

Caution
Growth of poisoning bacteria under low temperature

<table>
<thead>
<tr>
<th>Name of bacteria</th>
<th>Growth temp.</th>
<th>Optimum temp</th>
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<tbody>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>0～45°C</td>
<td>(30～35°C)</td>
</tr>
<tr>
<td><em>Yersinia enterocolitica</em></td>
<td>0～44°C</td>
<td>(28～29°C)</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em></td>
<td>3～45°C</td>
<td>(30°C)</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>5～46°C</td>
<td>(35～43°C)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>7～48°C</td>
<td>(35～40°C)</td>
</tr>
<tr>
<td>Enterohemorrhagic <em>E. coli</em></td>
<td>7～46°C</td>
<td>(35～40°C)</td>
</tr>
<tr>
<td><em>Vibrio parahaemolyticus</em></td>
<td>10～48°C</td>
<td>(35～37°C)</td>
</tr>
</tbody>
</table>

《These bacteria can grow in refrigerator》

*Staphylococcus aureus* can grow under the condition of Aw0.86
*Staphylococcus* doesn't have heat resistant property,
So boil pasteurization can be used for packaged foods
### List of poisoning bacteria

<table>
<thead>
<tr>
<th>Name of Bacteria</th>
<th>Spore forming</th>
<th>MHLW</th>
<th>FDA</th>
<th>Infection level</th>
<th>Minimum Temp.</th>
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<tbody>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>x</td>
<td>0.86</td>
<td>0.83</td>
<td>100,000&lt;</td>
<td>6.6°C&lt;</td>
</tr>
<tr>
<td><em>Bacillus cereus</em> (aerobic)</td>
<td>◎ heat resistant</td>
<td>0.93</td>
<td>0.92</td>
<td>100,000&lt;</td>
<td>10°C&lt;</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> (strict anaerobic)</td>
<td>◎ heat resistant</td>
<td>0.93</td>
<td>0.93</td>
<td>100,000&lt;</td>
<td>12°C&lt;</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em> Proteolytic (strict anaerobic)</td>
<td>◎ heat resistant</td>
<td>0.94</td>
<td>0.935</td>
<td>100,000&lt;</td>
<td>10°C&lt;</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em> Non-proteolytic (iditto)</td>
<td>◎ heat resistant</td>
<td>0.97</td>
<td>0.97</td>
<td>100,000&lt;</td>
<td>10°C&lt;</td>
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<tr>
<td><em>Vibrio parahaemolyticus</em></td>
<td>x</td>
<td>0.94</td>
<td>0.94</td>
<td>10,000&lt;</td>
<td>10°C&lt;</td>
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<tr>
<td><em>Salmonella</em></td>
<td>x</td>
<td>0.94</td>
<td>0.94</td>
<td>100-1,000</td>
<td>7°C&lt;</td>
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<tr>
<td><em>Listeria monocytogenes</em></td>
<td>x</td>
<td>0.90</td>
<td>0.92</td>
<td>?</td>
<td>4°C&lt;</td>
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<tr>
<td><em>Campylobacter jejuni</em></td>
<td>x</td>
<td>0.98</td>
<td>0.98</td>
<td>100&gt;</td>
<td>5°C&lt;</td>
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<tr>
<td><em>enterohemorrhagic Escherichia coli</em> (O-157, etc.)</td>
<td>x</td>
<td>0.95</td>
<td>0.95</td>
<td>100&gt;</td>
<td>7°C&lt;</td>
</tr>
</tbody>
</table>
Laminated pouches for retortable pouch foods

Without paper carton

- PET 12μm
- ONy 15μm
- Al箔 7μm
- CPP 60μm

Printed, adhesive

With paper carton

- PET 12μm
- Al箔 7μm
- CPP 70μm

Printed, adhesive
Composition of retort pouch for cooked foods

ONy(15)-PR/CPP(70)  PET(12)-PR/PVDC(16)/ONy(15)/CPP (50)

PET(12)-PR/ONy(15)/Al(9)/CPP(70)  PET(12)-PR/Al(9)/CPP(70)
Hamburg steak
Meat ball

CPP/ONy/LLDPE
MXD Nylon/LLDPE
CPP/CNy/PE/EVOH/CNy/LLDPE
Effects of barrier level of pouch, temperature and light on the sensory score of packaged Hamburg 

