

防腐劑和抗氧化劑及 其在食物內的功能

Preservatives and Antioxidants Their Functional Mechanisms in Food

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定義 *

Definition *

- 防腐劑指任何能抑制、減慢或遏止食物的發酵、發酸或其他變壞過程或能掩蓋食物腐爛徵狀的物質

Preservative means any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other deterioration of food or of masking any of the evidence of putrefaction

- 抗氧化劑指任何可延遲、減慢或防止食物因氧化作用而發出酸敗氣味或味道變壞的物質

Antioxidant means any substance which delays, retards or prevent the development in food of rancidity or other flavour deterioration due to oxidation

*根據《食物內防腐劑規例》(第132BD章)

*According to the Preservatives in Food Regulations, Cap. 132BD, HK Laws

國際編碼系統內食物添加劑 的作用類別*

Functional Classes of Food Additives in International Numbering System (INS)*

作用類別 (供標籤食物之用) Functional Classes (for labelling purposes)	定義 Definition	細類 (技術用途) Sub-Classes (technological functions)
防腐劑 Preservative	防止由微生物引致的變壞過程，從而延長食物的保質期 Prolongs the shelf-life of a food by protecting against deterioration caused by microorganisms	抗菌防腐劑、抗真菌劑、噬菌體 控制劑、化學抑生劑／酒類催陳 劑、消毒劑 Antimicrobial preservative, antimycotic agent, bacteriophage control agent, chemosterilant/ wine maturing agent, disinfection agent
抗氧化劑 Antioxidant	防止由氧化作用引致的變壞過程(例如脂肪酸敗和變 色)，從而延長食物的保質期 Prolongs the shelf-life of foods by protecting against deterioration caused by oxidation, such as fat rancidity and colour changes	抗氧劑、抗氧增效劑、螯合劑 Antioxidant, antioxidant synergist, sequestrant

* 與《食物及藥物(成分組合及標籤)規例》(第132W章)附表3 — 預先包裝食物的標記及標籤(2004年第85號法律公告)第5節所指的添加劑作用類別相同

* Identical with the functional classes of additive for the purpose of sub-paragraph (5) of Schedule 3 – Marking and Labeling of Prepackaged Foods in CAP 132W Food and Drugs (Composition and Labeling) Regulations of Hong Kong Laws (L.N. 85 of 2004)

D.I. CRISPY HONEY SAUSAGE 龍堡脆皮蜜糖腸

INGREDIENTS: pork, chicken, water, sugar, soy protein, starch, salt, emulsifier(452), natural flavouring, flavour enhancer(621), antioxidant(316), honey, acidity regulator(330), preservative(250), color(12)

配料: 豬肉, 雞肉, 水, 糖, 大豆蛋白, 澱粉, 食鹽, 乳化劑(452), 天然調味料, 增味劑(621), 抗氧化劑(316), 蜜糖, 酸度調節劑(330), 防腐劑(250), 色素(129)

USE BY (此日期前食用): DD日MM月YY年17/10/06



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240g
(NET WEIGHT)

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E621 穀氨酸一鈉

E316 異抗壞血酸鈉

E129 誘惑紅AC

E250 亞硝酸鈉

E452

多磷酸鹽類

(i) 多磷酸鈉類

(ii) 多磷酸鉀類

(iii) 多磷酸鈣鈉

(iv) 多磷酸鈣類

E330 檸檬酸

E472e 二乙酰酒石酸甘油酯和脂肪酸甘油酯

E920 L-半胱氨酸

七穀方包 7 Grain Bread

成分：小麥粉(含有麩質的穀類)，水，7穀粉(含有麩質的穀類)，人造牛油，奶粉，鹽，麵包改良劑(小麥粉(含有麩質的穀類)，乳化劑(E472e)，麵粉處理劑(E920)，抗氧化劑(E300))，酵母，防腐劑(E282)

Ingredients: Wheat Flour (Cereal Containing Gluten), Water, 7 Grain Mix (Cereals Containing Gluten), Margarine, Milk Powder, Salt, Bread Improver (Wheat Flour (Cereal Containing Gluten), Emulsifier (E472e), Flour Treatment Agent (E920), Antioxidant (E300)), Yeast, Preservative (E282)

E282 丙酸鈣

E300 抗壞血酸

歐洲聯盟准許的食物添加劑(網址：
<http://www.foodlaw.rdg.ac.uk/additive.htm>)

添加劑／防腐劑安全嗎？

Are Additives/Preservatives safe?

- 聯合國糧食及農業組織／世界衛生組織聯合食物添加劑專家委員會就食物添加劑進行嚴格的安全評估

Vigorous safety assessment of food additives by JECFA

- 毒物評估及測試

Toxicological evaluation and testing

- 每日可攝入量

Acceptable daily intakes (ADIs)

- 建議安全用量

Recommended safety level of use

- 通過安全認證(GRAS)

General Recognized As Safe (GRAS)

四川泡菜防腐劑超標八成

【明報專訊】內地傳媒揭發四川問題泡菜後，本報早前發現銅鑼灣一間食肆有售四川泡菜，食物環境衛生署到該店取走泡菜化驗，昨證實四川成都出產的「人人牌好廚佳泡酸菜」，含有的防腐劑苯甲酸鈉（benzoic acid）超出法例標準八成。過量進食苯甲酸鈉會引發哮喘、鼻膜炎病者發病。

食環署早前從兩間店舖取走本地有售的四川泡菜樣本，其中一間銅鑼灣店舖，是由本報提供資料。經化驗後，食環署證實銅鑼灣店取得的樣本，防腐劑苯甲酸鈉的含量為百萬分之四百四十，較法例規定百萬分之二百五十高出近八成，而其他化驗項目如亞硝酸鈉及敵敵畏等則沒有超標。

過量進食引發哮喘

食環署發言人認為超標情況未算嚴重，對人體產生不良影響機會很低，該分量亦低於內地標準百萬分之五百及食物法典委員會規

定的百萬分之一千。

發言人表示會跟進市面其他泡菜，另一個泡菜樣本未有結果。他指苯甲酸鈉常用於汽水、醃菜、香腸等食品。進食過量苯甲酸鈉，會令哮喘、鼻膜炎或蕁麻疹患者引致病發或過敏反應。

