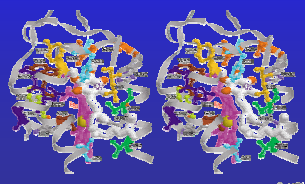
Chapter 1, section 2

COMPOSITION AND COMPOSITIONAL CHANGES DURING DEVELOPMENT AND STORAGE



I. IMPORTANCE OF COMPOSITION

- In relation to human food
  - Nutritive value - energy value, vitamins, minerals, protein, fiber
  - Eating quality - taste, aroma, texture
  - Appearance - color (pigment changes)
  - Safety - alkaloids, nitrates, mycotoxins

I. IMPORTANCE OF COMPOSITION

- In relation to postharvest requirements
  - Temperature - e.g. starch-sugar conversions
  - Light - e.g. chlorophyll and solanine development 茄碱
  - Duration of storage

I. IMPORTANCE OF COMPOSITION

- In relation to understanding metabolic processes
  - Fruit softening and other processes associated with ripening
  - General senescence of various plant organs
  - Physiological disorders

I. IMPORTANCE OF COMPOSITION

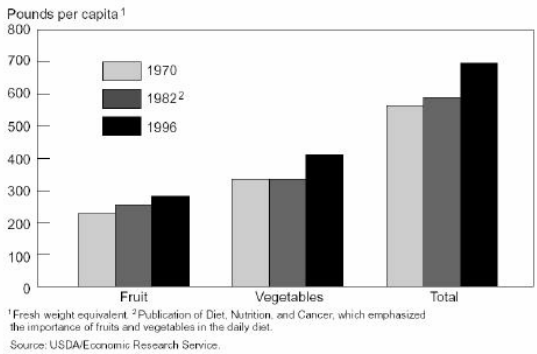
- In relation to commercial practices
  - Maturity standards - melons, grapes, citrus, avocados, etc.
  - Quality standards
  - Raw-product evaluation of processing commodities - peas, corn, potatoes, onions, grapes, cling peaches, etc.
  - Guidelines for the plant breeder - FDA's GRAS ("Generally regarded as safe") regulations

一般认为安全

Food and Drug Administration(美国)食品及药物管理局

Figure 1-5.

Per capita consumption of fruits and vegetables increased 23 percent between 1970 and 1996



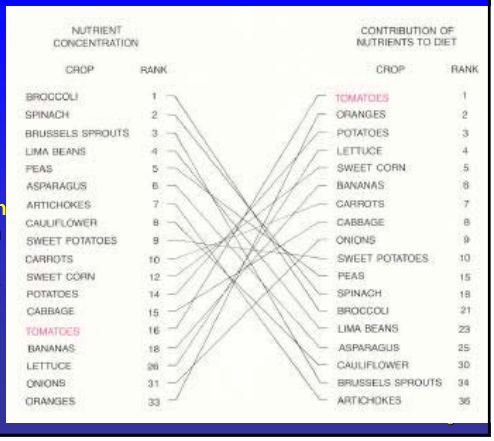
1 Fresh weight equivalent. 2 Publication of Diet, Nutrition, and Cancer, which emphasized the importance of fruits and vegetables in the daily diet.

Source: USDA/Economic Research Service.

II. FRUITS AND VEGETABLES AS FOODS

- Energy (calories)
  - Carbohydrate foods - cassava, potato, sweetpotato, yam, taro, breadfruit, green banana, plantain, jackfruit
  - Fat foods - avocado, nuts
- Proteins and amino acids
  - legumes, nuts
- Vitamins, minerals and dietary fiber
  - most fruits and vegetables

Relative nutritional value and contribution to nutrition of various vegetables



CONTRIBUTION OF CONSTITUENTS TO QUALITY ATTRIBUTES OF FRUITS AND VEGETABLES

Constituent	Level (%)	Structure	Contribution: Flavor	Food Value	Appearance
Water	75-95	X	X	X	X
Carbohydrates	2-25	X	X	X	
Protein	1-8	X	?	X	
Lipids	<1	X	X	X	X
Organic acids	<1		X	X	
Amino acids			X	X	
Pigments			?	X	X
Vitamins			?	X	
Minerals (ash)			X	X	
Volatiles			X	X	

III. FACTORS INFLUENCING COMPOSTION

- Genetic: selection of cultivars and rootstocks
- Preharvest environmental factors:
  - Climatic: temperature, light, pollutants, etc.
  - Cultural: soil type, nutrient and water supply, thinning, spacing, etc.
  - Harvesting stage: maturity, ripeness, physiological age
  - Postharvest treatments: environmental factors, handling methods, duration between harvesting and consumption, etc.