Sensory Score (+3 ~ -3)

Storage period (days)

Limit of normal taste acceptability

Al = OPP/Al/CPP 0
PVDC=OPP/PVDC/CPP 10
PA= ONy/CPP 100
02 cc/m2 • day • atm

Light = 3500-5300 lux
Aseptic Packaged Foods in Japan
Aseptic package of sliced ham
Deep drawn & vacuum package

Aseptic package of sliced ham
Deep drawn & gas exchange package
ACTIVE PACKAGE

OXYGEN ABSORBING TRAY 《Oxigard》

( TOYOSEIKAN CO., LTD )

Aseptic Packaged Cooked Rice

- The mixed powder of reduced iron and oxidation catalyst are blended with base resin and used as a molding composition.
- Water in cooked rice is the trigger and absorb oxygen function appears in this type of tray.
- The photo. shows a practical use of "Oxigard" tray of PP type multi-layer for aseptic cooked rice.
Carbon dioxide gas exchange
Packaging for meat products
《Vienna sausage, wiener》

Hygienic control, CO$_2$ exchange package
low temperature distribution
Rice cakes packaged with oxygen absorber

- High gas barrier plastic pouch
- Packaged rice cake
- Oxygen absorber

Aseptic and non-aseptic

Mold

O2
Control of water activity

1.00・・・ High moisture foods
Retort package and aseptic package
Below 0.94・・・ Boil pasteurization is allowed in Japan

0.90・・・ Intermediate moisture foods
Below 0.88・・・ Oxygen absorber for semi dried noodle
Below 0.85・・・ Oxygen absorber, Boil pasteurization is allowed in the Philippines and other countries

Below 0.70 ・・・ Semi-dry foods
Below 0.65 ・・・ Dry foods, moisture proof packaging prevent oxidation packaging
Methods for lowering of Aw

1. Addition of NaCl
2. Addition of sugars, amino acids, other solutes, etc.
3. Drying (Removing of free water)
   - Natural drying, sun drying
   - Smoking and drying (hot smoking)
   - Roasting and sun drying
   - Mechanical drying, tunnel drying, etc.
Tsukudani
boiled in sweetened soy sauce with ginger

Small fishes
Cut fishes
Shellfishes
Mushrooms
Seaweeds
Vegetables

Tsukudani and cooked rice
Many kinds of smoked fishes are sold in the open market in Bataan city.
Seasoned, Smoked & Dried Milk Fish (Aw 0.85)
Seasoned, Smoked & Dried and Boil Pasteurized Milk Fish
Dried banana, OTOP shop in Bangkok, Thailand
Dry fishes packaged in LDPE bag
Dry fishes packed in LDPE bag
Effects of environmental factors on the oxidation of fats and oils

- Oxygen permeability
- Transparency
- Oxygen
- Light (UV)
- Metal ions
- Fatty acids
- Fats & Oils
- Oxidation
- Hydroperoxide
- Oxidation of pigment, Vitamin
- Radical
- Browning
- Poisoning
- Flavor change
- Carbonyls, Acids
- Malonaldehyde
- Moisture
- Water Vapor Permeability
- Oxygen
- Light (UV)
- Metal ions
- Fatty acids
- Fats & Oils
- Oxidation
- Hydroperoxide
- Oxygen
- Light (UV)
- Metal ions
- Fatty acids
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- Hydroperoxide
- Oxidation of pigment, Vitamin
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- Flavor change
- Carbonyls, Acids
- Malonaldehyde
- Moisture
- Water Vapor Permeability
Salted mackerel in market in south America in 1980’s

After keep longer meat color change to yellowish and taste also change to pungent like chili consumers prefer chili taste

These color and taste come from oxidation of highly unsaturated fatty acid of fish

POV of fish meat was increased over 1000 sometimes poisoning occur, and also no good for health
Poisoning by instant noodles in Japan

Deep fried type instant noodles was developed in 1957 in Japan

Early time, many poisoning incidents happened by oxidation of oil in the instant noodles
⇒ from deep fried to air dried noodles, good package, and regulation of POV, AV

Similar incidents happen in Africa now by instant noodles imported from China. There is no regulation of shelf life in Africa.
Japanese standard of oxidation of oily foods
ACID VALUE (AV) and PEROXIDE VALUE (POV)
(1977, Nov.)