本報記者向該零售店查詢，負責人得悉超標結果後，稱決定不再入貨。他指過去是滿足食客要求，透過內地店舖直接購買泡菜回港售賣，貨量一向不多。

本報早前在銅鑼灣一店舖找到四川出產的泡菜，食環署經化驗，證實該種泡菜防腐劑苯甲酸鈉含量超標。

（資料圖片）



14 May 2004 Ming Pao A8

八仙果質檢分5類標準亂

有多種標準的涼果一覽

食品名稱

八仙果



可歸類為多少個類別

5個，「蜜餞果皮」、「裹糖屑」、「乾果」、「醃製橄欖」、「醃製食品」

所涉及防腐劑

二氧化硫

苯甲酸

所涉及標準

100、100、
2000、100、
100

0、1000、0、
250、250

話梅



3個，「裹糖屑」、「醃製食品」、「梅脯」

二氧化硫

苯甲酸

100、100、
2000

1000、250、
0

芒果乾



2個，「裹糖屑」、「乾果」

二氧化硫

苯甲酸

100、2000

0、1000

註：二氧化硫及苯甲酸含量單位：ppm（百萬分之一）

TABLE 8.4 Types and properties of antimicrobial substances used in the food processing industry. *Salts of acids, such as sodium acetate, calcium citrate, sodium benzoate, calcium propionate, potassium sorbate, and sodium nitrite all have antimicrobial properties, as does sodium chloride and sucrose. Sulfur dioxide (SO₂) can be derived from a variety of sulfur additives such as bisulfite, and can create a multitude of effects in foods.*

Antimicrobial Compound	Effective Against	Some Food Applications
acetic acid salt (sodium acetate)	bacteria, molds	bread; as vinegar in pickled products and mayonnaise
benzoic acid salt (sodium benzoate)	molds and yeasts	ketchup, jams, syrups, orange juice products, syrups
Na and Ca propionate	bacteria, molds	bread, cake, cheese foods
potassium sorbate	bacteria, molds	breads
salt (sodium chloride)	bacteria, yeast, mold	baked products, canned foods, meats
sodium nitrite	<i>Clostridium</i>	cured meat products
sodium benzoate	molds and yeasts	condiments, fruit juices
sugar (sucrose)	bacteria, yeast, mold	baked products, fruit preserves, meats
sulfite, sulfur dioxide (SO ₂)	bacteria, yeast, mold	dried fruit, lemon juice, molasses, wines

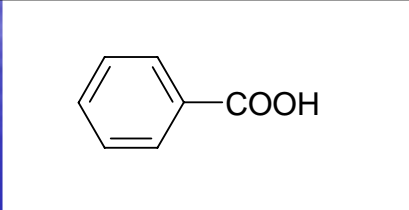
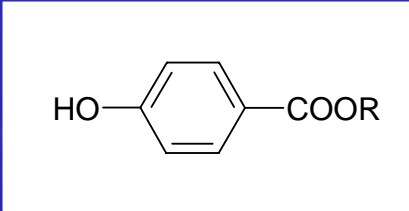
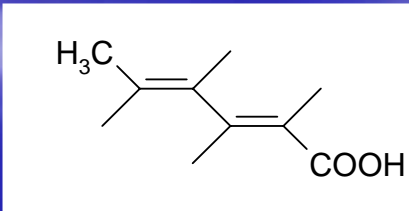
表8.4 用於食物加工業的抗菌物質類別與特質

正如氯化鈉和蔗糖，乙酸鈉、檸檬酸鈣、苯甲酸鈉、丙酸鈣、山梨酸鉀、亞硝酸鈉等酸鹽類全部均具有抗菌特質。二氧化硫可透過亞硫酸氫鹽等各種硫添加劑衍生，並能在食物中產生多種作用。

抗菌化合物	針對微生物	應用在食物的例子
乙酸鹽(乙酸鈉)	細菌、霉菌	麵包、在醃漬食品及蛋黃醬中作醋
苯甲酸鹽(苯甲酸鈉)	霉菌及酵母菌	茄汁、果醬、糖漿、橙汁飲品、糖漿
丙酸鈉及丙酸鈣	細菌、霉菌	麵包、蛋糕、芝士食品
山梨酸鉀	細菌、霉菌	麵包
鹽(氯化鈉)	細菌、酵母菌、霉菌	烘製食品、罐頭食品、肉類
亞硝酸鈉	芽孢梭菌屬細菌	經加工處理的肉類製品
苯甲酸鈉	霉菌及酵母菌	辛辣調味品、果汁
糖(蔗糖)	細菌、酵母菌、霉菌	烘製食品、經加工的水果、肉類
亞硫酸鹽、二氧化硫(SO ₂)	細菌、酵母菌、霉菌	乾果、檸檬汁、糖蜜、酒

具抗菌作用的短鏈酸衍生物的特點

Characteristics of Antimicrobial short-chain acid derivatives

名稱 Name		pKa	未離解酸的狀態 Undissociated acid form	實際的酸鹼值幅度 Effective pH range	針對微生物 Target microbes	應用 Applications
英文 English	中文 Chinese					
Benzoic Acid	苯甲酸	4.2		2.5 – 4.0	細菌 bacteria	強酸食物、果汁飲品、醃漬食物、沙律調味料、果醬 High-acid foods, fruit drinks, pickles, salad dressings, jams
Parabens	對羥基苯甲酸甲酯	8.47		酸性及鹼性 Acidic & alkaline	酵母菌及霉菌、革蘭氏陽性細菌 Yeasts & molds, gram positive bacteria	水果蛋糕、汽水、魚產品、香精 Fruit-cakes, soft drinks, fish products, flavor extracts
Sorbic acid	山梨酸	4.8		酸性 acidic	酵母菌及霉菌 Yeasts & molds	酒、果汁、乾果、茅屋芝士、肉類、魚產品 Wine, fruit juice, dried fruit, cottage cheese, meat, fish products

防腐劑

二氧化硫及亞硫酸鹽

Preservatives

Sulfur dioxide and sulfites

- 抗菌作用：二氧化硫穿過細胞膜活化腺苷三磷酸酶(ATPase)系統，消耗腺苷三磷酸，令細胞死亡

Antimicrobial action: penetration of SO_2 across cell membrane to activate ATPase system, depleting ATP that resulted in cellular death

