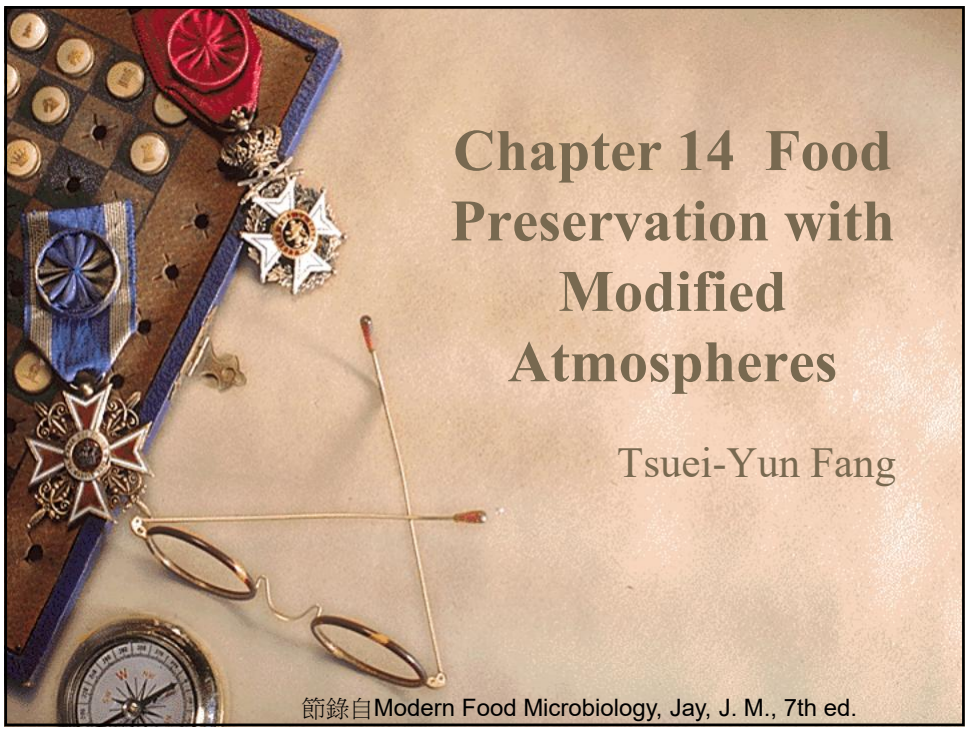
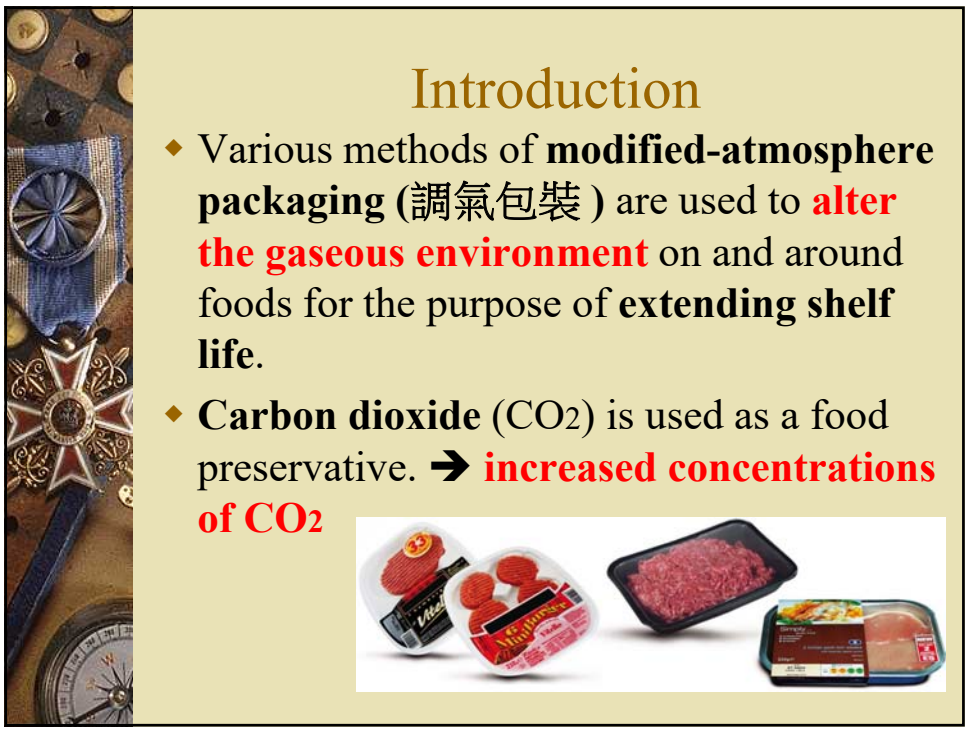
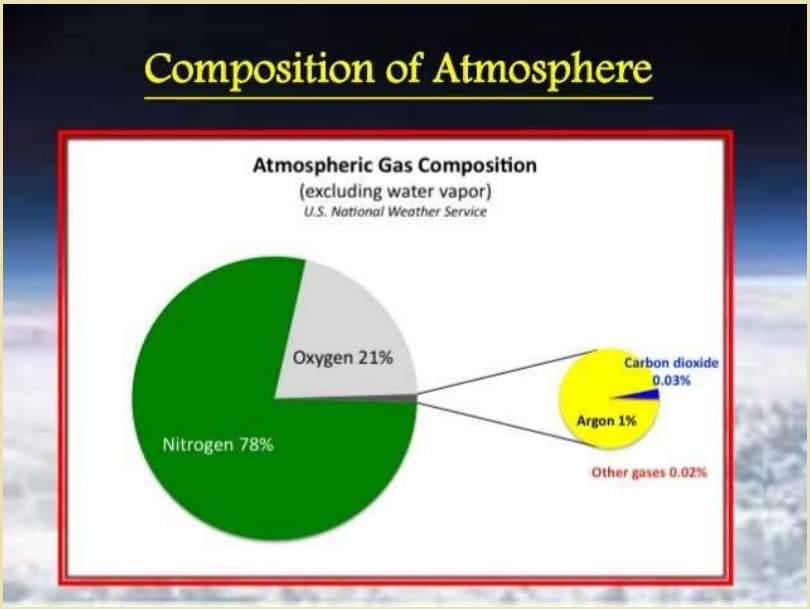