Deep fried instant noodle
# Oxygen and WVTR of Plastic Films

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (μm)</th>
<th>Oxygen TR (24°C) cc/m²·day·atm</th>
<th>Water Vapor TR (40°C) g/m²·day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymethyl pentene (PMP)</td>
<td>25</td>
<td>47,000</td>
<td>110</td>
</tr>
<tr>
<td>Polybutadiene (BDR)</td>
<td>30</td>
<td>13,000</td>
<td>200</td>
</tr>
<tr>
<td>Ethylene vinyl acetate copoly. (EVA)</td>
<td>30</td>
<td>10,000-13,000</td>
<td>80 - 520</td>
</tr>
<tr>
<td>Soft polyvinyl chloride (PVC)</td>
<td>30</td>
<td>10,000</td>
<td>80 - 1,100</td>
</tr>
<tr>
<td>Polystyrene (OPS)</td>
<td>30</td>
<td>5,500</td>
<td>133</td>
</tr>
<tr>
<td>Poly lactic acid (PLA)</td>
<td></td>
<td>&lt;</td>
<td>Same level as OPS</td>
</tr>
<tr>
<td>Low density polyethylene (LLDPE)</td>
<td>30</td>
<td>6,000</td>
<td>18</td>
</tr>
<tr>
<td>High density polyethylene (HDPE)</td>
<td>30</td>
<td>4,000</td>
<td>7</td>
</tr>
<tr>
<td>Very thin HDPE</td>
<td>12</td>
<td>10,000</td>
<td>17</td>
</tr>
<tr>
<td>Casted polypropylene (CPP)</td>
<td>30</td>
<td>4,000</td>
<td>8</td>
</tr>
<tr>
<td>Oriented polypropylene (OPP)</td>
<td>20</td>
<td>2,200</td>
<td>5</td>
</tr>
</tbody>
</table>

Moisture-proof package
## Oxygen and WVTR of Plastic Films

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<tr>
<th>Material</th>
<th>Thickness (μm)</th>
<th>Oxygen TR (24°C) cc/m²·day·atm</th>
<th>Water Vapor TR (40°C) g/m²·day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casted nylon (CNy)</td>
<td>15</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Oriented nylon (ONy)</td>
<td>15</td>
<td>75</td>
<td>134</td>
</tr>
<tr>
<td>Polyester (PET)</td>
<td>12</td>
<td>120</td>
<td>25</td>
</tr>
<tr>
<td>Polyvinylidene chloride (PVDC)</td>
<td>30</td>
<td>1-5</td>
<td>2</td>
</tr>
<tr>
<td>PVDC coated OPP (KOP)</td>
<td>22</td>
<td>8-20</td>
<td>5</td>
</tr>
<tr>
<td>PVDC coated ONy (KON)</td>
<td>18</td>
<td>8-12</td>
<td>12</td>
</tr>
<tr>
<td>PVDC coated PET (KPET)</td>
<td>15</td>
<td>8-12</td>
<td>6</td>
</tr>
<tr>
<td>Ethylene vinylalcohol copolymer (EVOH)</td>
<td>15</td>
<td>0.3-8</td>
<td>30</td>
</tr>
<tr>
<td>Aluminum metalized PET (Thin)</td>
<td>12</td>
<td>20</td>
<td>0.8-1.4</td>
</tr>
<tr>
<td>Aluminum metalized PET (Thick)</td>
<td>12</td>
<td>0.8-1.0</td>
<td>1</td>
</tr>
<tr>
<td>SiOx, deposited PET (SiOx)</td>
<td>12</td>
<td>0.1-0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>AlOx deposited PET (AlOx)</td>
<td>12</td>
<td>0.6-1.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Aluminum foil (Al)</td>
<td>7,9,12</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Moisture-proof and anti-oxidation package
Dry foods (Snack foods)

Key words of Quality Changes & Preservation

**Oxidation** ････････Oxygen, Light, Metal ions, Pigments
Nitrogen exchange package
Visible & UV light cut package
Addition of anti-oxidants (prevent poisoning)