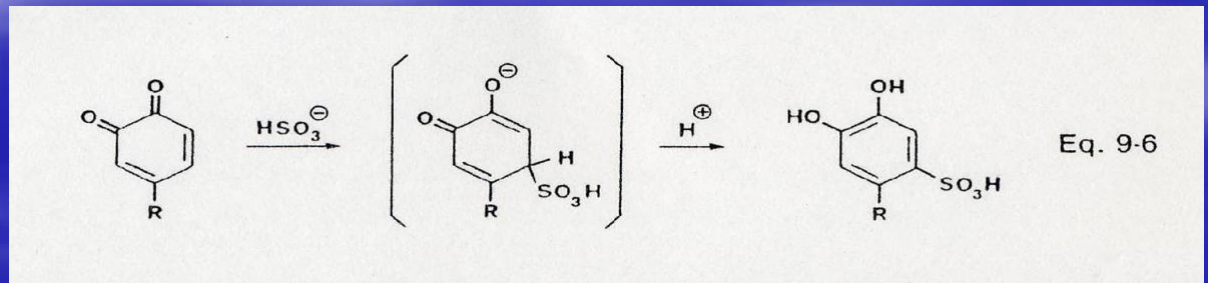
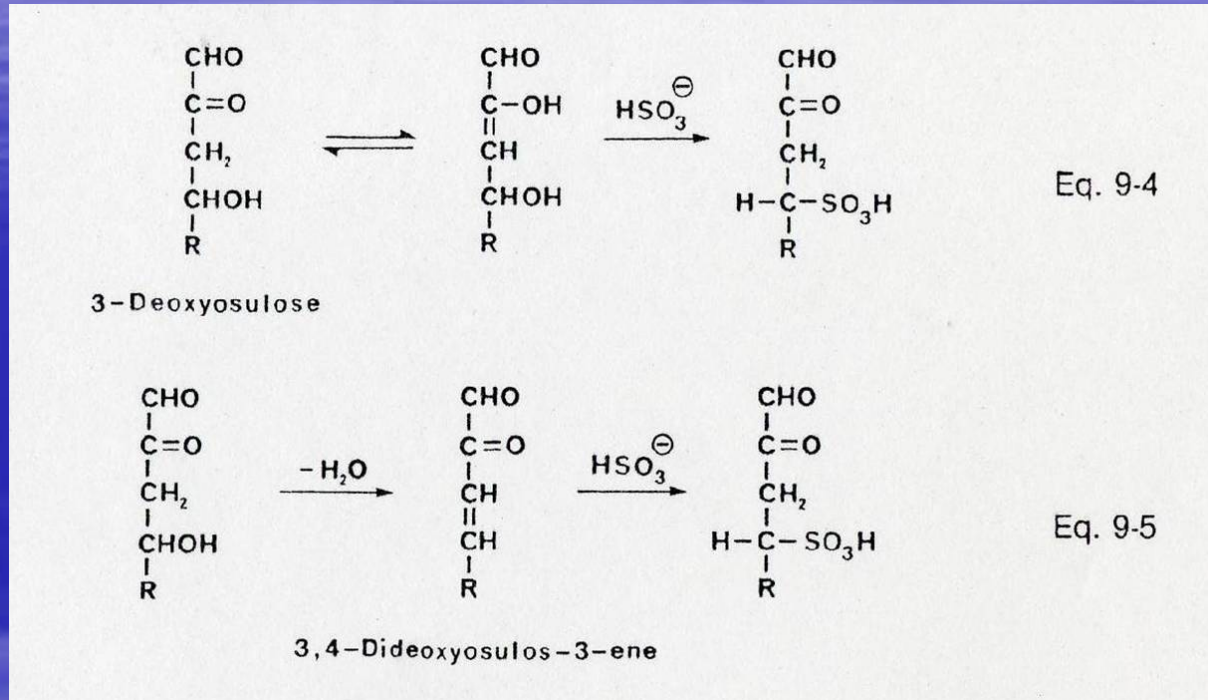
- 在酒類用作防腐劑：只會抑制霉菌和細菌，而不會抑制人工培植的酵母菌

Application as preservatives (in wines): preferential inhibition of molds and bacteria but not cultured yeast

防腐劑
 二氧化硫及亞硫酸鹽
 Preservatives
 Sulfur dioxide and sulfites

■ 用作抗氧化劑：抑制非酶褐變及酶促褐變 [化學方程式 9-4至9-6]

Application as antioxidant: inhibition of nonenzymatic and enzymatic browning [equations 9-4 to 9-6]



防腐劑

二氧化硫及亞硫酸鹽

Preservatives

Sulfur dioxide and sulfites

透過二氧化硫(可逆轉的)及高溫、提高酸鹼值和低糖水平(高水活性)等加工處理狀況，減退花色素甙色素

Discoloration of anthocyanin pigments by sulfur dioxide (reversible) and processing conditions including high temperature, increased pH and low sugar level (high Aw)

