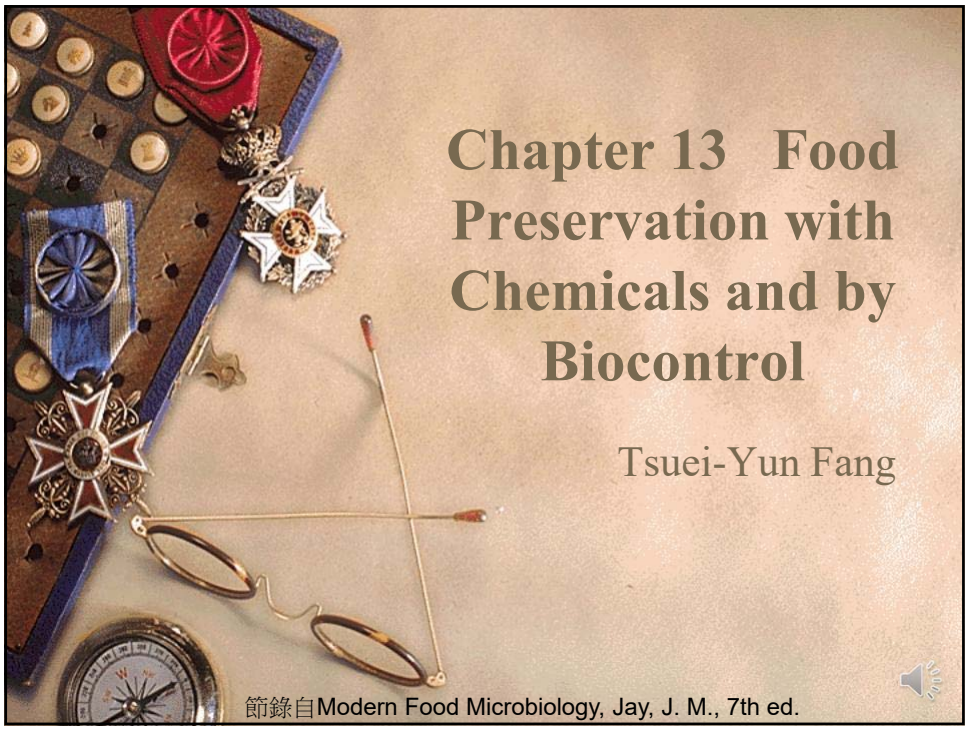
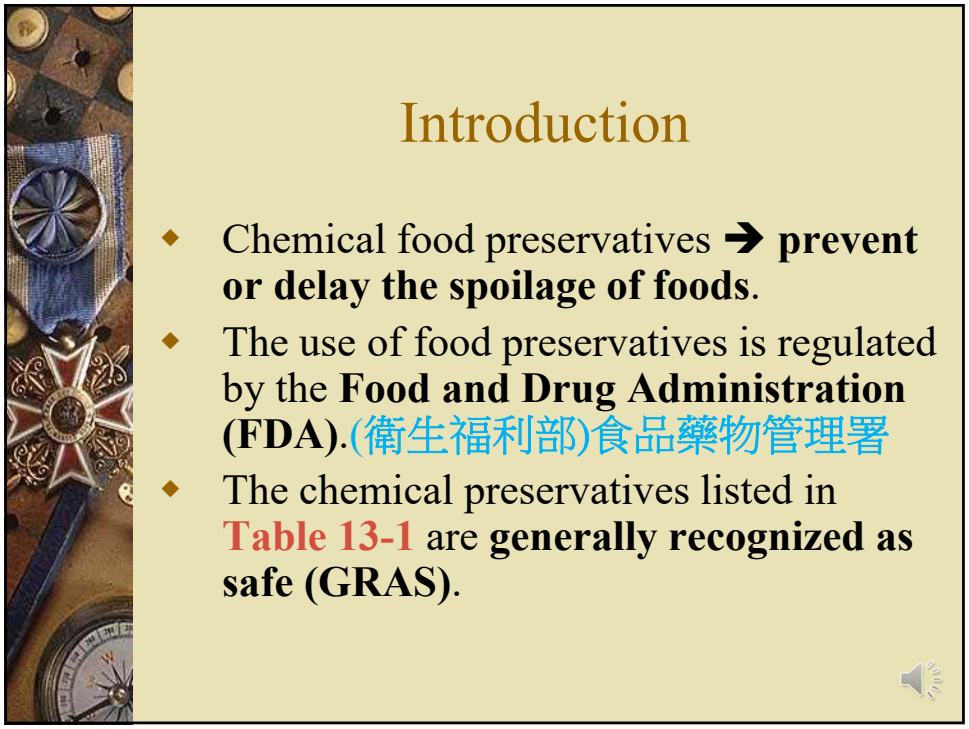
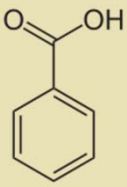
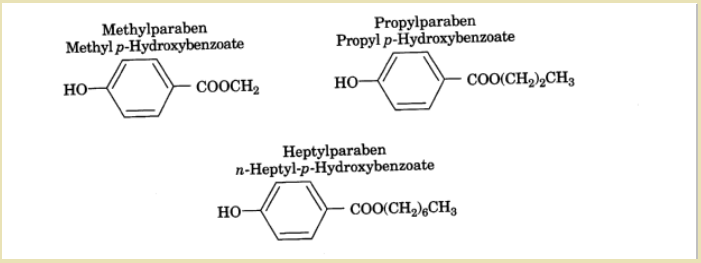

Chapter 13 Food Preservation with Chemicals and by Biocontrol
Tsuei-Yun Fang
節錄自Modern Food Microbiology, Jay, J. M., 7th ed.


Introduction
Chemical food preservatives ➔ prevent or delay the spoilage of foods.
The use of food preservatives is regulated by the Food and Drug Administration (FDA).(衛生福利部)食品藥物管理署
The chemical preservatives listed in Table 13-1 are generally recognized as safe (GRAS).

Benzoic Acid and the Parabens (苯甲酸及對羥苯甲酸酯類)



- Benzoic acid and its sodium salt along with the esters of *p*-hydroxybenzoic acid (parabens) are permissible in foods ≦ **0.1%**



Benzoic Acid and the Parabens

- Benzoic Acid


Margarine, pickle relishes, apple cider, soft drinks, tomato ketchup, salad dressings


- Parabens

Bakery products, soft drinks, pickles, salad dressings


Benzoic Acid and the Parabens

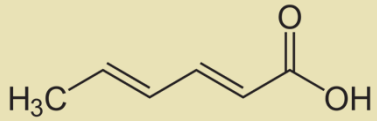
- antimicrobial activity ➔ **undissociated molecule** ➔ most **active at the lowest pH**
- The **pK of benzoate is 4.2** ➔**used in high-acid products (pH<4.0-3.7)** ➔ as a **mold and yeast inhibitor**
- The **pK for the parabens is around 8.47**. ➔ effective at **pH ≦ 8.0➔ as a mold and yeast inhibitor**

Benzoic Acid and the Parabens

Mode of action:

- **inhibit the cellular uptake of substrate molecules**
- The **undissociated form** is essential to the **antimicrobial activity** of **benzoate** as well as for other **lipophilics** such as **sorbate** and **propionate**.