Chapter 14 Food Preservation with Modified Atmospheres
Tsuei-Yun Fang
節錄自Modern Food Microbiology, Jay, J. M., 7th ed.


Introduction
Various methods of **modified-atmosphere packaging (調氣包裝)** are used to **alter the gaseous environment** on and around foods for the purpose of **extending shelf life**.
Carbon dioxide (CO_2) is used as a food preservative. ➔ **increased concentrations of CO_2**

Composition of Atmosphere



Hypobaric (Low Pressure) Storage

- Food are stored in air under **low pressure (e.g. 10~80 mm Hg, 1 atm = 760 mm Hg), low temperature (e.g. 0°F), and high humidity (e.g. 95%)**, all of which are precisely controlled along with ventilation (通風).

Fruits and vegetables 10~80 mm Hg

Meats and seafoods ~10 mm Hg

Hypobaric (Low Pressure) Storage

- The hypobaric state results in reduced concentrations of oxygen ➔ reduced fat oxidation.
- In one study using pork loins (猪里肌):

10 mm Hg, 0°F, and 95% humidity was up to six times more effective on shelf-life than air storage.

Vacuum Packaging

- **Air is evacuated from gas-impermeable pouches followed by sealing** (from 1 bar reduced to 0.3~0.4 bar, 1 bar= 0.9869 atm).
- Upon storage of a vacuum-packed food product, **an increase in CO_2 may occur due to respiration. Up to 10-20%** may developed within four hours.
- **Retarding aerobic spoilage organisms, fat oxidation, and discoloration.**
- **Minimizing product shrinkage** due to no moisture loss.

Modified Atmosphere Packaging (MAP)

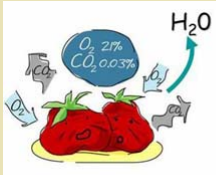
- A **hyperbaric** (高壓) **process** to alter the chamber or package atmosphere by **flushing with varying mixtures of CO_2 , N_2 , and /or O_2**.
- Two types of MAP:
  - **High-O_2 MAP**: up to 70% O_2 , 20-30% CO_2, and 0-20% N_2 ➔suitable for red meats

  - **Low-O_2 MAP**: 10% O_2 , 20-30% CO_2 with N_2 added as necessary ➔ minimize the activities of spoilage organisms

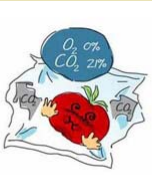
With time, the gas compositions may be changed.

Equilibrium-Modified Atmosphere (EMA)

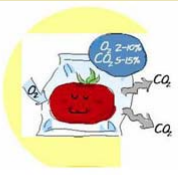
- EMA packaging (平衡調氣包裝) is achieved by flushing a **gas-permeable pack** with gas, or sealing the pack without alteration.
- EMA is used for fresh fruits and vegetables.