**Absorption of moisture** ････Humid air (texture change)
Moisture-proof package (with desiccant)

**Flavor change** ････(to environment, from environment)
Flavor barrier package, High barrier

**Off-odor development** ････Materials with no smell

**Mechanical damage** ････Shock absorbing package
Shock absorbing methods

**Vacuum Metalized** film is used for these purposes
- Potato chips ・・・・ VM PET with N2 gas exchange
- Nuts Mixture ・・ Al foil and KONy with oxygen absorber
Package of dry foods in Japan

- Boiled and dried sardine
  - KONy/CPP + O2 absorber
  - KOP/LLDPE + O2 absorber
  - OPP/PVA/LLDPE

- Rice cracker
  - OPP/CPP + desiccant
  - KOP/CPP

- Shavings of dried bonito
  - EVOH/CPP + N2 gas
Chemical, Biological factors affecting to flavor change of packaged foods

- Low temperature keeps the quality of foods
- Fats & Oils, Pigment
- Reducing sugar, Amino acid
- Microorganisms, Enzymes
- Oxygen
- Moisture
- Temperature
- Volatile components
- Flavor, Aroma
- Carbonyl compounds
- Bad odor components
- Odor of plastics
- Sorption
- Migration

Diagram notes:
4. Odor of plastics affects Bad odor components.
5. Sorption affects Volatile components, Flavor, Aroma.
6. Migration affects Bad odor components.
FRESHNESS-KEEPING FILM FOR FRESH PRODUCES

ACTIVE PACKAGE

P-PLUS® SUMITOMO
Anti-fog OPP, PLA

Bean Sprout

- Tailored gas permeable (micro-perforated) film for modified atmosphere packaging (MAP). Freshness-keeping & extend shelf life of fresh produces
- High Gas Permeable films for fresh produces
Quality Deterioration of Fresh Produces

- Fresh produces are living even after harvesting. The distribution conditions are decided by how to continue their respiration.
- Mechanical damage occurs by transportation.
- Withering and weight loss occur by transpiration.
- Loss of sugar, acid, vitamin occurs by respiration.
- Aging of cellular systems occurs by metabolism.
- Spoilage occurs by growth of microorganisms.
Microbial growth of cut vegetable under different temperatures during storage.

Microbiological control under the level of $10^2$ from harvesting to retail keep under $2 \, ^{\circ}\text{C}$.
THE PRINCIPLE OF FRESHNESS-KEEPING METHODS OF FRESH PRODUCE

① Vegetables should be kept under lower temperature for controlling their respiration and transpiration.
② Vegetables are packaged for controlling their respiration and transpiration.
③ Some kind of fruits and vegetables are packaged with ethylene scavenger for preventing over ripening.
Quality of vegetable is decreasing by respiration and transpiration

- Withering occurs by transpiration
  Appearance, Weight loss, Changes in gloss, color, etc. (over 5% loss of weight)
  Environmental conditions: Temperature, Humidity
  Surface area of leafy vegetables

- Loss of components occurs by respiration
  Taste (Sugar, Acids), Flavor, Vitamin C, etc.
  Environmental conditions: Oxygen concentration
Respiration rate of vegetables

- **Gold needle mushroom**
- **Cut vegetables**
- **Broccoli**
- **Cut Lettuce**
- **Lettuce**
- **Tomato**
- **onion**
- **Leafy vegetables**
  - 100<
  - 30-100
- **Fruit vegetables**
  - 10-30
- **Root vegetables**
  - 1-10
  - \(\text{CO}_2\text{mg/kg 10°C}\)

**Storage temperature**

- \(\text{CO}_2\text{mg/kg 10°C}\)
- 100<
Precooling and cold distribution are essential for preserving quality of vegetables

- Vegetables should be cooled as soon as possible after harvesting for controlling their respiration and transpiration, and should be distributed under low temperature and if possible under lower oxygen condition by packaging.

- Precooling: Hydro-cooling
  
  (Showering of cool grand water)
  
  Vacuum cooling
  Crush ice cooling
  Differential pressure air cooling
Differential pressure fun

Differential pressure sheet

Paper board box

Palette

Differential pressure room
What is MAP?

- Ambient temp.
- 21% of oxygen
- Short shelf life

- Ambient temperature
- Anaerobic Respiration
- Off-odor development

- Low temperature
- Low oxygen
- Prolong shelf life
MA package, CA storage, Gas exchange package

- MAP is the abbreviation of Modified Atmosphere Package mainly used for high respiration fresh produces by high gas permeable plastic films. CO2 is produced by the respiration of vegetables. Sometimes N2 gas or mixed gas flushing is applied for decreasing initial O2 concentration.