Ranges in tuber nutrient composition among potato varieties

	mg/150g fresh wt.	% of U.S. RDA
Protein	1050-8850	2.4-19.65
Ascorbic acid	12.00-45.00	19.95-75.00
Thiamine	0.051-0.219	3.45-14.55
Riboflavin	0.015-0.078	0.90-23.25
Niacin	0.81-4.65	4.05-23.25
Folacin	0.0075-0.015	3.75-7.50
Vitamin B_6	0.195-0.63	9.75-31.50
Calcium	4.50-24.00	0.45-2.40
Magnesium	16.50-45.00	4.20-11.25
Iron	0.20-1.80	1.05-10.35
Copper	trace-0.60	0-3.45
Phosphorus	27.00-96.00	2.70-9.60

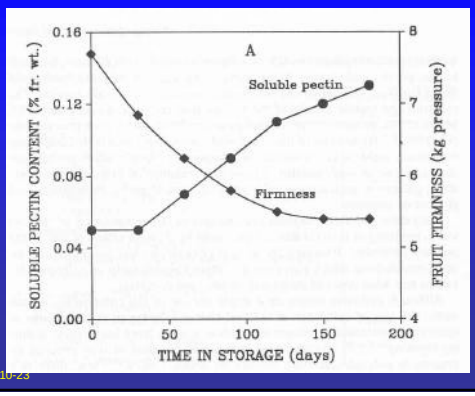
recommended dietary (或daily)allowance 推荐的日摄食量

Composition of tomato fruit grown with normal or high fertilizer levels

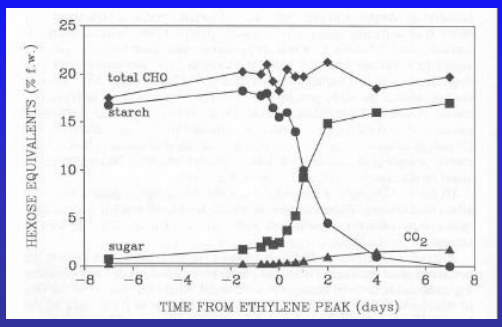
Fertilizer	pH	Total acid (%)	Soluble solids (%)	Total solids (%)	Brix acid ratio
Normal[z]	4.35	0.287	4.96	5.22	17.5
High[y]	4.34	0.335	5.14	5.43	15.5
LSD@5%	NS	0.015	0.17	0.18	1.3

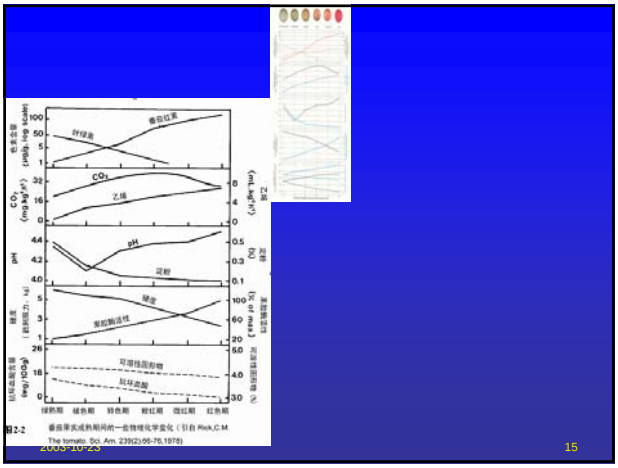
[z]Total of 72-43-81 lb per acre of N-P-K, respectively.
[y]Total of 142-83-158 lb per acre of N-P-K, respectively.
Vittum et al., 1962

