Composition and Compositional Changes During Development: *Part I*

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I. Importance of Composition

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

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Phytonutrients or Phytochemicals

TABLE 8.2
Common Phytonutrients, Potential Food Sources and Associated Postulated Health Benefits

Phytonutrient	Health benefit	Potential food sources
Flavonoids	Fights oxidation and blood clots	Apples, citrus fruits, cranberries, grapes, broccoli, celery, onions, tea, red wine
Carotenoids	Fights oxidation	Yellow/red fruits and vegetables: papaya, carrots, peppers, tomatoes, dark green leafy vegetables (e.g., spinach)
Allyl sulfides	May reduce blood cholesterol, helps liver detoxify carcinogens	Chives, garlic, leeks, onions
Isothiocyanates	May block carcinogens from damaging DNA	Cruciferous vegetables: broccoli, cabbage, sunflower
Indoles	May convert estrogen into less cancer-promoting form of the hormone	Cruciferous vegetables: broccoli, cabbage, sunflower
Terpenes	May help the liver to detoxify carcinogens	Citrus fruits: oranges, tangerines, limes, lemons
Isoflavones	May block entry of estrogen into cells, reducing the risk of breast, colon, or ovarian cancers; may alleviate menopausal symptoms	Soy

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I. Importance of Composition

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

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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

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I. Importance of Composition

- **In relation to commercial practices**
  - **Maturity standards**
    - *e.g.,* melons, grapes, citrus, avocados, etc.
  - **Quality standards**
    - *e.g.,* watermelon.
  - **Raw-product evaluation of processing commodities**
    - *e.g.,* peas, corn, potatoes, onions, grapes, cling peaches, etc.
  - **Guidelines for the plant breeder**
    - *e.g.,* natural toxic substances (*i.e.,* solanine) vs. those classified by FDA as "GRAS" ("generally regarded as safe").

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Per capita availability of fruits increased 13 percent between 1970 and 2005

Item	Per capita availability[1] 1970	Per capita availability[1] 2005	Change, 1970 to 2005	2005 loss-adjusted food availability[2]
	Pounds, fresh-weight equivalent		Percent	Cups/day
Citrus, melons, and berries[3,4]	138.8	136.4	-2	0.36
Citrus	113.7	101.2	-11	.26
Fresh	28.8	21.6	-25	.06
Processed (juice)	84.9	79.6	-6	.20
Melons[3]	21.6	25.8	19	.05
Watermelon	13.5	13.8	2	.03
Cantaloup	7.2	10.1	40	.02
Berries[3]	3.5	8.9	156	.05
Fresh and frozen strawberries	2.9	7.7	163	.03
Other fruits[3,4]	101.9	136.0	36	.57
Fresh bananas	17.4	25.1	45	.08
Fresh apples	17.2	16.9	-1	.12
Fresh grapes	2.9	8.6	197	.04
Apple juice	6.4	22.5	254	.07
Grape juice	2.4	5.6	135	.02
Canned applesauce	5.7	4.3	-24	.07
Canned olives	1.0	1.4	48	.03
Canned peaches	6.8	3.3	-50	.01
Raisins	5.8	7.3	25	.02
Total fruits	240.7	272.4	13	.92

Per capita availability of vegetables increased 23 percent between 1970 and 2005

Item	Per capita availability[1] 1970	Per capita availability[1] 2005	Change, 1970 to 2005	2005 loss-adjusted food availability[2]
	Pounds, fresh-weight equivalent		Percent	Cups/day
Dark-green vegetables[3,4]	3.8	20.2	425	0.16
Leafy lettuces[5]	.6	10.9	1,856	.08
Broccoli	1.5	8.3	446	.04
Deep-yellow vegetables[3,4]	15.0	21.4	43	.10
Carrots	9.5	11.9	24	.06
Sweet potatoes	5.4	4.5	-17	.02
Other starchy vegetables[3,4]	155.5	155.5	---	.63
Potatoes	121.7	125.6	3	.55
Corn	27.8	26.9	-3	.06
Other vegetables[3,4]	154.9	210.5	36	.80
Head lettuce	22.4	21.1	-6	.12
Canned tomatoes	62.1	73.6	18	.13
Garlic	.4	2.4	450	.01
Fresh tomatoes	12.1	20.2	66	.07
Fresh onions	10.1	21.0	107	.07
Cucumbers	8.5	10.2	20	.03
Bell peppers	2.2	7.1	227	.03
Cabbage	11.0	9.3	-15	.06
Celery	7.3	5.9	-19	.04
Total vegetables	336.8	414.6	23	1.72

Source: Dietary assessment of major trends in U.S. food consumption, 1970-2005. EIB-33. USDA ERS, 2008

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II. Fruits and Vegetables as Foods

- **Energy (calories)**
  - Carbohydrate foods - cassava, potato, sweetpotato, yam, taro, breadfruit, green banana, plantain, jackfruit.
  - Fat foods - avocado, olive, nuts.
- **Proteins and amino acids**
  - Legumes, nuts.
- **Vitamins, minerals, dietary fiber and antioxidants**
  - Most fruits and vegetables.

