Composition and Compositional Changes During Development: Part II

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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

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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 soluble (sweet) sugars in horticultural crops.
  - Dessert fruits and certain vegetables, *e.g.*, sweetcorn, peas, sweetpotatoes, are relatively high in sugars.

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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.

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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 pectin polymers to pectin fragments and galacturonic acid.

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V. Major Components of Fruits and Vegetables

- **Carbohydrates**

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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

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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.

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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.
    - avocado 4-30%
    - olive 15-40%
    - tree nuts 45-65%
  - In the other horticultural crops, lipids occur mainly as components of the cell membranes, cuticle, and epidermis.

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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.
  - Lipids are involved in wound healing (suberin).

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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.

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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.

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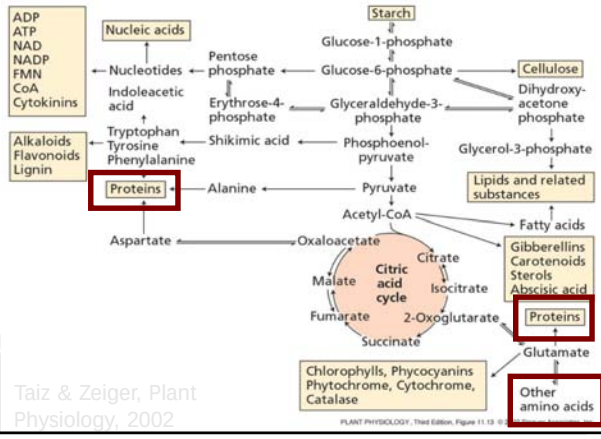
V. Major Components of Fruits and Vegetables

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



Taiz & Zeiger, Plant Physiology, 2002

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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: low pH (<4.5) inhibits microbial growth.

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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)

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V. Major Components of Fruits and Vegetables

- **Pigments**
  - **Chlorophyll** - 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.

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V. Major Components of Fruits and Vegetables

- **Pigments**
  - **Carotenoids** (yellow, orange and orange-red).
    - 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.
  - Carotenoids are important antioxidants - important for human health.

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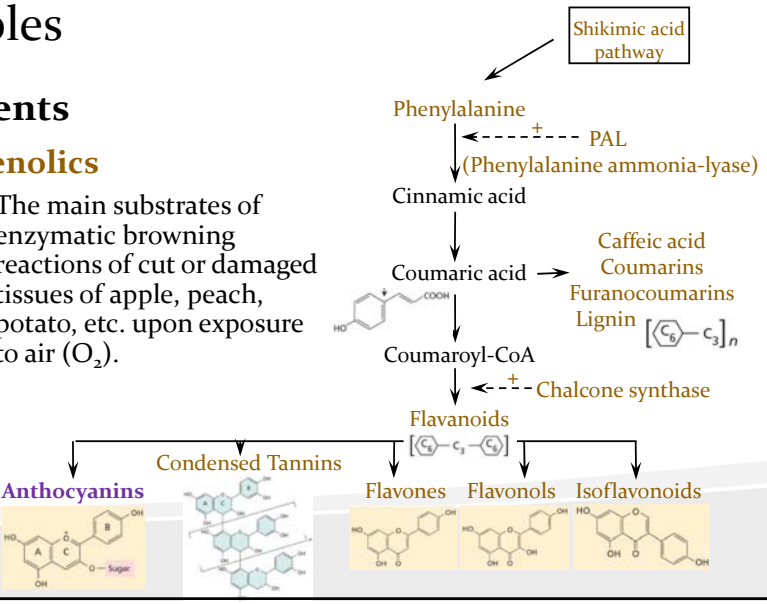
V. Major Components of Fruits and Vegetables

- **Pigments**
  - **Phenolics**
    - The main substrates of enzymatic browning reactions of cut or damaged tissues of apple, peach, potato, etc. upon exposure to air (O_2).