Normal Atmosphere



Normal Plastic Bag



EMAP Bag

Controlled-Atmosphere Packaging (控氣包裝) or Storage (CAP, CAS)

- A typical MAP: the compositions may change upon storage
- **CAP**: **the gas compositions remain unchanged** for the duration of the storage period
- CAP requires **aluminum foil laminates (鋁箔層壓板), metal or glass containers**, since single plastic film is not entirely imperious to gases.

PRIMARY EFFECTS OF CO_2 ON MICROORGANISMS

The following facts are well established following prolonged exposure of microorganisms to about **10% CO_2 and above**.

1. **The inhibitory activity increases as incubation or storage temperatures decrease.← greater solubility of CO_2** in water at the lower temperatures + the additive effect of **lower than optimal growth temperature**

PRIMARY EFFECTS OF CO_2 ON MICROORGANISMS

2. **Concentrations** from about 5-100% have been used, **20-30% seems optimal**, with no additional benefits derived from higher levels.

3. **Inhibition increases as pH is decreased into the acid range.** The vacuum packaging of red meats with pH >6.0 is not effective.

PRIMARY EFFECTS OF CO_2 ON MICROORGANISMS

4. In general, the **Gram-negative bacteria are more sensitive** to CO_2 inhibition than Gram-positives, with **pseudomonads (假單胞菌)** being among the most sensitive and **clostridia** (梭狀桿菌) the most resistant (Table 14 - 4).

Upon prolonged storage of meats, **CO_2 effects a rather dramatic shift in biota** from one that is largely Gram-negative in fresh products to one that is largely or exclusively Gram-positive (Table 14-5).

PRIMARY EFFECTS OF CO_2 ON MICROORGANISMS

5. Both **lag and logrithmic phases** of growth **are retarded**.

6. **CO2 under pressure is considerably more antimicrobial**. The destructive action is believed to occur when pressure is released suddenly.

Mode of Action

1. CO_2 affects the **permeability of cell membranes**
2. CO_2 interferes with the **normal functions of amino acid-binding proteins.**

Application in Food Products

- Vacuum packaging, MAP, and CAS can extend the shelf-life of a wide variety of food products.
  - Fresh and processed meats
  - Poultry
  - Seafood
  - Fruits and vegetables






THE SAFETY OF MAP FOODS

Clostridium botulinum

As a general rule, foods that are to be subjected to MAP should possess one or more of the following antibotulinal hurdles:

1. have a water activity (a_w) <0.93
2. have a pH of 4.6 or less
3. cured with NaCl or NO_2
4. contain high levels of nonpathogens (for raw meat, poultry, and the like)
5. maintained in frozen state
6. maintained at 40°F (4.4°C) or below
7. have a definitive shelf life (e.g., not to exceed 10 days)

THE SAFETY OF MAP FOODS

Listeria monocytogenes (李斯特菌)

- The fact that this bacterium **can grow in the refrigerator temperature range** raises concerns about its presence and potential for growth in MAP foods.
- Regarding the behavior of this organism on vacuum-packaged beef, it has been shown that critical factors are **storage temperature, pH, and type of tissue**, whether lean or fat. The organism grew more extensively on fat than lean beef.

THE SAFETY OF MAP FOODS

Other Pathogens

- When cooked bologna-type sausage (法蘭克福香腸 semidry) was vacuum packaged, the growth of *Yersinia enterocolitica* (耶爾辛氏腸炎桿菌) and salmonellae (沙門氏菌) was restricted but not that of *Staphylococcus aureus*(金黃色葡萄球菌).
- *Clostridium perfringens* (產氣莢膜菌) was also inhibited, and growth inhibition was attributed to the normal biota.

SPOILAGE OF MAP AND VACUUM-PACKAGED MEATS

- When vacuum-packaged meats undergo long-term refrigerator spoilage, often the predominant organisms are **lactobacilli, other lactics** or ***Brochothrix thermosphacta*** **(熱殺索絲菌)**. Other organisms can be found and may predominate.

SPOILAGE OF MAP AND VACUUM-PACKAGED MEATS

- Among the determining factors are the following:
  1. whether the product is **raw** (lower pH) **or cooked**
  2. **concentration of nitrites** present
  3. relative load of **psychrotrophic bacteria (嗜冷細菌)**
  4. the degree to which the vacuum-package film excludes O_2
  5. product pH

Volatile Components of Vacuum-Packaged Meats and Poultry

- The **off-odors and off-flavors** produced in vacuum-packaged meat products by the spoilage biota are summarized in Table 14-6.
- In general, short-chain fatty acids are produced by both **lactobacilli** and ***B. thermosphacta*** (熱殺索絲菌**)** and spoiled products may be expected to contain these compounds, which confer **sharp off-odors**.
- In vacuum-packaged luncheon meats, **acetoin** and **diacetyl** have been found to be the most significant relative to spoiled meat odors.