Sorbic acid (已二烯酸;山梨酸)



- Sorbic acid is employed as a food preservative, usually as the calcium, sodium, or potassium salt. ➔are permissible in foods ≦ **0.2%**.
- More effective in **acid foods (3.7- 4.0< pH <4.6)** ➔used as **fungal inhibitors**➔works best ≦ **pH 6.0**
- more effective than sodium benzoate between pH 4.0 and 6.0

Sorbic acid

- **pK = 4.8**
- primarily effective against **molds and yeasts**
- also effective against ***Staphylococcus aureus*, salmonellae, coliforms, psychrotrophic** (嗜冷的) **spoilage bacteria** (especially the **pseudomonads**假單胞菌屬), and ***Vibrio parahaemolyticus*** 腸炎弧菌

Sorbic acid

- The resistance of the lactic acid bacteria to sorbate➔use as a fungistat in products that undergo lactic fermentations.
- The widest use of sorbates is as **fungistats (抑真菌劑)** in products such as cheeses, bakery products, fruit juices, beverages, salad dressings, and the like.

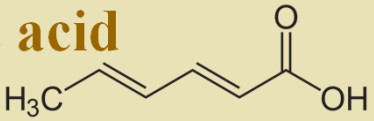




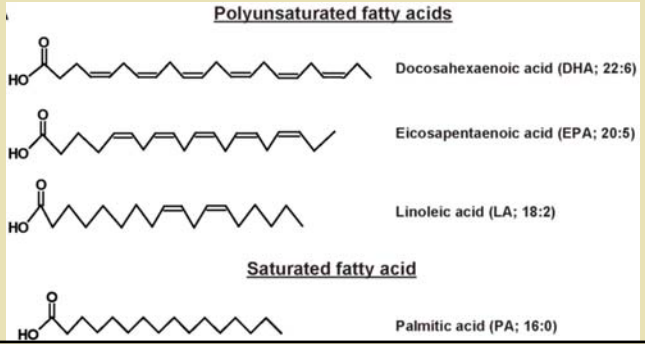
Sorbic acid

- use in **meat products** in combination with **nitrites**
- **no significant differences are found in botulinal protection.**
  - **120 ppm $NaNO_2$**
  - **40 ppm $NaNO_2$ and 0.26% potassium sorbate**
    - was proposed by the U.S. Department of Agriculture (USDA) in 1978 but postponed in 1979. ➔**"chemical"-like flavors** and producing prickly (刺痛的) mouth sensations

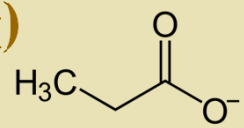
Sorbic acid



- With respect to safety, **sorbic acid is metabolized in the body to CO_2 and H_2O** in the same manner as **fatty acids** normally found in foods.



Propionates (丙酸)



- This acid and its calcium and sodium salts are permitted in breads, cakes, certain cheese, and other foods, primarily as a **mold inhibitor**.

- permissible in foods ≦**0.32%**
- The **pK is 4.87** ➔Active in **low-acid foods** (pH 4.6-6.8)

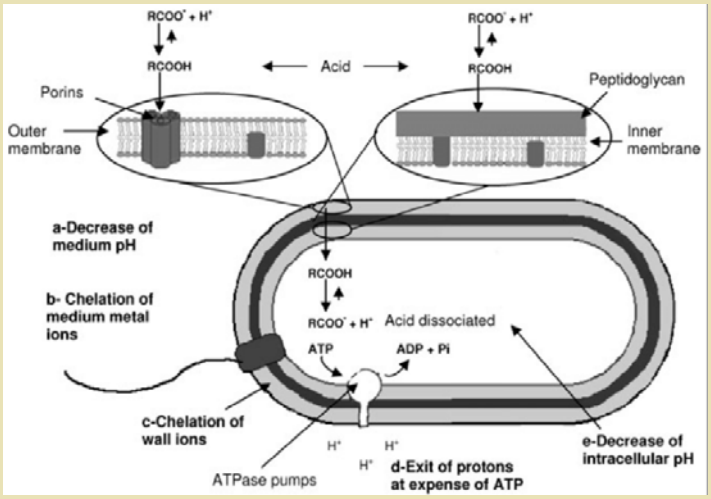
The antimicrobial mechanism of **lipophilic acids** (sorbate, benzoate, and propionate)

- Involves the **proton motive force** (PMF 質子驅動力)
- Hydrogen ions (protons) and hydroxyl ions are separated by the cytoplasmic membrane, **hydrogen ions (outside the cell) giving rise to acidic pH** and **hydroxyl ions (inside the cell) giving rise to pH near neutrality**.

The antimicrobial mechanism of **lipophilic acids** (sorbate, benzoate, and propionate)

- The membrane gradient represents **electrochemical potential** that the cell employs in the **active transport** of some compounds such as amino acids.
- After these weak lipophilic acids diffusing across the membrane, **the undissociated molecule ionizes inside the cell** and **lowers intracellular pH**. ➔ a **weakening of the transmembrane gradien**t such that amino acid transport is affected adversely

The antimicrobial mechanism of organic acids



COMPREHENSIVE REVIEWS IN FOOD SCIENCE AND FOOD SAFETY—Vol. 8, 2009

Sulfur Dioxide and Sulfite
(二氧化硫及亞硫酸鹽)

- Sulfur dioxide (SO_2) and the sodium and potassium salts of sulfite ($^{=}SO_3$,亞硫酸鹽), bisulfite ($^{-}HSO_3$,重亞硫酸鹽), and metabisulfite ($^{=}S_2O_5$,焦亞硫酸鹽) all act similarly.➔in foods **200-300 ppm**
- Sulfur dioxide is used in its gaseous or liquid form or salts on dried fruits, in lemon juice, molasses, wines, fruit juices, and others.




Sulfur Dioxide and Sulfite

- Because sulfites destroy thiamin, they are **not permitted in meats** or other foods recognizable as **sources of thiamine** (Vitamin B_1).
- The sulfites react with various food constituents including **nucleotides, sugars, disulfide bonds**, and others.
- Also used as an **antioxidant**.
- SO_2 is **bacteriostatic** against ***Acetobacter* spp.** (醋酸桿菌屬) and the **lactic acid bacteria** at low pH, concentrations of 100-200 ppm being effective in fruit juices and beverages. It is **bactericidal at higher concentrations**.

Sulfur Dioxide and Sulfite

- SO_2 also show **inhibition on spores of *Clostridium botulinum* (肉毒桿菌)** and **on the growth of salmonellae (沙門氏菌) and other Enterobacteriaceae (腸桿菌科).**

- **Molds** such as *Botrytis* (葡萄孢菌屬) can be controlled on grapes by periodic gassing with SO_2 and bisulfite can be used to **destroy aflatoxins** (黃麴毒素).
  - Both aflatoxins B_1 and B_2 can be reduced in corn.