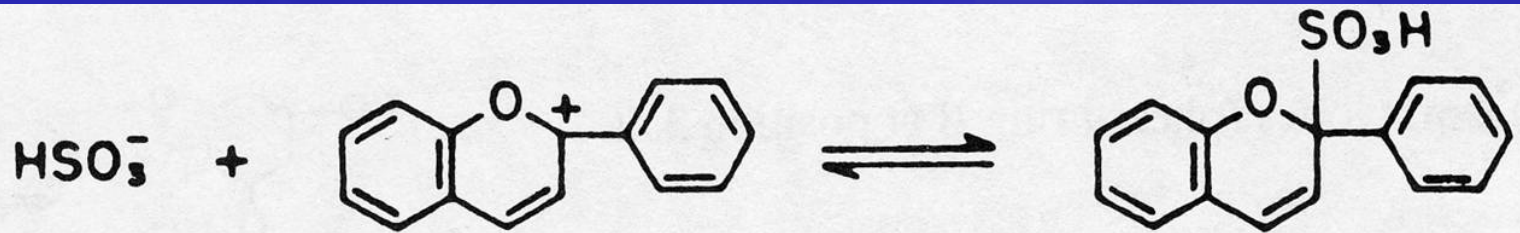


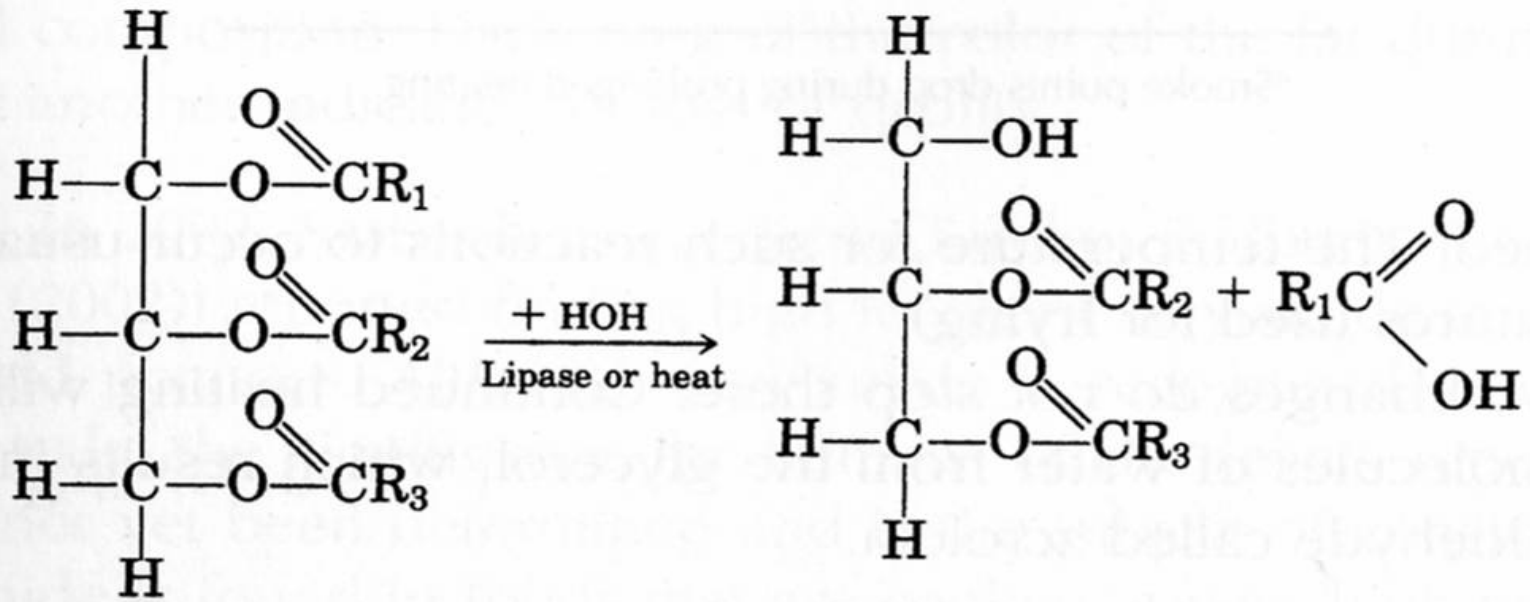
Figure 6-26 Reaction of Bisulfite with the Anthocyanin Carbonium Ion

水解酸敗

Hydrolytic Rancidity

游離脂肪酸在脂質和水遇上催化劑產生反應而形成，又或透過脂肪酶作用形成

Formation of free fatty acids caused by either the reaction of lipid and water in the presence of a catalyst or by the action of lipases



Lipolysis

氧化酸敗

Oxidative rancidity

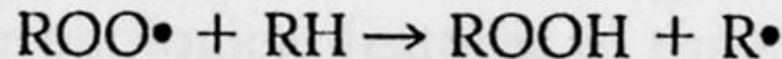
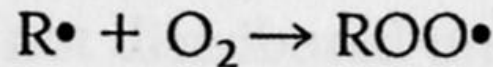
複雜的脂質氧化過程包括三個階段：
起始階段、加長階段及終止階段

Complex lipid oxidation processes involving three phases: initiation, propagation, and termination

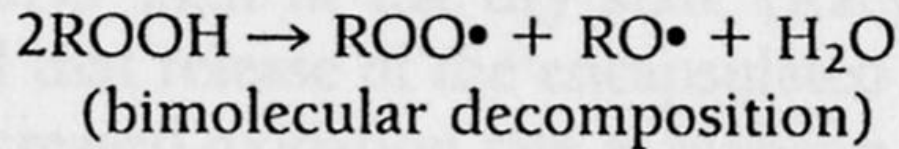
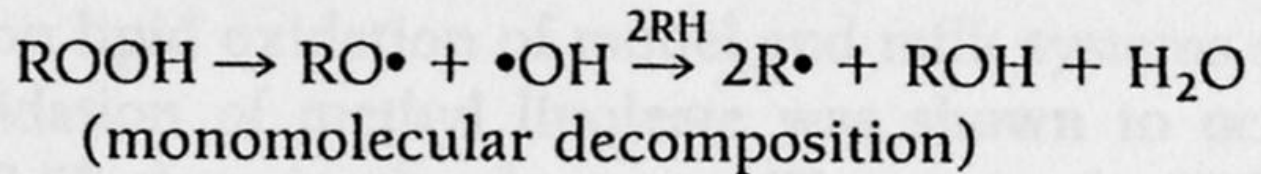
Initiation



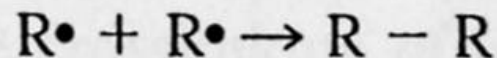
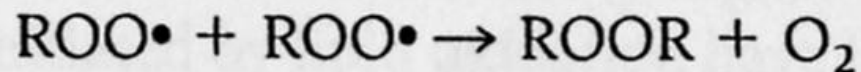
Propagation



Branching



Termination



抗氧化劑(酚類)

Antioxidants (Phenolics)