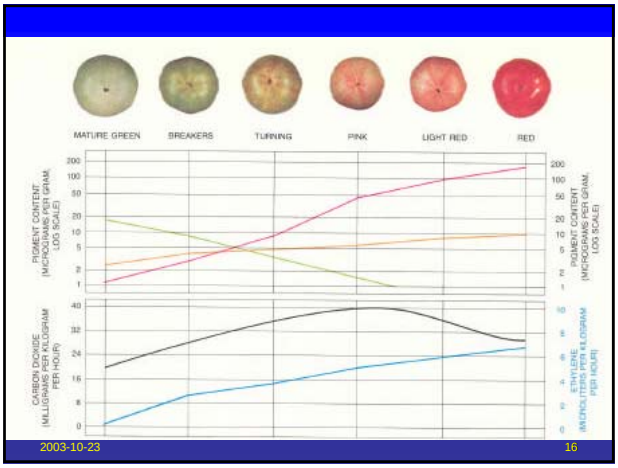
Relationship between pectin hydrolysis and textural changes in ripening apples

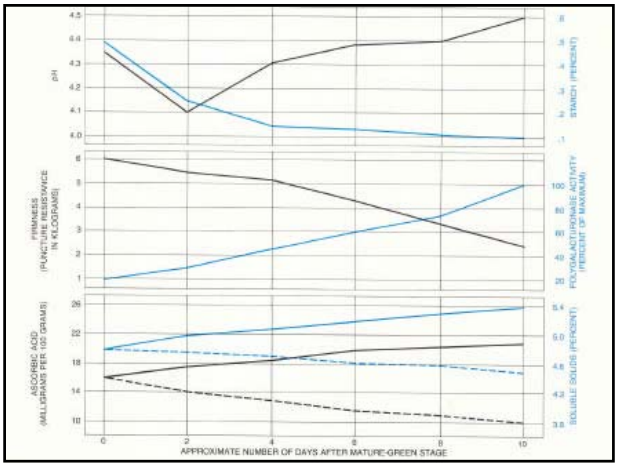


Hydrolysis of starch and increase in soluble sugars in ripening bananas









Effects of delay to cooling on composition of strawberries after storage for 1 week at 1C plus 1 day at 20C

Cultivar	pH	Dry weight Titr. acidity (%)	SSC (%)	Ascorbic acid (mg 100 g -1)	Sugars (g 100 g-1) Fructos	Glucose	Sucrose
No delay to cooling							
'Sweet Charlie'	3.52 a	5.87 b	54.49 b	485.4 a	8.19 b	6.19 b	0.79 b
'Oso Grande'	3.48 a	5.49 c	50.69 b	483.1 a	10.84 b	6.95 b	0.84 b
'Chandler'	3.39 b	6.79 a	60.38 a	453.5 a	16.35 a	10.79 a	5.86 a
Average	3.46 A	6.05 A	55.12 A	474.0 A	11.79 A	7.97 A	2.49 A
6 h delay to cooling							
'Sweet Charlie'	3.51 a	5.16 b	48.86 a	411.5 a	8.45 b	6.99 b	0.27 c
'Oso Grande'	3.51 a	4.77 b	45.24 b	412.1 a	10.81 a	8.44 a	1.67 b
'Chandler'	3.39 a	5.62 a	49.04 a	380.1 a	4.71 c	2.18 c	2.69 a
Average	3.47 A	5.18 B	47.05 B	401.2 B	7.99 B	5.87 A	1.54 A

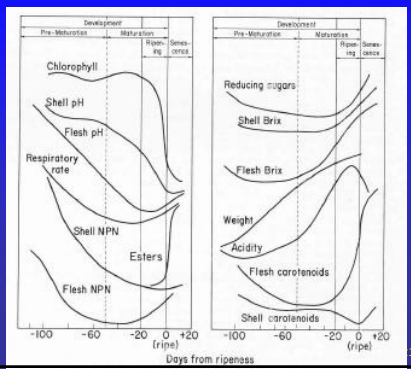
IV. COMPOSITIONAL CHANGES DURING DEVELOPMENT

- Essential to determining the optimum horticultural (harvest) maturity
- Important in relating sensory characteristics to composition of the commodity
- Important in developing means of controlling the rate of compositional changes