Sulfur Dioxide and Sulfite

- The actual mechanism of action of SO_2 is not known.
  - One suggestion is that the **undissociated sulfurous acid** (亞硫酸 H_2SO_3) **or molecular SO_2** is responsible for the antimicrobial activity (Its greater effectiveness at low pH tends to support this).
  - The other suggestion is that the antimicrobial action is due to the **strong reducing power** that allows these compounds to **reduce oxygen tension** to a point below that at which aerobic organisms can grow or by **direct action on some enzyme system**.

Sulfur Dioxide and Sulfite

- SO_2 is also thought to be an **enzyme poison**, inhibiting growth of microorganisms by **inhibiting essential enzymes**.
  - Its **use in the drying of foods to inhibit enzymatic browning** is based on this assumption.
  - Because the sulfites are known to **act on disulfide bonds**, it may be presumed that certain essential enzymes are affected.

http://www.lilyfarm.idv.tw/cm/cfb/cfb.htm

Nitrites and Nitrates (亞硝酸及硝酸)

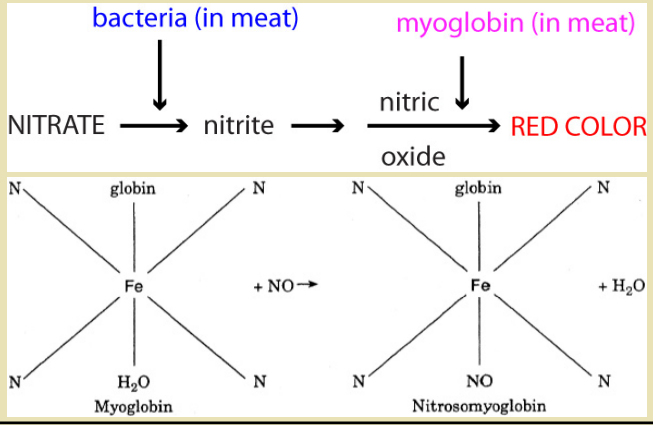
- Sodium nitrate ($NaNO_3$) and sodium nitrite ($NaNO_2$) are used in curing formulas for meats because they
  - **stabilize red meat color**,
  - **inhibit some spoilage and food poisoning organisms**,
  - contribute to **flavor development**.

Nitrites and Nitrates

- The **nitrite ion is more important than the nitrate** in preserved meats.
- Many bacteria can utilize nitrate as an electron acceptor to produce nitrite.
- **The nitrite ion is highly reactive ➔** serving as **both a reducing and an oxidizing agent.**
- In an acid environment, nitrite ion can be reduced to yield **nitric oxide (NO) ➔**important for **color fixation in cured meats**.

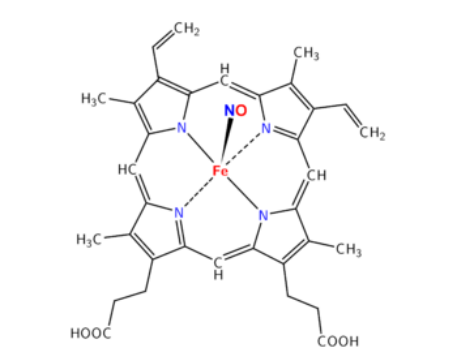
Nitrites and Nitrates

- **Nitric oxide reacts with myoglobin** (肌紅蛋白) under reducing conditions to produce the desirable **red pigment nitrosomyoglobin** (亞硝化肌紅蛋白).



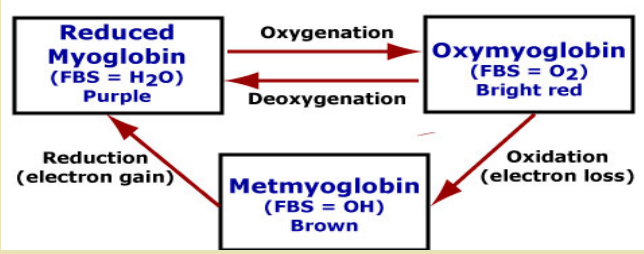
Nitrites and Nitrates

- Nitroso-



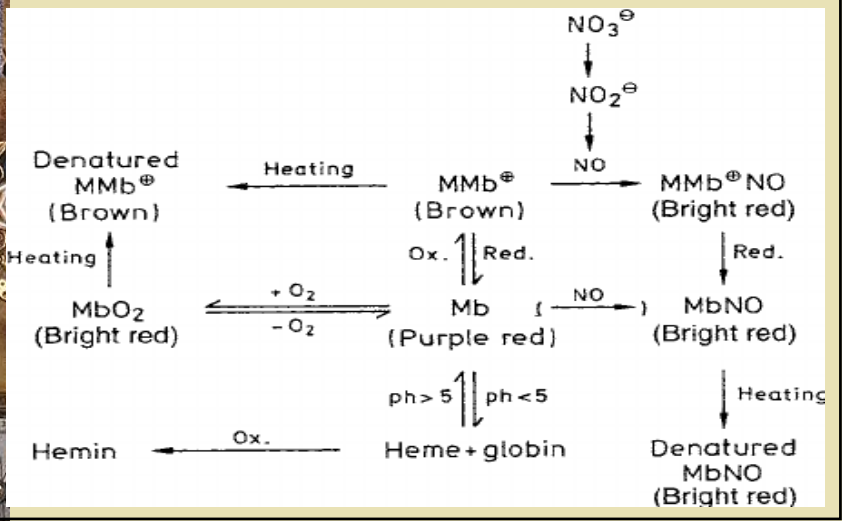
Nitrites and Nitrates

- When the meat pigment exists in the form of **oxymyoglobin (氧合肌紅蛋白)**, this compound can be oxidized to **metmyoglobin (**高鐵肌紅蛋白)(brown color).

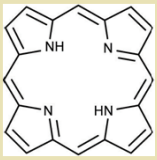


Nitrites and Nitrates

- Nitric oxide can reduce **metmyoglobin** to yield **nitrosomyoglobin**.



Nitrites and Nitrates



- Nitric oxide can react with other porphyrin(卟啉,紫質)-containing compounds such as catalase, peroxidases, cytochromes, and others ➔ some of its antibacterial effects against aerobes may be due to this action.
- The **antibacterial effect of NO_2 increases as pH is lowered** within the acid range➔ increase in the **undissociated HNO_2.**

Nitrites and Nitrates

Organisms Affected

- Although the greatest concern relative to nitrite inhibition is ***Clostridium botulinum***, the compound is antimicrobial for other organisms.
  - Against other clostridia (梭菌屬)
  - Against ***Staphylococcus aureus*** at high concentrations.
- It is **ineffective against Enterobacteriaceae** (including the salmonellae) and the **lactic acid bacteria**.