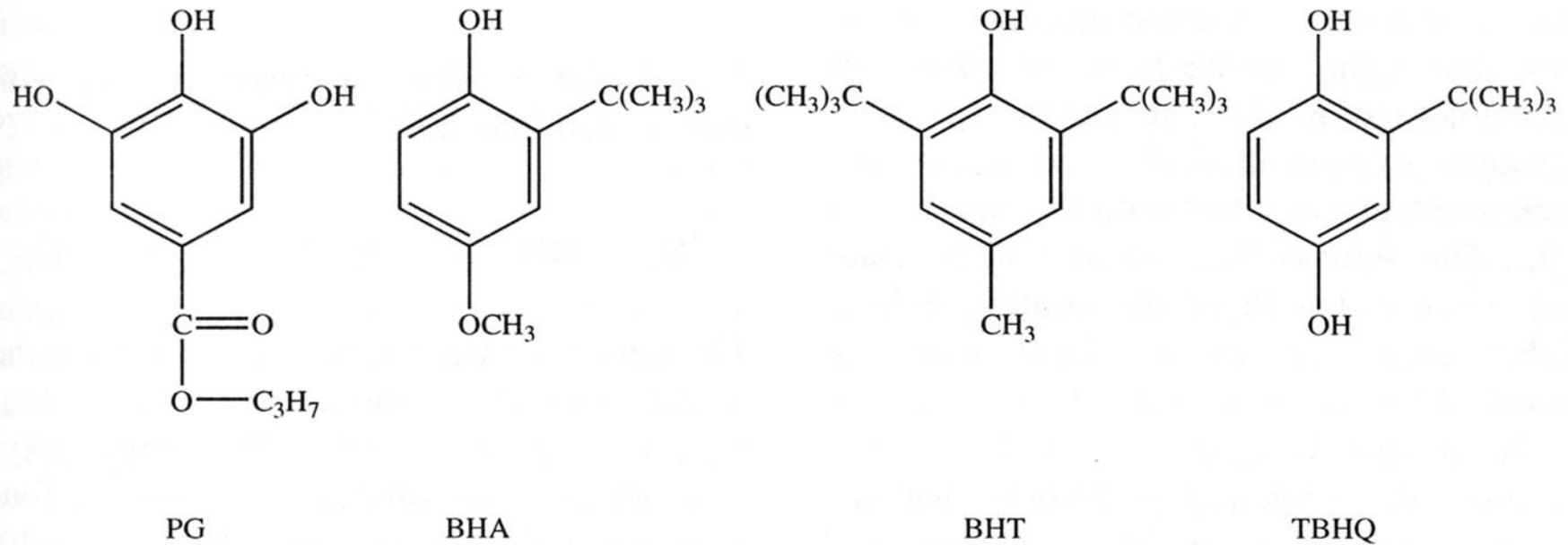
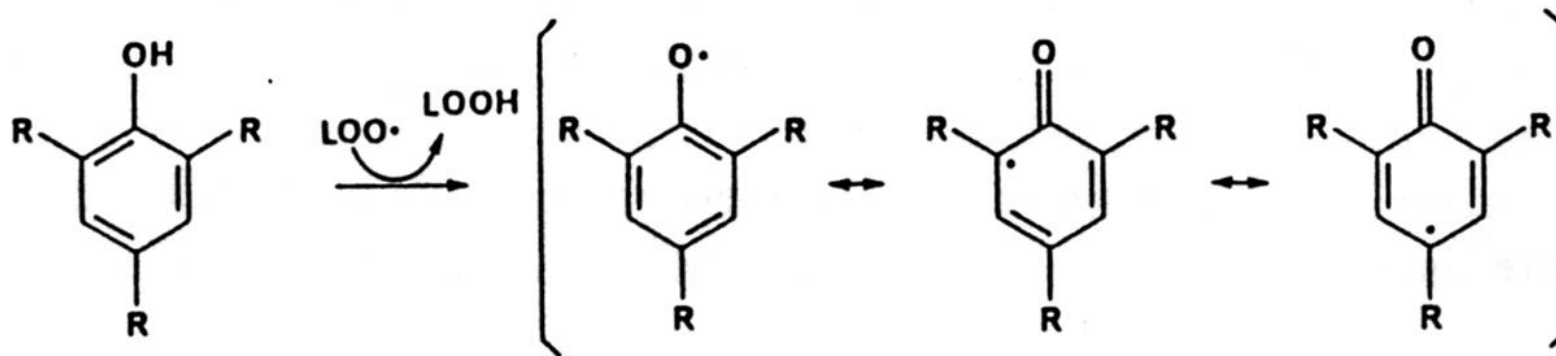


Figure 2-18 Structure of Propyl Gallate (PG), Butylated Hydroxyanisole (BHA), Butylated Hydroxy Toluene (BHT), and Tert-Butyl Hydroquinone (TBHQ)

酚類抗氧化劑的反應機理

Reaction mechanism of phenolic antioxidants

1-45.1



Eq. 1-45

1-45.2

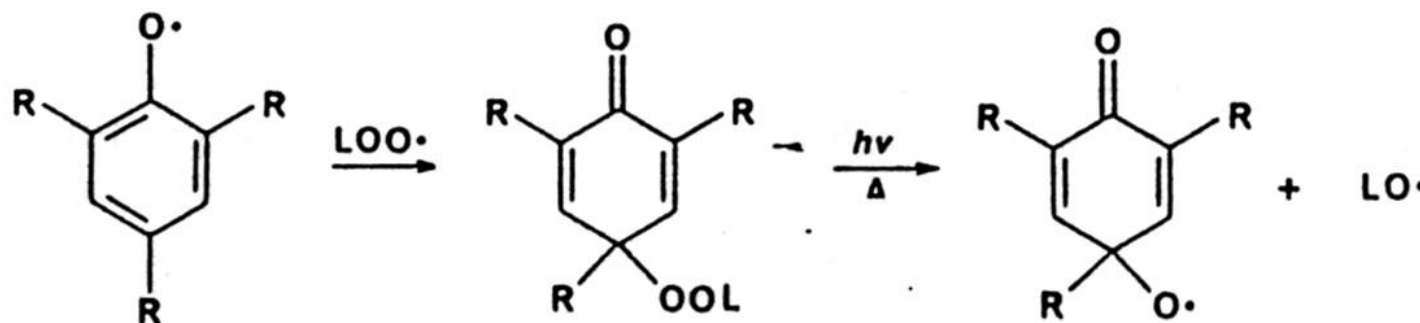


Table 11.2 Some Chemical and Natural Antioxidants and Their Uses

Antioxidant	Action/Characteristics	Applications
EDTA ^a	Slow oxidation by metals	Vegetable oil-containing foods
Citric acid	Chelate metals in meat	Meats
Phosphates	Complexes with metal ions	Meats
BHA ^b	Survives baking and frying	Foods containing animal fats
BHT ^c	Survives baking and frying	Foods containing animal fats
TBHQ ^d	Survives frying temperatures	Vegetable oil-containing foods
Propyl gallate	Heat sensitive	Vegetable oil-containing foods
Tocopherols	Can add with vitamin C, etc.	Foods containing animal fats
Rosemary	Delay free radical formation	Meats, irradiated ground beef
Thyme, oregano	Avoid warmed over-flavor	Comminuted poultry, meat, fish
Dried plums	Retard lipid oxidation	Sausage and other ground meat
Honey	Darker is more effective	Ground turkey

^aEthylenediaminetetraacetic acid

^bButylated hydroxyanisole

^cButylated hydroxytoluene

^dTertiary-butylhydroquinone

表11.2 化學和天然抗氧化劑及其用途

抗氧化劑	作用／特點	應用
乙二胺四乙酸	減慢金屬引致的氧化作用	含菜油的食物
檸檬酸	使肉類中的金屬生成螯合物	肉類
磷酸類	與金屬離子絡合	肉類
丁基羥基茴香醚	能抵受烘焙及煎炸過程	含動物脂肪的食物
二丁基羥基甲苯	能抵受烘焙及煎炸過程	含動物脂肪的食物
特丁基對苯二酚	能抵受煎炸過程的高溫	含菜油的食物
梂酸丙酯	對熱敏感	含菜油的食物
生育酚	能與維他命C等一同添加	含動物脂肪的食物
迷迭香	延遲自由基形成	肉類、帶光澤的肉碎
百里香、牛至	避免風味變壞	切碎的禽肉、肉類、魚類
乾李子	減慢脂質氧化	香腸及其他肉碎
蜜糖	深色較有效	火雞肉碎