IV. COMPOSITIONAL CHANGES DURING DEVELOPMENT

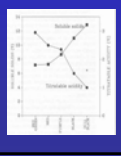
- Quantifying differences in compositional changes as influenced by the postharvest environment is important in selecting optimum conditions that would result in the best possible quality for the consumer

Physicochemical properties of pineapple fruit during development

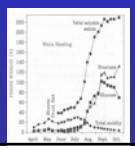


- Gortner et al., 1967

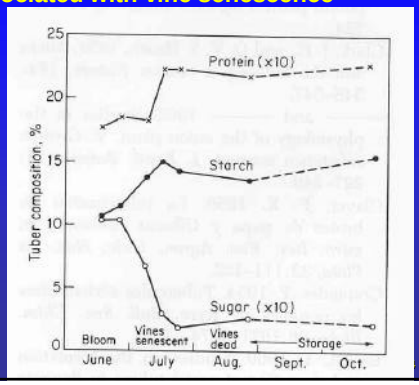
Sugar increase and acid decrease during blackberry ripening on the vine



Sugar accumulation during grape ripening on the vine



Potato tuber compositional changes associated with vine senescence



- Appleman and Miller,
- 1926

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Carbohydrates
  - the most abundant and widely distributed food component derived from plants
  - amounts vary widely

Leafy and stem vegetables	2 - 9%
Starchy roots and tubers	15 - 25
Citrus fruits	10 - 12
Dessert fruits	10 - 25

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Carbohydrates
  - The structural framework, taste and food value of a fresh commodity is related to its carbohydrate content
  - Sucrose, glucose and fructose are the main sugars in horticultural crops
  - Dessert fruits and certain vegetables, e.g., sweetcorn, peas, sweetpotatoes, are relatively high in sugars

一些果蔬中葡萄糖、果糖和蔗糖的含量（%）

种类	蔗糖	葡萄糖	果糖
苹果（红玉）	2.97	2.39	5.13
苹果（红星）	4.41	2.82	5.35
枇杷（田中）	1.34	3.46	3.6
李子	0	0	4.2
樱桃（拿破仑）	0	3.8	4.6
梨（长十郎）	1.8	1.39	3.85
梨（二十世纪）	0.59	2.27	5.1
洋梨（巴梨）	0.61	2.16	6.91
柿子（富有）	0.76	0.17	5.41
桃子	5.14	0.76	0.93
葡萄（甲州）	0	8.09	6.92
草莓（福羽）	0.17	1.35	1.59
西瓜	3.06	0.68	3.41
番茄（粟原）	0	1.62	1.61

不同果蔬中葡萄糖、果糖、蔗糖含量（%）

品种	果糖	葡萄糖	蔗糖
苹果	6.5~11.8	2.5~5.5	1.0~5.3
梨	6.0~9.7	1.0~3.7	0.4~2.6
桃	3.9~4.4	4.2~6.9	4.8~10.7
杏	0.1~3.4	0.1~3.4	2.8~10.9
草莓	1.6~3.8	1.8~3.1	0~1.1
葡萄	7.2	7.2	0~1.5
李	1.0~7.0	1.5~5.2	1.5~9.2
香蕉	6.9 (4)	6.9 (6)	2.70 (7)
桔	1.48	0.66	4.51
樱桃	7	5	0
番茄		2	0
菠萝	1	2	8

表：苹果果实在成熟期间的化学成分变化（%）

化学成分	果实部位	采收时	贮藏后
还原糖	果肉	4.7	7
非还原糖	果肉	2.8	0.4
淀粉	果肉	2	0.1
酸（苹果酸）	果肉	1	0.6
维生素C	果肉	0.21	0.07
蛋白质	果肉	0.2	0.24
原果胶	果肉	0.68	0.08
可溶性果胶	果肉	0.11	0.45
叶绿素	果皮	2.2×10^{-4}	1.5×10^{-4}
胡萝卜素	果皮	3.3×10^{-5}	8×10^{-5}

（J. B. Biale, 1962）

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Carbohydrates
  - Polysaccharides are the main structural components of cell walls and are important in texture and softening
    - include cellulose, hemicelluloses, and pectin
  - Starch serves as a storage carbohydrate and is organized into small grains within the cell