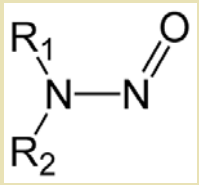
The Perigo effect/factor (皮瑞果因子)

- Produced from **heating of the culture medium with nitrite** ➔10 times more inhibitory to botulism than nitrite alone
- The Perigo factor does not form in filter-sterilized media. It develops in canned meat only when nitrite is present during heating. Once formed, it is not affected greatly by pH change.
- Questionable in cured meats

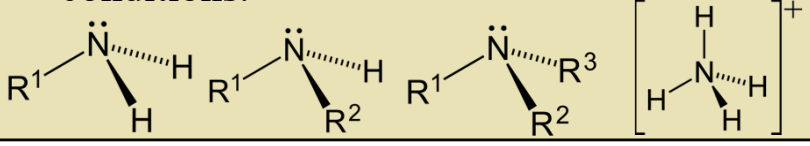
Nitrites and Nitrates

- The **antibotulinal activity of nitrite in cured meats** is of greater public health importance than the facts of color and flavor development.
  - **For color and flavor development,** initial nitrite levels as low as **15-50 ppm** are enough for various meat products.
  - The **antibotulinal effect requires at least 120 ppm** for bacon, comminuted cured ham, and canned, shelf-stable luncheon meat.

Nitrosamines (亞硝胺)



- When nitrite reacts with secondary amines, **nitrosamines** are formed, and many are known to be **carcinogenic.**
- Tertiary amines and quaternary ammonium compounds also yield nitrosamines with nitrite under acidic conditions.



Nitrite-Sorbate and Other Nitrite Combinations

- In an effort to reduce the potential hazard of nitrosamine formation in bacon, the USDA in 1978 reduced the input NO_2 level for bacon to **120 ppm** and set a **10-ppb** maximum level for nitrosamines.
- A proposal to allow the use of **40 ppm nitrite in combination with 0.26% potassium sorbate** for bacon was made in 1978 but rescinded a year later when taste panel studies revealed undesirable effects.

Nitrite-Sorbate and Other Nitrite Combinations

- Many studies have shown that **0.26% sorbate** in combination with **40 or 80 ppm nitrite** is effective in preventing botulinal toxin production. (Table 13-2)
- **Chelating Agent (螯合劑):** EDTA (500 ppm) and 8-hydroxyquinoline (200 ppm) have been evaluated as a **nitrite-sparing agent (亞硝酸鹽節約劑)**.

Mode of Action

- Nitrite inhibits *C. botulinum* by reacting with **iron-sulfur enzymes** such as ferredoxin and thus **preventing the synthesis of ATP from pyruvate**.
- The **phosphoroclastic system** of *C. sporogenes* (產孢梭菌) and *C. botulinum* is inhibited by **nitric oxide** ➔ accumulation of pyruvic acid in the medium.

Mode of Action

The phosphoroclastic reaction involves the breakdown of **pyruvate** with **inorganic phosphate and coenzyme A** to yield **acetyl phosphate**. In the presence of ADP, ATP is synthesized from acetyl phosphate with **acetate** as the other product.

$$\text{Pyruvate} + P_i \xrightarrow[\text{ferredoxin}]{\text{CoA}} \text{Acetyl-P} \xrightarrow{\text{ADP}} \text{ATP} + \text{Acetate}$$

Electrons are transferred first to **ferredoxin** and from ferredoxin to H^+ to form H_2 in a reaction catalyzed by **hydrogenase**. **Ferredoxin and hydrogenase** are iron-sulfur (nonheme) proteins or enzymes.

Mode of Action

- **Nitric oxide reacted with iron—sulfur complexes** to form iron-nitrosyl complexes. ➔ destruction of iron-sulfur enzymes such as ferredoxin.
- The resistance of the lactic acid bacteria to nitrite inhibition ←**lack ferredoxin**

Summary of Nitrite Effects

- When added to processed meats, nitrite has definite **antibotulinal effects**. It also forms desirable product **color** and enhances **flavor** in cured meat products.
- **The antibotulinal effect:**
  - **inhibition of vegetative cell growth**
  - **the prevention of germination and growth of spores**

Summary of Nitrite Effects

- Clostridia other than *C. botulinum* are affected in a similar manner. Whereas **low initial levels** of nitrite are adequate for **color and flavor** development, considerably **higher levels** **are necessary for the antimicrobial effects**.
- **When nitrite is heated in media or canned meats** ➔ produce **Perigo effect/factor** or Perigo inhibitor. It is not affected greatly by pH changes.

Summary of Nitrite Effects

- Measurable levels of nitrite decrease considerably during heating in meats and during postprocessing storage—more at higher storage temperatures than at lower.
- The antibotulinal activity of nitrite is interdependent with pH, salt content, temperature of incubation, and numbers of botulinal spores. Heat-injured spores are more susceptible to inhibition than uninjured.

Summary of Nitrite Effects

- Lactic acid bacteria are relatively resistant to nitrite.
- **Endospores remain viable in the presence of the antibotulinal effect** and will germinate when transferred to nitrite-free media.
- **Nitrite has a pK of 3.29** and exists as undissociated nitrous acid at low pH values. The maximum undissociated state and consequent **greatest antibacterial activity of nitrous acid (nitrite) are between pH 4.5 and 5.5.**

NaCl and Sugars

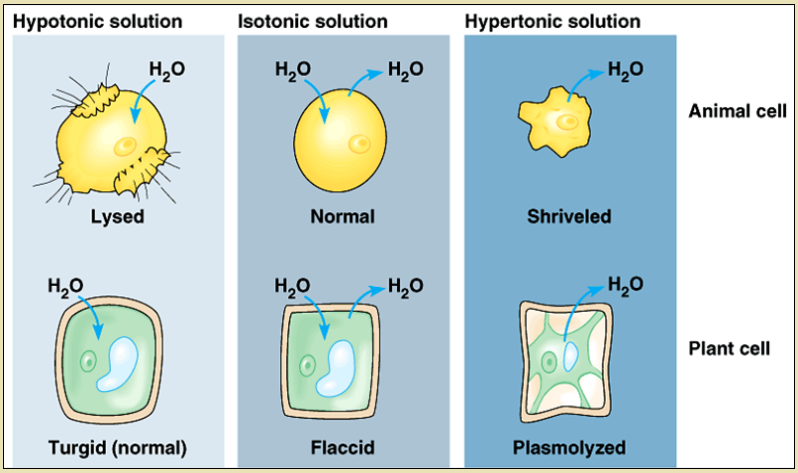
- At high concentrations, salt exerts a **drying effect** on both food and microorganisms.
- **0.85-0.90% salt** produces an **isotonic** condition for nonmarine microorganisms.
- When microbial cells are suspended in a **5% saline** solution➔ the cell is **plasmolysis**➔ growth inhibition and possibly death.

NaCl and Sugars

- When high concentrations of salt are added to fresh meats ➔ **both the microbial cells and those of the meat undergo plasmolysis (shrinkage)➔drying of the meat + inhibition or death of microbial cells**🡐 Enough salt must be used to effect **hypertonic** conditions.

- The inhibitory effects of salt are **not dependent on pH**. Most nonmarine bacteria can be inhibited by **20% or less of NaCl**, whereas some molds generally tolerate higher levels.

Hypotonic, Isotonic, and Hypertonic



biowithvanessa.wordpress.com

NaCl and Sugars

- Organisms that can grow in the presence of and **require high concentrations of salt** are referred to as **halophiles**; those that can withstand but not grow in high concentrations are referred to as **halodurics.**
- Sugars, such as sucrose, exert their preserving effect in essentially the same manner as salt. One of the main differences is in **relative concentrations**.
  - It **requires about six times more sucrose than NaCl** to effect the same degree of inhibition.