抗氧化劑(添加劑)作護色劑

Antioxidants (additives) as colour retention agent

食品法典委員會准許的護色劑

Some colour retention agents in Codex

抗壞血酸*

Ascorbic acid*

異抗壞血酸(抗壞血酸D-異構體)*

Erythorbic acid (D-isomer of ascorbic acid)*

葡萄糖酸亞鐵

Ferrous gluconate

抗壞血酸鹽鈉*

Sodium Ascorbate*

硝酸鈉

Sodium nitrate

亞硝酸鈉

Sodium nitrite

氯化亞錫

Stannous chloride

•並未涵蓋在諮詢文件中准許在食物中使用的其他防腐劑和抗氧化劑的修訂建議內

* Not included in the proposed amendment of additional preservatives and antioxidants permitted for food use in the Consultation Paper

不被視作防腐劑或抗氧化劑的物質

Substances not considered as preservatives or antioxidants

- 抗壞血酸或其鹽或酯仍在“第132BD 章訂明不被視作防腐劑或抗氧化劑的物質”一覽表內

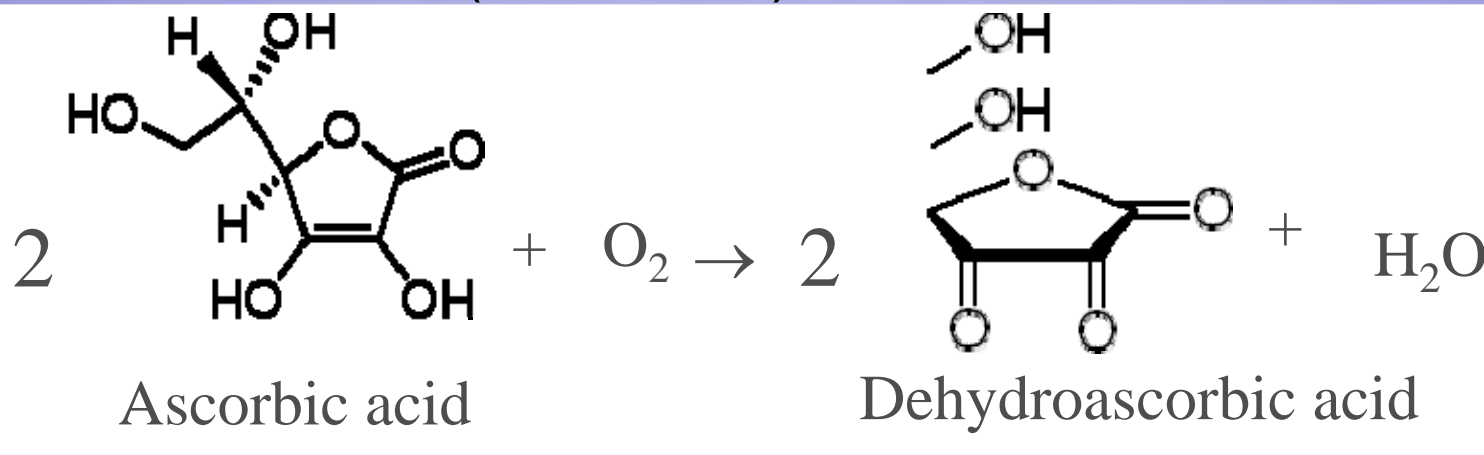
Ascorbic acid, its salts or esters are still included in the list of “Substances not considered as preservatives or antioxidants in the Cap.132BD regulations”

- 葡萄糖酸亞鐵和氯化亞錫等其他護色劑將會加進一覽表內，成爲准許使用的防腐劑和抗氧化劑

Other color retention agents such as ferrous gluconate and stannous chloride will be added into the list as permitted preservatives and antioxidants

抗壞血酸(維他命C) — 多功能的添加劑

Ascorbic acid (Vitamin C) A multifunctional additive



- 抗菌作用：與亞硝酸鹽一同抑制經加工處理肉類內的肉毒桿菌 (Ashworth and Spencer, 1972)
Antimicrobial function: in conjunction with nitrite to inhibit growth of *Clostridium botulinum* in cured meats (Ashworth and Spencer, 1972)
- 營養添加劑：添加在營養食物中作維他命C
Nutritive additive: as vitamin C to fortified foods
- 作還原劑(亞硝胺)
As reducing agent (nitrosamine)
- 作抗氧化劑(脂質氧化)
As antioxidant (lipid oxidation)
- 作抗氧化劑(護色)
As antioxidant (colour retention)

抗壞血酸

Ascorbic Acid

- 在脂肪、魚類和奶製品中作抗氧化劑，防止脂質氧化(圖9-24)
As an antioxidant to protect against lipid oxidation in fats, fish and dairy products (Fig. 9-24)

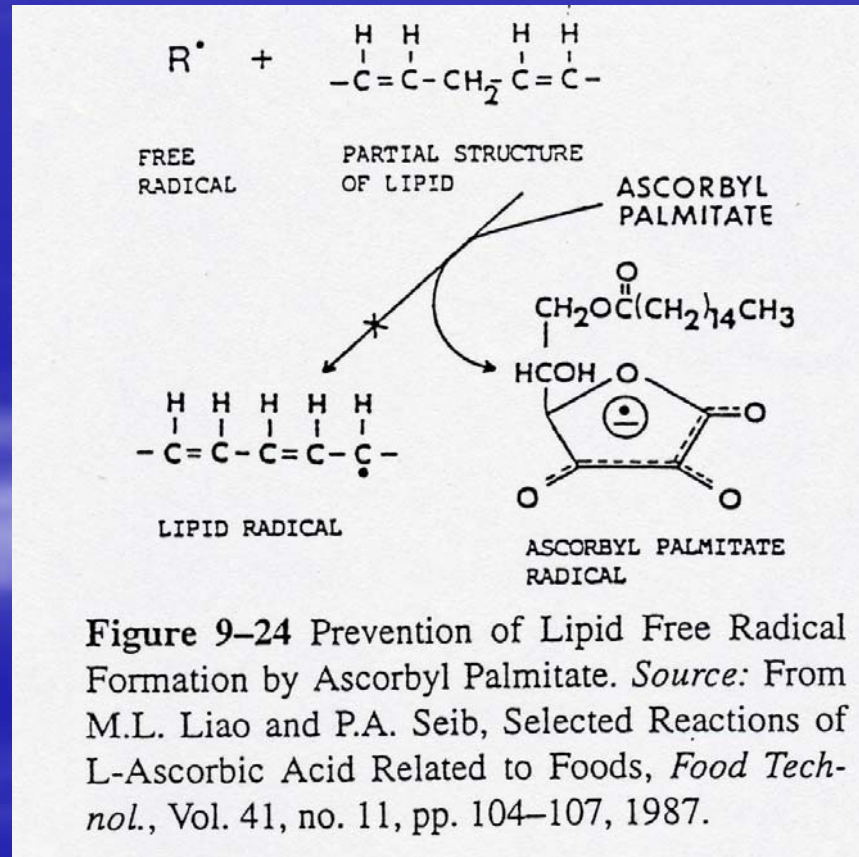


Figure 9-24 Prevention of Lipid Free Radical Formation by Ascorbyl Palmitate. *Source:* From M.L. Liao and P.A. Seib, Selected Reactions of L-Ascorbic Acid Related to Foods, *Food Technol.*, Vol. 41, no. 11, pp. 104-107, 1987.