- CA is the abbreviation of Controlled Atmosphere storage mainly used for prolong storage time of fruits “apple” in warehouse. CO2 is produced by gas burning. Sometimes the term “CA package” is used in Japan, but not correct.
CA storage warehouse for apple in AOMORI

Oxygen Temp. 0°C

Storage days
CA Storage of apple in AOMORI prefecture

5 kg of apples stored by CA
Gas exchange package is mainly used for processed foods with high gas barrier films. Nitrogen is used for preventing oxidation and oxidative browning etc. and carbon dioxide is used for preventing microbial growth under low temperature, especially for mold and bacteria.

In the United States, the meaning of MAP includes not only package of fresh produces but also gas exchange package of processed foods.
P-type and E-type MA packages for Fresh Fruits & Vegetables

Perforated film
11% O₂ 10% CO₂
High transmission
11% O₂ 2.8% CO₂
3% O₂ 4.5% CO₂

Storage period (days)

Threshold level of off-odor 3-5% of oxygen

P-type
No change
E-type
Decrease
Vacuum

4.5% CO₂
0% O₂
21%
Open-type package

Film: OPP with big hole
Anti-fog, Clip...

Tray: OPS with PVC wrap
LLDPE wrap
better under low temp.

(Semi-E-type)
E-type MA  P-type MA  Dole-type MA

Limited films  
Low temperature  
Volume change  
LDPE, PVC-tray etc

Maintain same temperature  
High permeability, any film  
High accumulation of $\text{CO}_2$  
Micro-perforated films

Low temperature  
Low permeation, any film  
Limited period, high $\text{CO}_2$  
PET, ON, Tray-top seal
Initial oxygen concentrations of Gas Ex-type MA package controlled by gas exchange are lower than E-type MA and P-type MA. Respiration rates of vegetables are depressed by this method from early stage of storage and freshness and color could be kept by this method.
Comparison between E-type, B-type, P-type MA and Gas ex-type MA package of fresh produces.

<table>
<thead>
<tr>
<th>Type of MAP</th>
<th>Effect of temperature fluctuation</th>
<th>CO₂ accumulation</th>
<th>Volume change during storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-type MA</td>
<td>Small effect to gas concentration</td>
<td>Low</td>
<td>Decrease volume</td>
</tr>
<tr>
<td>Dole-type</td>
<td>Big effect to the shelf life</td>
<td>High</td>
<td>No change</td>
</tr>
<tr>
<td>P-type MA</td>
<td>Big effect to CO₂ concentration</td>
<td>High</td>
<td>No change</td>
</tr>
<tr>
<td>E-type MA + Gas flush</td>
<td>Small effect to gas concentration</td>
<td>Low</td>
<td>Decrease volume</td>
</tr>
<tr>
<td>P-type MA + Gas flush</td>
<td>Less effect to CO₂ concentration</td>
<td>Less than P-type</td>
<td>No change</td>
</tr>
</tbody>
</table>
Common package for leafy vegetables with big holes
Common package for tomato with holes. Tomato color can be kept longer by MAP
Dole-type MA method for leafy cut vegetables in Thailand
Dole-type MA method for fresh cut apple sold in 7-11 shop in Thailand
Dole-type MA method for leafy vegetables in Thailand

Common package for leafy vegetables with big holes
E-type MA package for golden needle mushroom. Package volume decrease like vacuum package but off-odor development doesn’t occur in this case.
E-type MA package for white ball mushroom. Package volume decrease like vacuum package.
FACTORS AFFECTING TO THE QUALITY CHANGE OF CUT FRUITS & VEGETABLES AND FOR PREVENTION

1. Microbial growth • • • Pretreatment, temp. control
2. Off-odor development • • • Low oxygen conc.
   Control by packaging and temperature
3. Browning • • • • • • • High oxygen
   Control by packaging and temperature
4. Withering • • • Water vapor TR of packaging film
5. Decrease of taste • • Temp. control, pretreatment
6. Physiological injury • • High CO₂, Low temperature depending on the kind of fresh produces
Thank you for your kind attention!