NaCl and Sugars

- The most common uses of sugars as preserving agents are in the making of **fruit preserves (fruit+sugar), candies, condensed milk**, and the like. ➔ **high concentrations of sugar** makes **water unavailable** to microorganisı

NaCl and Sugars

- Microorganisms differ in their response to **hypertonic concentrations of sugars**, with yeasts and molds being less susceptible than bacteria.
  - Some yeasts and molds can grow in 60% sucrose, whereas much lower levels inhibit most bacteria.
- Organisms that are able to grow in high concentrations of sugars are designated **osmophiles (嗜高滲透壓生物); osmoduric (耐高滲透壓)** microorganisms are those that are unable to grow but are able to withstand high levels of sugars.

Indirect Antimicrobials

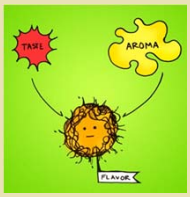
- The compounds and products in this section are multifunctional food additives.
- They are added to foods primarily for effects other than antimicrobial.
  - **Antioxidants**
  - **Flavoring agents (including spices and essential oils)**
  - **Phosphates**
  - **Medium-chain fatty acids and esters**

Antioxidants

- Although used in foods primarily to **prevent the autooxidation of lipids**, many phenol antioxidants (Table 13-8) have been shown to **possess antimicrobial activity** against a wide range of microorganisms.
- These compounds have been evaluated extensively as **nitrite-sparing agents** in processed meats and in combination with other inhibitors.

Flavoring Agents 調味劑

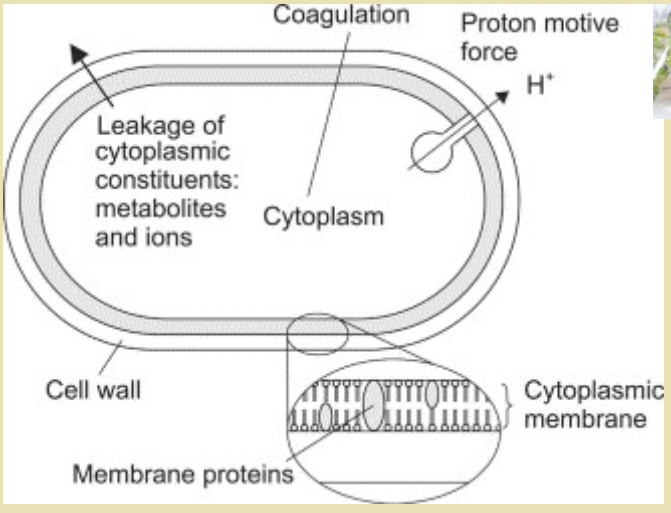
- Impart aromas and flavors to foods
- more **antifungal** than antibacterial.
- The **essential oils** and **spices** have received the most attention by food microbiologists
- One of the most effective flavoring agents is **diacetyl (雙乙醯)**, which imparts the **aroma of butter**. It is more effective against Gram-negative bacteria and fungi than against Gram-positive bacteria.



Flavoring Agents

- **Diacetyl inhibits arginine utilization** by **reacting with arginine-binding proteins** of Gram-negative bacteria.
- Many spices possess significant antimicrobial activity. Their antimicrobial activities are due to **specific chemicals** or **essential oils**.

Sites of action for essential oils

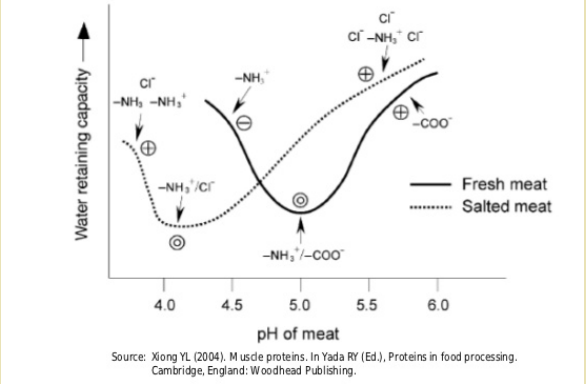


International Journal of Food Microbiology 94, 223-253

Phosphates

- Added to processed meats to increase their **water holding capacity**.
- Food-grade phosphates range from one P (e.g. trisodium phosphate, TSP) to at least 13 P (sodium polyphosphate).
- They possess antibotulinal activity, especially when combined with nitrites.
- Filter-sterilized phosphate preparations were more inhibitory than autoclaved ones.
- Active growth of cells was necessary for its bactericidal effect.

Salt - Effect on Water Holding Capacity



Source: Xiong YL (2004). Muscle proteins. In Yada RY (Ed.), Proteins in food processing. Cambridge, England: Woodhead Publishing.

- Phosphate are basics and raise the pH of meat
- Phosphate are anions (-) and may create a chloride effects on charges

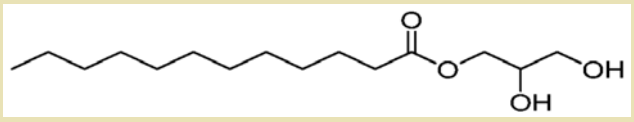
Medium-Chain Fatty Acids and Esters

- Acetic, propionic, and sorbic acids are **short-chain fatty acids** used primarily as preservatives.
- **Medium-chain fatty acids** are employed primarily as **surface-active** or **emulsifying agents**.
- The antimicrobial activity of the medium-chain fatty acids is best known from **soaps**, which are **salts of fatty acids**. Those most commonly employed are composed of **12-16 carbons**.

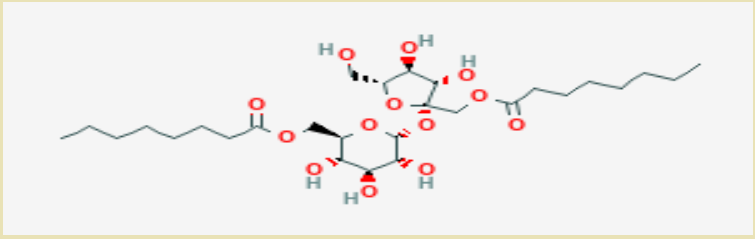
Medium-Chain Fatty Acids and Esters

- Fatty acids are effective primarily against **gram-positive bacteria** and **yeasts**.
- The **monoesters of glycerol** and the **diesters of sucrose** **are more antimicrobial** than the corresponding free fatty acids and better than sorbic acid and the parabens as antimicrobials.

Medium-Chain Fatty Acids and Esters



- **Monolaurin (glyceryl monolaurate單月桂酸甘油酯)** is the most effective of the glycerol monoesters, and **sucrose dicaprylate** is the most effective of the sucrose diesters.



Preservative system

- Using **combinations of chemicals**
- Consist of three compounds—monolaurin/EDTA/butylated hydroxyanisole (BHA), for example.
  - Although EDTA (可以螯著多種金屬離子) possesses little antimicrobial activity by itself, it makes gram-negative bacteria more susceptible by rupturing the outer membrane and thus enhances the effect of fatty acids or fatty acid esters.
  - Antioxidant BHA would exert effects against bacteria and molds and also serve as an antioxidant.
  - By use of such a system, **the development of resistant strains could be minimized** and the **pH of a food could become less important** relative to the effectiveness of the inhibitory system.