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Carbohydrates
  - Changes in carbohydrates after harvest of horticultural commodities are among the most important from the standpoint of quality
    - Sugar loss due to respiration
    - Conversion of starch to sugars and sugars to starch
    - Conversion of sucrose to reducing sugars
    - Solubilization and breakdown of protopectin to pectin and pectic acid

表：柑桔果汁糖分的季节变化

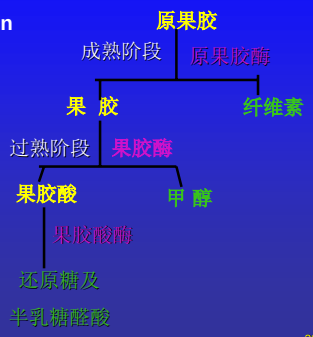
每100ml果汁所含糖量（g）

收获日期(月/日)	葡萄糖	果糖	蔗糖	全糖
伏令夏橙				
2月17日	1.74	2.44	4.31	8.49
3月29日	1.97	2.46	5.04	9.47
4月22日	2.29	2.55	4.95	9.79
5月25日	2.13	2.49	5.13	9.75
Dancy桔				
9月15日	1.19	1.55	2.19	4.93
10月26日	1.24	1.49	3.64	6.39
11月30日	1.02	1.58	4.97	7.57
12月29日	1.09	1.54	4.64	7.27

(Ting et Attaway, 1971)

Pectin

- 1 原果胶protopectin
- 2 果胶(pectin)
- 3 果胶酸(pectic acid)



V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Proteins
  - fruits and vegetables are relatively low compared with cereals and animal products

Fruits	<1%
Leafy and stem vegetables	1- 2
Starchy vegetables	0.5- 3
Legumes	3- 8

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Proteins
  - Proteins are involved as enzymes catalyzing metabolic processes
  - Formation or activation of new enzymes is physiologically important in various processes
    - e.g., ripening and senescence
  - Changes in the levels and activities of enzymes due to changes in cell membrane permeability may be involved in chilling injury

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Lipids
  - generally low in fruits and vegetables with the exception of those commodities in which lipids serve as storage reserves
    - e.g., avocado (4-20%), olive (15-40%) and tree nuts (45-65%)
  - In the other horticultural crops, lipids occur mainly as components of the cell membranes, cuticle, and epidermis

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Lipids
  - Oil content is an index of avocado maturity
  - the lipids of the cuticle and epidermis are important to the appearance of most commodities
  - The cuticle is also important in protection against water loss, pathogens and mechanical injuries

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Lipids
  - Membrane lipids may play a role in chilling injury
    - the degree of fatty acid saturation influences membrane flexibility and may change upon exposure to chilling temperature
  - Chilling sensitive plants tend to have a high percentage of saturated fatty acids, which can undergo a phase change at chilling temperatures

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Organic acids
  - important in respiratory metabolism and as storage compounds
    - Organic acids are important intermediate products of metabolism. The Krebs (TCA) cycle is the main channel for the oxidation of organic acids in living cells and it provides the energy required for maintenance of cell integrity

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Organic acids
  - metabolized into amino acids, which are the building blocks of proteins
  - They can also be metabolized into many other constituents

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Organic acids as storage compounds
  - Some fruits, such as lemons and limes, contain as much as 2 to 3% acid of their total fresh weight
  - Titratable acidity, specific organic acids present and their relative quantities, and other factors influencing the buffering system affect pH, which can vary from 2 to 7 among various commodities
    - → food safety implications

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- 苹果酸 (malic acid) **HOOH-CH_2-CHOH-COOH**
- 柠檬酸 (citric acid) **HOOC-(CH_2)-C(OH)(COOH)-CH_2-COOH**
- 酒石酸 (tartaric acid) **HOOC-CHOH-CHOH-COOH**
- 草酸 (oxalic acid)
- 琥珀酸 (amber acid)

Tartaric acid > malic acid, citric acid > oxalic acid, amber acid

PREDOMINANT ORGANIC ACIDS IN VARIOUS FRUITS AND VEGETABLES

Predominant acid	Commodities
Malic	Fruits: apple, apricot, banana, cherry, grape, peach, pear, plum
	Vegetables: artichoke, broccoli, carrot, cauliflower, celery cucurbits, lettuce, okra, onion
Citric	Fruits: lemon, orange, currant, fig, gooseberry, guava, loganberry, pineapple, pomegranate, raspberry, strawberry
	Vegetables: leafy vegetables, legumes, tomato, potato, sweetpotato
Tartaric	Grape (about equal to malic)