抗壞血酸

Ascorbic acid

- 作還原劑，防止N-亞硝酸胺形成(圖9-25)

As a reducing agent to prevent the formation of N-nitrosamine (Fig. 9-25)

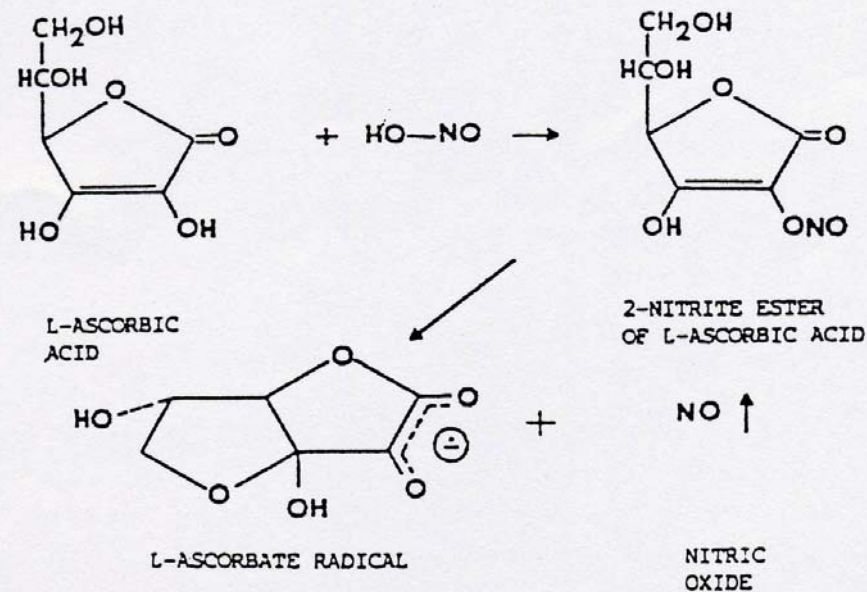


Figure 9-25 Reaction Between Nitrous Acid and Ascorbic Acid. *Source:* From M.L. Liao and P.A. Seib, Selected Reactions of L-Ascorbic Acid Related to Foods, *Food Technol.*, Vol. 41, no. 11, pp. 104-107, 1987.

抗壞血酸(護色劑)

Ascorbic acid (Color retention agent)

- 作還原劑，把原本褐色的物質還原為底物，防止黑色素(褐色素)形成，從而防止蔬菜和水果產品中的酶催褐變和變色(圖9-26)

As a reducing agent to prevent enzymic browning and discoloration in vegetables and fruit products by reduction of initial browning product back to the substrate and thus prevent melanin (brown pigment) formation (Fig. 9-26)

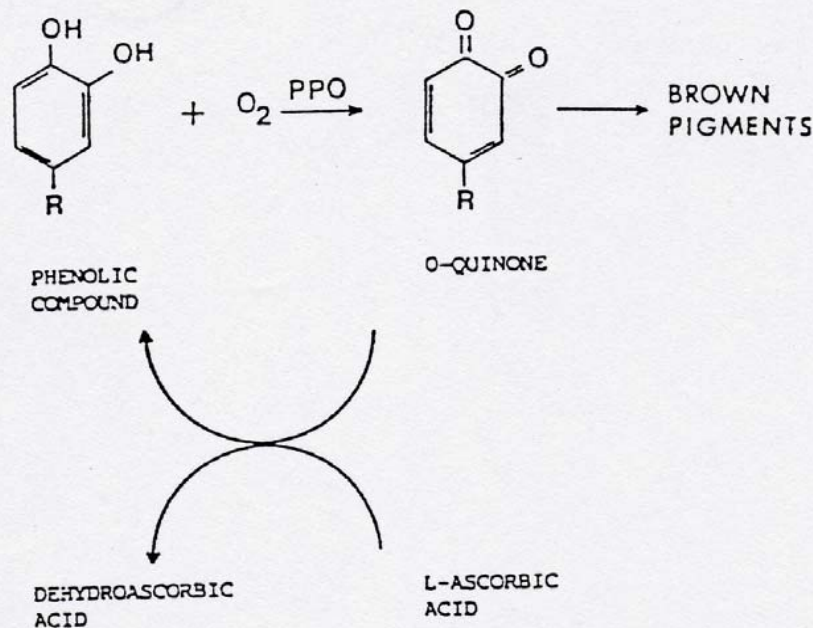


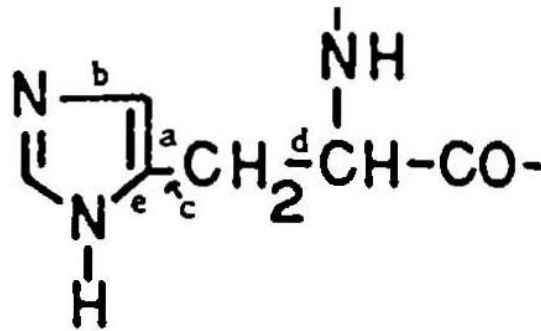
Figure 9-26 Reduction of Ortho-Quinone by Ascorbic Acid During Enzymic Browning. *Source:* From M.L. Liao and P.A. Seib, Selected Reactions of L-Ascorbic Acid Related to Foods, *Food Technol.*, Vol. 41, no. 11, pp. 104-107, 1987.

抗壞血酸(護色劑)

Ascorbic acid (Colour retention agent)

通過抗壞血酸鹽 / $\text{Cu}^{2+}/\text{O}_2$ 自由基產生系統破壞位於活性部位的組胺酸，令具有催褐作用的多酚氧化酶喪失活性 (Osuga and Whitaker, 1994)

inactivate the browning enzyme polyphenol oxidase by destruction of the active-site histidines via ascorbate/ $\text{Cu}^{2+}/\text{O}_2$ free radical generation system (Osuga and Whitaker, 1994)



Proposed scission of histidine residues by ascorbate/ Cu^{2+} to give aspartic acid (a-e), glutamic acid (b-e), alanine (c), glycine (d) and urea (a-e).