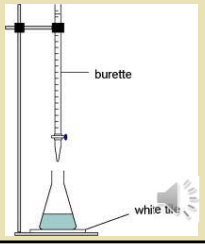
Acetic and Lactic Acids

- Acetic and lactic acids are widely employed as preservatives← **produced by lactic acid bacteria**. Products include pickles, sauerkraut (德國酸菜), and fermented milks.


- **The antimicrobial effects of organic acids** such as propionic and lactic is due to both the **depression of pH below the growth range** and **metabolic inhibition by the undissociated acid molecules**.

Acetic and Lactic Acids

- In determining the quantity of organic acids in foods, **titratable acidity** is of more value than pH alone, because the latter is a measure of hydrogen-ion concentration and **organic acids do not ionize completely**.
- In measuring titratable acidity, **the amount of acid that is capable of reacting with a known amount of base is determined**. ➔ ? volume of 0.1N alkali reacted/100g or 100 ml of original material



Acetic and Lactic Acids

- **The bactericidal effect of acetic acid :** When two species of *Salmonella* were added to an oil-and-vinegar-based salad dressing, the initial inoculum of 5 x 10^6 *S. enteritidis* could not be detected after 5 min nor could *S. typhimurium* be detected after 10 min.
- Organic acids are employed to **wash and sanitize animal carcasses** after slaughter to **reduce their carriage of pathogens** and **to increase product shelf life.**

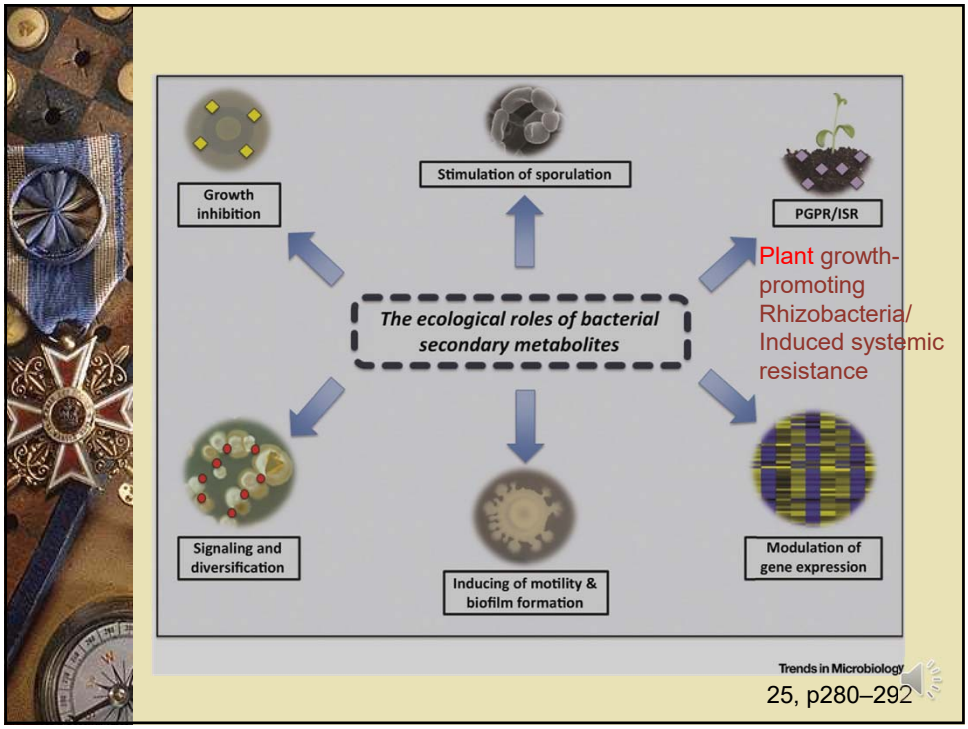
Salts of Acetic and Lactic Acids

- The sodium and potassium salts of acetic and lactic acids are widely used in food.
- **Sodium diacetate** ➔ used in bread and cakes ➔ prevent moldiness

- Extend shelf life of processed meats
- Against psychrotrophic pathogens *(Listeria monocytogenes*李斯特菌)
- Control growth of *Clostridium perfringens* (產氣莢膜梭菌)

Antibiotics

- **Antibiotics** are **secondary metabolites** produced by microorganisms that **inhibit or kill a wide spectrum of other microorganisms**.
  - Primary metabolites are considered essential to microorganisms for proper growth.
  - Secondary metabolites have no apparent significance to the growth or metabolism and are usually formed during the stationary phase of growth.
- Most antibiotics are **produced by molds and bacteria** of the genus ***Streptomyces*** (鏈絲菌屬), and a few by *Bacillus* (芽孢桿菌屬) and *Paenibacillus* (類芽孢桿菌屬).
- Many of the clinically useful agents are synthetic products.



Antibiotics (Table 13-9)

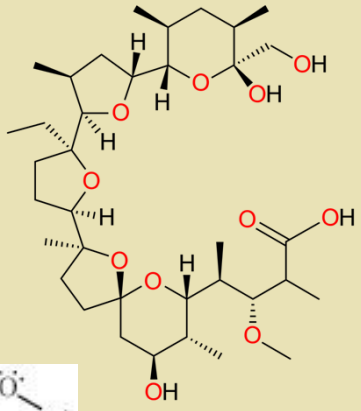
- **Several key considerations on the use of antibiotics as food preservatives** are summarized as follows:
  - The antibiotic agent **should kill, not inhibit**, the flora and should ideally **decompose into innocuous products** or **be destroyed on cooking** for products that require cooking.
  - The antibiotic **should not be inactivated** by food components or products of microbial metabolism.
  - The antibiotic **should not readily stimulate the appearance of resistant strains**.
  - The antibiotic **should not be used in foods if used therapeutically or as an animal feed additive**.

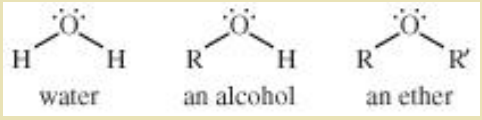
Monensin (孟寧素)

- Approved by FDA as a **cattle additive**, and it is used primarily to **improve feed efficiency in ruminants**.

- **Inhibits Gram-positive bacteria**
- Like nisin, monensin is an **ionophore** (離子載體, a lipid-soluble molecule that transports ions across a cell membrance) ➔ **destroys selective permeability of cell membranes**.

Monensin is a **polyether** antibiotic isolated from *Streptomyces cinnamonensis*.

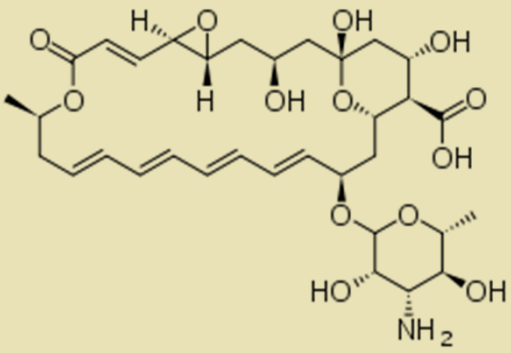




Natamycin (納塔黴素)

- Used as a **food preservative** with the consideration of the following facts:
  - **Against yeasts and molds** but not bacteria
  - Stimulates an unusually **low level of resistance** among fungi,
  - **Rarely involved in cross-resistance** among other antifungal polyenes
  - DNA transfer between fungi is less than bacteria.