表：几种果实中有机酸种类及含量

果实种类	pH	总酸量%	柠檬酸%	苹果酸%	草酸mg/kg	水杨酸%
苹果	3.00-5.00	0.2-1.6	+	+	-	0
梨	3.20-3.95	0.1-0.5	0.24	0.12	30	0
杏	3.40-4.00	0.2-2.6	0.1	1.3	140	0
桃	3.20-3.90	0.2-1.0	0.2	0.5	-	0
李		0.4-3.5	+	0.36-2.90	60-120	0.029
甜樱桃	3.20-3.95	0.3-0.8	0.1	0.5	0	0
葡萄	2.50-4.50	0.3-2.1	0	0.22-0.92	80	0.21-0.7
草莓	3.80-4.40	1.3-3.0	0.9	0.1	100-600	0.28

注：+ 表示存在。- 表示微量。0 表示缺乏

表：果蔬pH值概况表

名 称	pH值	名 称	pH值
柠檬	2.2-3.5	番茄	4.1-4.8
橙	3.5-4.9	胡萝卜	5
葡萄	2.5-4.9	菜豆	5.4
香蕉	5.2	菠菜	5.7

蔬菜种类	主要有机酸
菠菜	草酸 苹果酸 柠檬酸
甘蓝	柠檬酸 苹果酸 琥珀酸 草酸
莴苣	苹果酸 柠檬酸 草酸
蓼	甲酸 醋酸 戊酸 青芋 草酸
甜菜叶	草酸 柠檬酸 苹果酸
石刁柏	柠檬酸 苹果酸
笋	草酸 酒石酸 乳酸 柠檬酸 葡糖醛酸

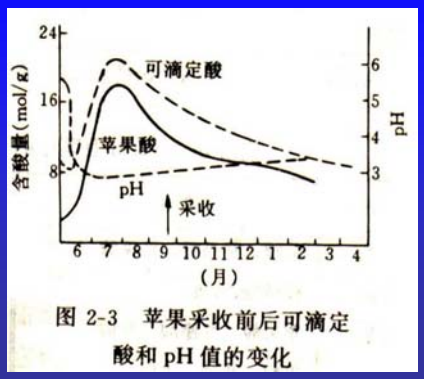


图 2-3 苹果采收前后可滴定酸和 pH 值的变化

Sugar: acid and TSS:acid

糖酸比，固酸比

- Determine maturity (成熟度)
- Flavor (风味)

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Pigments色素
  - Chlorophyll叶绿素 - control of chlorophyll degradation (loss of green color) is important from a quality standpoint in both fruits and vegetables
  - normally we wish to retard the process in vegetables and promote it in ripening fruit.

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Pigments
  - Carotenoids 类胡萝卜素(yellow, orange and orangered)
    - very stable compounds that remain intact even when senescence is well advanced
    - Synthesis of these pigments is important during fruit development, but may be masked by chlorophyll (e.g., citrus, bananas)
    - In tomato, carotenoid synthesis is concurrent with chlorophyll degradation
    - Content of B-carotene (pro-vitamin A), a major carotenoid, is important for nutrition

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Pigments
  - Phenolics
    - the main substrates of enzymatic browning reactions of cut or damaged tissues of apple, peach, potato, etc. upon exposure to air
    - Phenolic content is generally higher in fruits than vegetables and is higher in immature than mature fruits

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Pigments
  - Phenolics
    - Astringency in immature fruits and other tissues is related to the content of tannins
    - Phenolics are thought to play a role in the resistance of some immature tissues to attack by pathogens

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Pigments
  - Anthocyanins花色素苷 - flavonoids 类黄酮 (red, blue and purple)
    - water soluble, unstable glycosidic compounds that are readily hydrolyzed to free anthocyanidin or oxidized to give brown oxidation products
    - The colors of anthocyanins are influenced by vacuolar pH. Often they are confined to the cells of the epidermal layer