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V. Major Components of Fruits and Vegetables

- **Pigments**
  - Phenolics
    - Phenolics are thought to play a role in the resistance of some immature tissues to attack by pathogens.
      - pre-existing compounds
      - **phytoalexins** are formed in response to attack

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V. Major Components of Fruits and Vegetables

- **Pigments**
  - **Phenolics**
    - Phenolic content is generally higher in fruits than vegetables and is higher in immature than mature fruits.
      - Astringency in immature fruits and other tissues is related to the content of tannins.
    - Phenolics are important antioxidants, important for human health.

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V. Major Components of Fruits and Vegetables

- **Pigments**
  - **Anthocyanins** - flavonoids (red, blue and purple) are phenolic compounds.
    - 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 ("blush" formed in response to sunlight).

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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 at least in climacteric crops (50-75%) yet it does not contribute to typical fruit aromas.
  - Typically, only a few key volatiles out of 50-100 are important for the particular aroma of a given commodity.

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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.

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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	

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V. Major Components of Fruits and Vegetables

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

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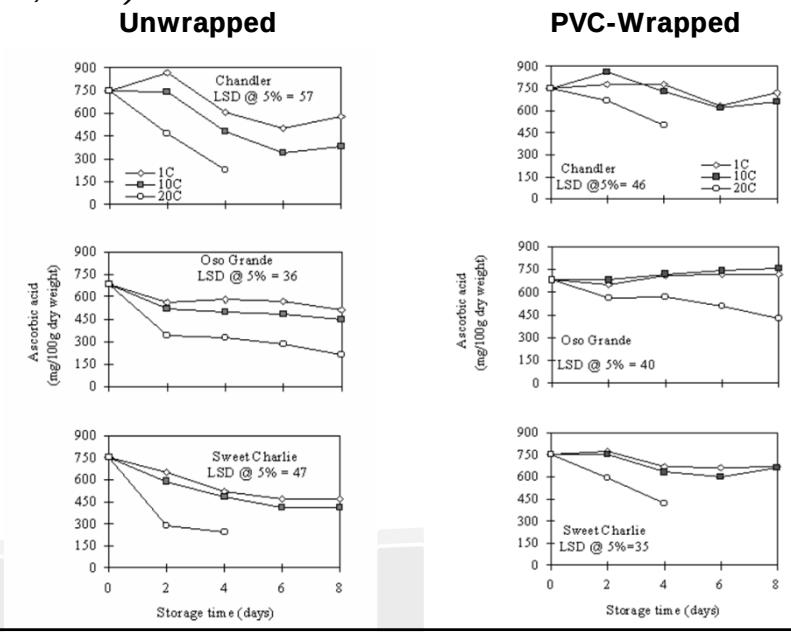
Total ascorbic acid content in strawberries stored at 1, 10 or 20°C (Nunes et al., 1998)



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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 (abuse) temperatures in the presence of oxygen

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Effect of Storage Temperature and Time on Vitamin Content of 'Russet Burbank' Potatoes

	(mg/100g DW)					
Temp. & Duration	Ascorbic acid	Thiamine	Riboflavin	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

(Augustin, *et al*, 1978)

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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

Delaporte, 1971

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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

Burgheimer *et al.*, 1967

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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 w/o ethylene at 20°C	12.3
Picked mature-green ripened with ethylene at 20°C	15.5

Kader et al., 1978

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V. Major Components of Fruits and Vegetables

- **Minerals**
  - Important nutritionally and in various physiological processes.
    - Active sites of enzymes (*e.g.*, Mg)
    - Hormone binding sites (*e.g.*, Cu)
    - Used to make organic compounds (*e.g.*, N & S)
    - Involved in energy storage (*e.g.*, P)
  - 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).

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Classification of minerals

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

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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 (i.e., ATP).
  - **High nitrogen content** is often associated with reduced soluble solids content, lower acidity, and increased susceptibility to physiological disorders in fruits.

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Conclusion

- **Composition has several important considerations in postharvest horticulture**
  - Nutritional value
  - Physiological role of constituents
  - Contributions to taste and appearance
  - Relationship to harvest and postharvest practices

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