Natamycin is classified as a macrolide polyene (巨環內酯多烯).

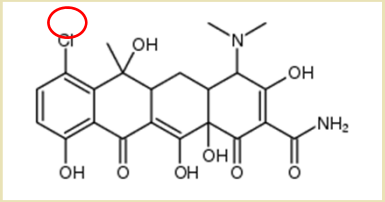


Natamycin

- Quite effective **against yeasts and molds** but not bacteria.
- Isolated from *Streptomyces natalensis* (納塔鏈黴菌).
- Natamycin appears to act in the same manner as other polyene antibiotics—by **binding to membrane sterols** and inducing **distortion of selective membrane permeability**.
  - Because bacteria do not possess membrane sterols, their lack of sensitivity to this agent is thus explained.

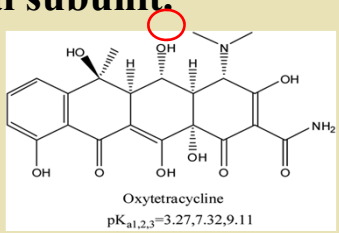
Tetracyclines (四環黴素)

- used to treat **bacterial infections**
- produced by the *Streptomyces*
- **protein synthesis inhibitor by associating with the 30S ribosomal subunit.**



Chlortetracycline (CTC)

氯四環素；金黴素



Oxytetracycline (OTC)

土黴素；氧四環素

Tetracyclines (四環黴素)

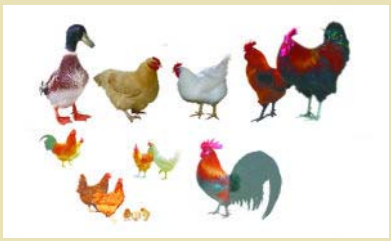
- Chlortetracycline (CTC) and oxytetracycline (OTC) delay bacterial spoilage of seafoods, poultry, red meats, vegetables, raw milk, and other foods.

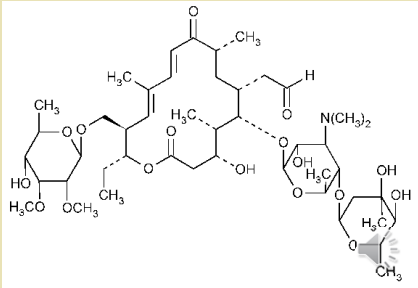



- CTC is generally more effective than OTC.
- The tetracyclines are both **heat sensitive** and **storage labile** in foods.
- They are used to **treat diseases** in humans and animals and are used also in **feed supplements**.

Tylosin (泰黴素)

- More inhibitory than nisin or subtilin.
- Used in **animal feeds** and also to **treat some diseases of poultry**
- Efective against **gram-positive** bacteria
- **Inhibits protein synthesis** by associating with the 50S ribosomal subunit.





Antifungal Agents for Fruits

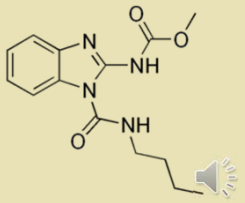
Table 13–10 Some Chemical Agents Employed to Control Fungal Spoilage of Fresh Fruits

Compound	Fruits
Thiabendazole	Apples, pears, citrus fruits, pineapples
Benomyl	Apples, pears, bananas, citrus fruits, mangoes, papayas, peaches, cherries, pineapples
Biphenyl	Citrus fruits
SO_2 fumigation	Grapes
Sodium-α-phenylphenate	Apples, pears, citrus fruits, pineapples

Antifungal Agents for Fruits

- **Benomyl** (苯菌靈) is applied uniformly over the entire **surface of fruits**. It can penetrate the surface of some vegetables and is used worldwide to control **crown rot** (冠腐病) and **anthracnose** (炭疽病) of bananas, and **stem-end rots** (果柄腐爛) of citrus fruits.

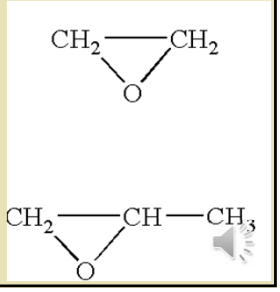




Ethylene and Propylene Oxides (環氧乙烷及環氧丙烷)

- Exist as **gases** and are employed as fumigants (燻蒸劑) in the food industry.
- Applied to dried fruits, nuts, spices, and so forth, primarily as **antifungal compounds.**
- are **alkylating agent** (烷基化劑).



Ethylene oxide

- Its antimicrobial activity is presumed to be related to **alkylation**.
  - In the presence of **labile H** atoms, the unstable three-membered ring (三元環) of ethylene oxide splits.
  - The H atom attaches itself to the oxygen, forming **a hydroxyl ethyl radical**, ·CH_2CH_2OH
  - ·CH_2CH_2OH attaches itself to the position in the organic molecule left vacant by the H atom. The **hydroxyl ethyl group blocks reactive groups** within microbial proteins, thus resulting in inhibition.
- Among the groups capable of supplying a labile H atom are **—COOH, —NH_2, —SH, and —OH**.

Ethylene oxide

- Affect endospores of *C. botulinum* by **alkylation of guanine and adenine components of spore DNA** .
- Used as a **gaseous sterilant** for flexible (柔軟的) and semirigid (半硬式的) containers for packaging aseptically processed foods.
- Similarly effective against vegetative cells and endospores.

BIOCONTROL

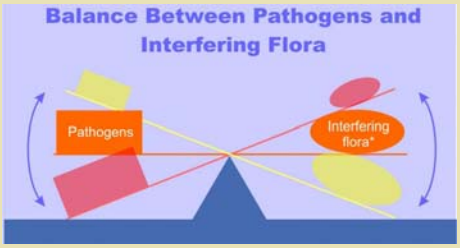
- **The use of one or more organisms to inhibit or control other organisms**.
- May require **a living organism** (such as lactic acid bacteria) or it may be effected by **indirect actions or agents** (such as the production of bacteriocins).
- Related to the food protection provided by the activities of the **lactic acid bacteria**, **bacteriocins**, **endolysins** (溶菌酶) , **bacteriophages**, and "**protective cultures**" in general.

Microbial Interference

- The general **nonspecific inhibition or destruction** of one microorganism by other members of the same habitat or environment.
- The mechanisms are not clear, but some observations are worthy of note.
  - The background biota needs to be **larger in a number of viable cells** than the organism to be inhibited.
  - The interfering biotas (生物群) generally **not homogeneous**, and the specific roles that individual species play are unclear.

Microbial Interference

- Possible explanations:
  - Competition of nutrients
  - Competition for attachment/adhesion sites
  - Unfavorable alteration of the environment
  - Combinations of these.