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Volatile compounds
  - Responsible for the characteristic aromas of fruits and vegetables
  - The total amount of carbon involved is much less than 1% of that evolved as CO_2
  - Ethylene is the major volatile formed (50-75%) yet it does not contribute to typical fruit aromas
  - Typically, only a few key volatiles are important for the particular aroma of a given commodity

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- **Volatile compounds**
- Banana:200多种挥发成分，不同阶段其主要成分为：
  - 绿香蕉—己烯醇(hexenol)
  - 成熟香蕉—丁子香酚(eugenol; oxymethoxy allylbenzene)
  - 过熟香蕉—异戊醇(isoamyl alcohol; isoamylol)
  - 香蕉类---醋酸异戊酯(isoamyl acetate)
  - 果香类---醋酸丁酯(butyl acetate)
  - 霉臭类---醋酸甲酯(methyl acetate)

Main Volatile compounds in some fruits and vegetables

果蔬名称	香气成分
苹果–成熟	乙基2-甲基丁酸盐
苹果–绿色	己醛、2-己烯醛
香蕉–绿色	己烯醛
–成熟	丁子香酚
–过熟	异戊醇
葡萄柚	Nootakatone
柠檬	柠檬醛
橙子	巴伦西亚桔烯
树莓	1-（π羟基苯）-3-丁酮
黄瓜	2,6-壬二烯
甘蓝 – 生	烯丙基介子油
–煮熟	二甲基二硫化合物
蘑菇	1-辛烷-3-醇蘑菇香精
马铃薯	2-甲氧-3-吡嗪-2,5二甲基吡嗪
萝卜	4-甲硫-反-3-丁醛异硫

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- **Vitamins**
  - **fruits and vegetables are generally good sources of vitamins, which are essential in human nutrition**
  - **Vitamins are classified as water-soluble and lipid-soluble**

Water-soluble and lipid-soluble vitamins found in plants

Water-Soluble Vitamins	Lipid-soluble Vitamins
Ascorbic acid (Vit. C)	Vitamin A
Thiamin	Vitamin D
Riboflavin	Vitamin E
Niacin	Vitamin K
Vitamin B_6	
Folacin	
Vitamin B_{12}	
Biotin	
Pantothenic acid	

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- **Vitamins**
  - **The water-soluble vitamins, especially ascorbic acid, are very susceptible to postharvest degradation when commodities are exposed to adverse handling and storage conditions, including high temperature, low relative humidity (wilting), physical damage and chilling injury**

Total ascorbic acid content in strawberries stored at 1, 10 or 20° C

unwrapped Wrapped

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Vitamins
  - Postharvest losses in vitamins A and B, while usually much smaller than losses in vitamin C, can occur at high temperatures in the presence of oxygen

EFFECT OF TEMPERATURE AND TIME ON VITAMIN CONTENT OF 'RUSSET BURBANK' POTATOES

Temp. & Duration	(mg/100g DW) Ascorbic acid	Thiamine	Ribo-flavin	Niacin	Folic acid	Vitamin B_6
Initial	86.6	0.36	0.14	6.7	0.06	0.95
3°C, 4wks.	44.2	0.30	0.11	5.3	0.05	1.06
7°C, 4wks.	50.3	0.31	0.11	5.9	0.05	1.07
3°C, 8wks.	39.7	0.40	0.15	5.1	0.05	1.56
7°C, 8wks.	34.7	0.42	0.14	4.3	0.05	1.46

(Data from Augustin, *et al*, 1978)

EFFECT OF CA ON ASCORBIC ACID CONTENT IN APPLES AT 15° C

Days in Storage	mg Ascorbic acid/100g FW Control	3% O_2
10	18.1	24.1
35	8.9	18.4
66	5.5	15.9
85	3.3	14.9

Adapted from: Delaporte, 1971

EFFECT OF CA ON ASCORBIC ACID CONTENT OF SPINACH AT 7.5° C

Days in Storage	mg Ascorbic acid/100g DW Control	4% O_2 + 9% CO_2
0	7.2	7.4
3	5.2	6.6
5	4.4	6.4
7	3.2	5.3