抗壞血酸(護色劑)

Ascorbic Acid (Color retention agent)

作還原劑，令經加工處理的肉類顏色保持穩定：抗壞血酸把亞硝酸還原，形成脫氫抗壞血酸(抗壞血酸的氧化狀態)及亞硝基(NO)。亞硝基在還原狀況下與肌紅蛋白反應，先產生亞硝化肌紅蛋白，然後產生亞硝酰血色素，令肉類呈現消費者喜愛的粉紅色(Doores, 1990) [圖4.40]

As a reducing agent to stabilize cured meat color: It reduces nitrite to form dehydroascorbic acid (its oxidized form) and nitric oxide (NO), which react with myoglobin under reducing conditions to yield nitrosomyoglobin and then nitrosylhemochrome which is responsible for the desirable pink color (Doores, 1990) [Fig. 4.40]

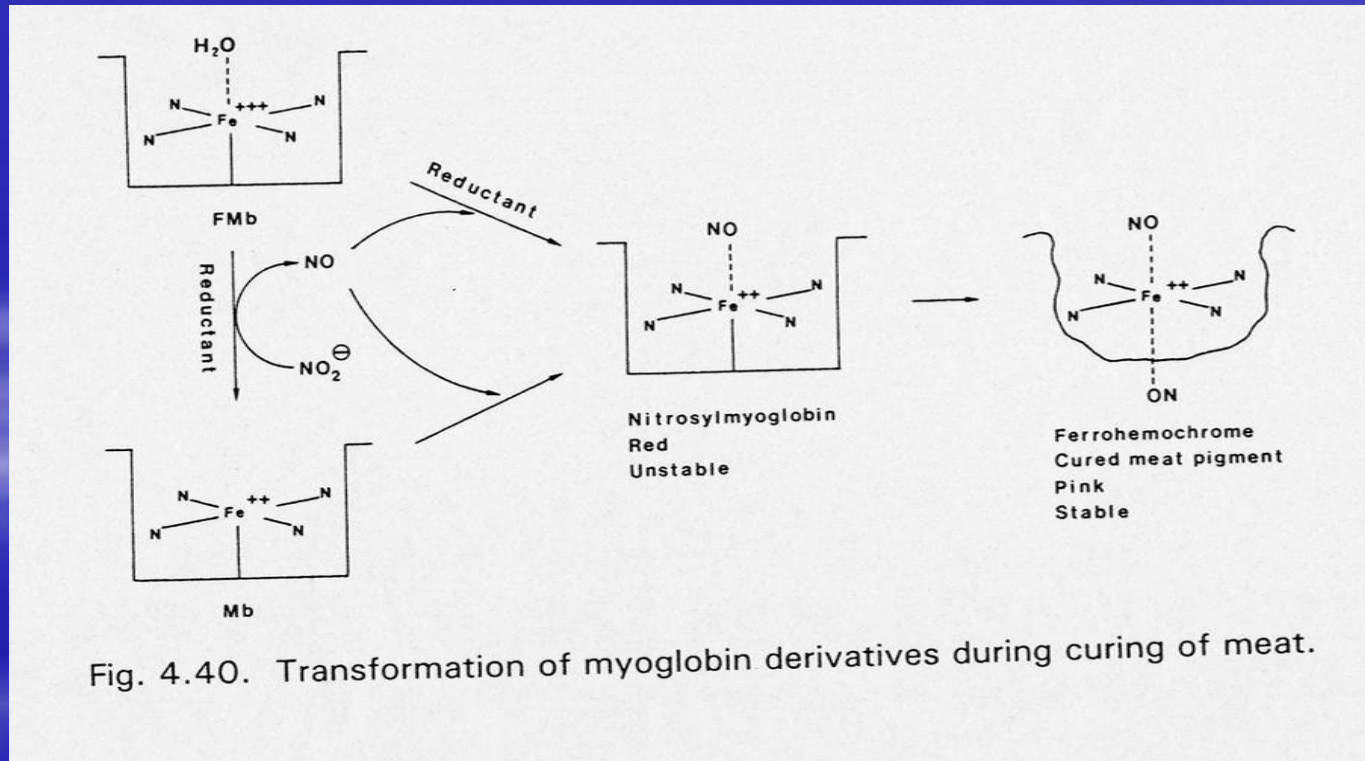
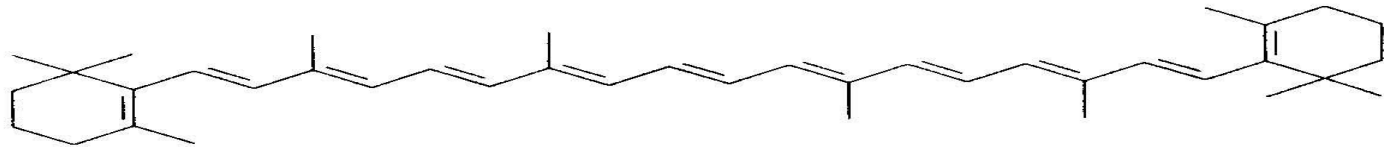


Fig. 4.40. Transformation of myoglobin derivatives during curing of meat.

抗壞血酸(護色劑)

Ascorbic Acid (Color retention agent)



β -CAROTENE
(C₄₀H₅₆)

保護 β -胡蘿蔔素

Protection of β -carotene

- β -胡蘿蔔素：具有長鏈雙鍵，易受氧化破壞，因而令顏色減退(Von Elbe and Schwartz, 1996)
 β -carotene: long chain of conjugated double bonds, susceptible to oxidative attack and cause decolourization (Von Elbe and Schwartz, 1996)
- 抗壞血酸可用作抗氧化劑(還原劑)，提供保護(Gordan *et al.*, 1985)
Ascorbic acid can offer protection by serving as antioxidant (as reducing agent) (Gordan *et al.*, 1985)

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參考資料

Reference Materials

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<http://www.gpoaccess.gov/cfr/index.html>
- Codex Alimentarius
<http://www.codexalimentarius.net/web/members.jsp?lang=EN>
- Compendium of Food Additives Specifications FAO Food and Nutrition Paper 52 and addenda 1 to 8.
<http://www.fao.org/WAICENT?FAOINFO?ECONOMIC?ESN?Jecfa/Jecfa.htm>
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- EU Directives
<http://www.ciaa.be>
- Scientific Committee on Food.
http://europa.eu.int/comm/food/fs/sc/scf/index_en.html