Lactic antagonism (乳酸拮抗作用)

- Lactic acid bacterium inhibits or kills closely related and food-poisoning and food spoilage organisms. ➔ The most effective method used was spraying the lactic organism on food surfaces
- Precise mechanisms are not clear. The possible factors identified are:
  - the production of antibiotics, H_2O_2, diacetyl, and bacteriocins
  - pH depression
  - nutrient depletion

Lactic antagonism (乳酸拮抗作用)

- **Protective cultures**: the microorganisms that can be found in or added to a food product to effect preservation/protection. e.g. Lactic acid bacteria.
- They should
  - present no health risks
  - provide beneficial effects on the product
  - have no negative impact on sensory properties (感官特質)
  - serve as "indicators" under abuse conditions

Nisin (乳酸鏈球菌素)

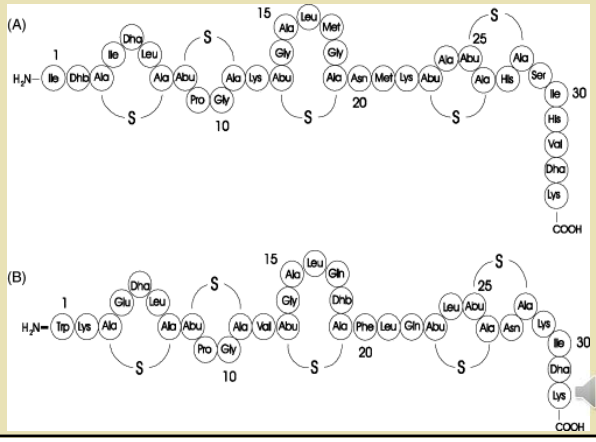
- Nisin is a **bacteriocin**.
- Like **antibiotics**, bacteriocins are chemical compounds **produced by microorganisms that inhibit or kill other microorganisms**.
- Unlike antibiotics, **bacteriocins inhibit or kill generally only closely related species** or **strains of the same species**.

Nisin (乳酸鏈球菌素)

- A polypeptide ➔ structurally related to subtilin.
- the most widely used antibiotic for food preservation

nisin

subtilin



Nisin (乳酸鏈球菌素)

- **Desirable properties as a food preservative** are the following:
  - a) **nontoxic**
  - b) produced naturally by ***Lactococcus lactis*** (乳酸乳球菌) strains
  - c) **heat stable** and **excellent storage stability**
  - d) **destroyed by digestive enzymes**
  - e) **not contribute to off-flavors or off-odors**
  - f) has a **narrow spectrum of antimicrobial activity**

Nisin (乳酸鏈球菌素)

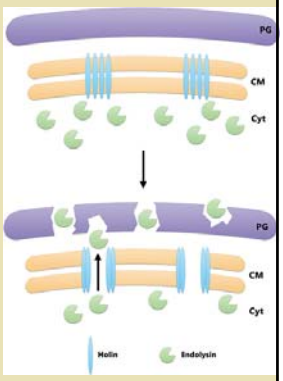
- **Effective against Gram-positive** bacteria, primarily **sporeformers**, and ineffective against fungi and gram-negative bacteria.
- **Mode of action**
  - nisin and subtilin appear to be identical.
  - **react with cytoplasmic membranes and result in pore formation**.
  - The formation of pore causes **the loss of accumulated amino acids** and **the inhibition of amino acid transport**.

Subtilin (枯草桿菌素)

- **Structurally similar to nisin**
- Produced by ***Bacillus subtilis***.
- Like nisin, it is effective against **gram-positive bacteria**, is **stable to acid**, and possesses enough **heat resistance** (121 ˚C, 30-60 min).
- Effective in canned foods at levels of **5-20 ppm** in **preventing the outgrowth of germinating endospores.**

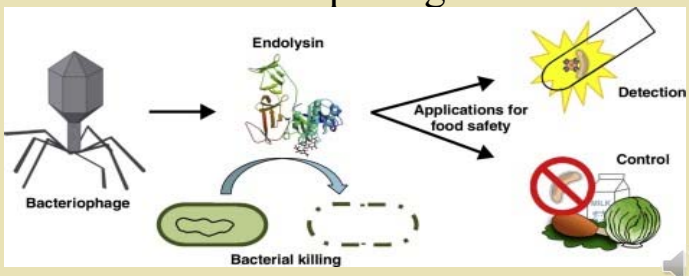
ENDOLYSINS (内溶素)

- **To release newly formed bacteriophages** from their host cell, two small hydrophobic proteins were used:
  - **Holins (穿孔素) disrupt the cell membrane and form holes** through which endolysins can pass.
  - **Endolysins** target bonds in the **peptidoglycan**, and upon the **destruction of this cell barrier**, the phage progeny is released.



ENDOLYSINS

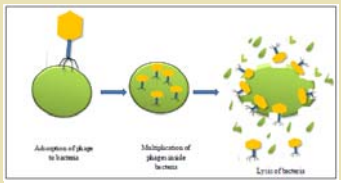
- In addition to their **lysis of bacterial cells from within**, endolysins from Gram-positive bacteria phages also **lyse bacteria exogenously**.
- Phage endolysin can control some foodborne bacterial pathogens.



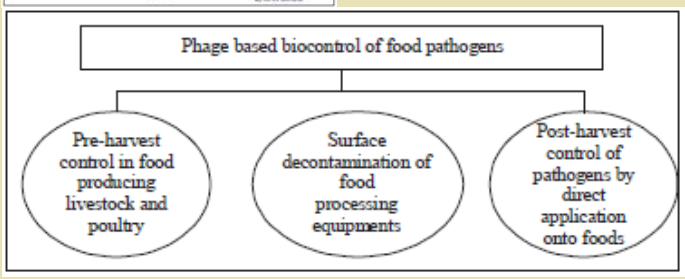
Current Opinion in Biotechnology 2016, 37:76–87

BACTERIOPHAGES AS BIOCONTROL AGENTS

- Lytic phages can destroy their specific host cells in foods.
- The true potential need more research

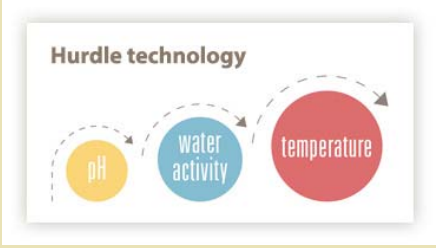


Asian Journal of Animal and Veterinary Advances 10 (11): 708-723, 2015



THE HURDLE CONCEPT

- Multiple factors or techniques are employed to effect the control of microorganisms in foods.
- Barrier technology, combination preservation, and combined methods



http://foodingredients.treetop.com/

- **愛吃燒烤、香腸，17歲男大腸癌離世**(2015-4-1優活健康網)
  - 香腸和臘肉都有亞硝酸鹽，進入人體會產生致癌物
  - 肉類經高溫燒烤產生致癌物
  - 建議同學們少吃，**要多吃蔬果多運動**
- **氣喘過敏頻發作？可能是香腸、火腿吃太多！**（華人健康網 2017-11-10）
  - 目前仍不清楚加工肉品造成氣喘惡化的確切原因，但可能與加工肉品含有大量的亞硝酸鹽、鹽分、脂肪有關係
  - 攝取加工肉品頻率最高的氣喘患者，症狀惡化的機率比食用頻率最低的患者高出76%