Adapted from: Burgheimer *et al.*, 1967

EFFECT OF ETHYLENE TREATMENT ON ASCORBIC ACID CONTENT OF TOMATO

Treatment	mg Ascorbic acid/100g FW when ripe
Picked Table-Ripe	19.2
Picked Mature-Green, Ripened at 20°C	12.3
Picked Mature-Green Ripened with Ethylene at 20°C	15.5

Adapted from: Kader et al., 1978

常见果蔬的维生素C含量情况表

种类	含量（mg/100g）	种类	含量(mg/100g)
中华猕猴桃	100-400	龙眼（石硖）	71.2
番石榴	125-180	香蕉	6
西番莲（印度）	21.9-69.9	番茄	12-35.7
甜橙	30-50	辣椒	76-198
芒果（吕宋）	28-44	青花菜	110
菠萝（卡因）	12.5-23.4	花椰菜	50
荔枝（糯米糍）	13-20	菠菜	33-43
柑桔	40	草莓	40
生菜	35	卷心菜	35
胡萝卜	30	甜菜 洋葱	5

蔬菜收获后维生素C含量变化表（管原1957）

种类	收获时	1周后（室温）	2周后（2-3℃
菠菜	196.5	98.7	131.5
莴苣	18.6	5.4	9.5
花椰菜	105	48.6	102.5
甘蓝	110.8	72.5	105.3
抱子甘蓝	95.2	40.6	81.5
白菜	75.8	46.8	64

注：单位：mg/100g

表：叶、果皮、果肉中维生素C的含量

水果	叶(mg%)	果皮(mg%)	果肉（mg%）
柿（富有）	455	38	25
温州蜜柑	230	76	25
夏橙	113	96	37

注：引自绪方邦安编《水果蔬菜贮藏概论》，陈祖铖等译，农业出版社，1982，22

Changes in Organic Acid and Ascorbic acid of banana fruit during ripening

	呼吸高峰期前	呼吸高峰期	呼吸高峰期后
苹果酸 (mg/100g)	182	720	831
柠檬酸 (mg/100g)	143	357	456
草酸 (mg/100g)	294	166	173
Vc (mg/100g)	7.3	3.1	2.8

部分水果和蔬菜中的维生素A含量（单位：微克/100

品种	含量	品种	含量	品种	含量
胡萝卜	1000	菠萝	500	红甘薯	500
水田芥	400	芒果	200	番茄	200
杏	150	白甘薯	50	香蕉	20
马铃薯	<5				

表：部分果蔬中维生素B含量（单位：微克/100克）

品种	含量	品种	含量	品种	含量
菠菜	80	青花菜	30	孢子甘蓝	30
甘蓝	20	生菜	20	香蕉	10
一般水果	<5				

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- **Minerals**
  - – **Important nutritionally and in various physiological processes**
  - – **Total minerals (ash content) of fruits and vegetables varies from about 0.1% (e.g., yams) to as much as 4.4% (e.g., kohlrabi)**

大头菜

Classification of minerals

Base-forming	Acid-forming	Trace elements
Ca	P	Fe
Mg	Cl	Cu
Na	S	Co
K		Mn
		Zn
		I
		Mo

V. MAJOR COMPONENTS OF FRUITS AND VEGETABLES

- Minerals
  - Potassium is the most abundant mineral in fruits and vegetables (as much as 1% in parsley)
    - occurs mainly in combination with organic acids
  - Calcium is the second most important mineral constituent
    - mainly associated with cell walls and membranes
  - Magnesium is a component of the chlorophyll molecule
  - Phosphorus is a constituent of proteins that are important in carbohydrate metabolism and energy transfer

Contents of Ca, P, Fe in some fruits (mg/100g)

Fruit	Ca	P	Fe
Apple	11	9	0.3
Pear	5	6	0.2
Peach	8	20	1.0
Grape	4	15	0.6
Orange	26	15	0.2

Contents of Ca, P, Fe in some vegetables (mg/100g)

Vegetable	Ca	P	Fe
Edible amaranth	116-464	46-80	1.87-5.6
spinach	15-239	19-75	1.6-2.9
mustard	56-149	21-42	0.6-3.3
Chinese cabbage	40-89	20-37	0.5-1.4
potato	13-60	15-68	0.4-4.8
capsicum	7-62	13-89	0.3-2.5