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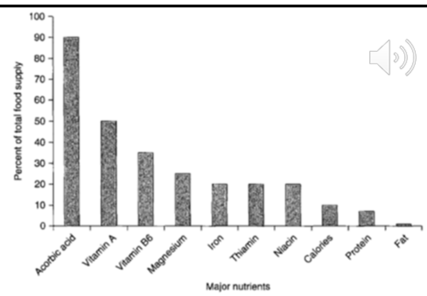

FIGURE 8.1 Percentage of nutritional contribution of fruits and vegetables of the total food supply. (Modified from Salunkhe et al. (1991), *Storage, Processing, and Nutritional Quality of Fruits and Vegetables*, Vol. 1, CRC Press, Boca Raton, FL.)

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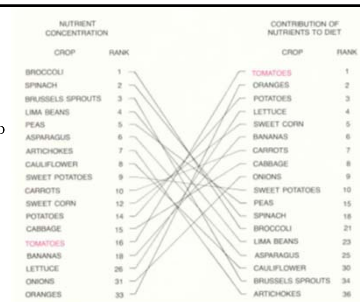
Relative nutritional value and contribution to nutrition of various vegetables



Stevens, 1974

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Contribution of Constituents to Quality Attributes of Fruits and Vegetables

Constituent	Level (%)	Structure	Contribution: Flavor	Contribution: Food Value	Contribution: 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	

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III. Factors Influencing Composition

- **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.

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Ranges in tuber nutrient composition among potato varieties

	mg/150 g fresh wt.	% of U.S. RDA	Range
Protein	1050-8850	2.4-19.65	8.4X
Ascorbic acid	12.00-45.00	19.95-75.00	3.8X
Thiamine	0.051-0.219	3.45-14.55	4.3X
Riboflavin	0.015-0.078	0.90-23.25	5.2X
Niacin	0.81-4.65	4.05-23.25	5.7X
Folacin	0.0075-0.015	3.75-7.50	2X
Vitamin B_6	0.195-0.63	9.75-31.50	3.2X
Calcium	4.50-24.00	0.45-2.40	5.3X
Magnesium	16.50-45.00	4.20-11.25	2.7X
Iron	0.20-1.80	1.05-10.35	9X
Copper	trace-0.60	0-3.45	---
Phosphorus	27.00-96.00	2.70-9.60	3.6X

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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

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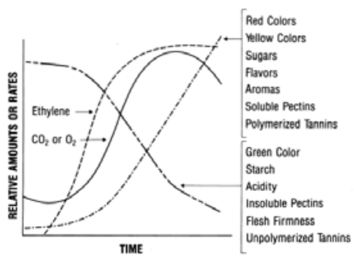

Fig. 22.4. Schematic presentation of compositional changes associated with fruit ripening in relation to ethylene production and respiration (CO_2 production or O_2 consumption).

LaRue & Johnson. 1989. Peaches, Plums & Nectarines

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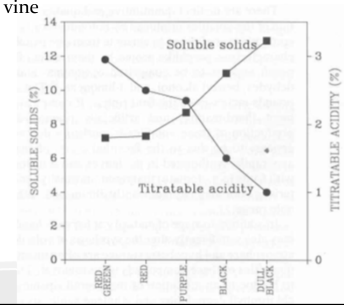
Sugar increase and acid decrease during blackberry ripening on the vine



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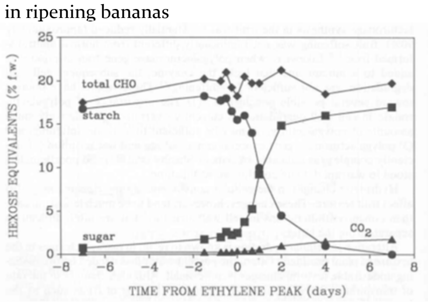
Hydrolysis of starch and increase in soluble sugars in ripening bananas



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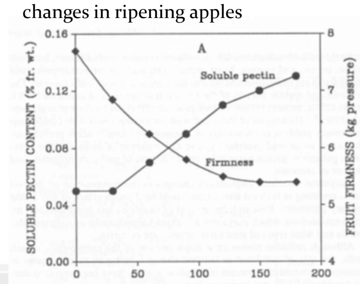
Relationship between pectin hydrolysis and textural changes in ripening apples



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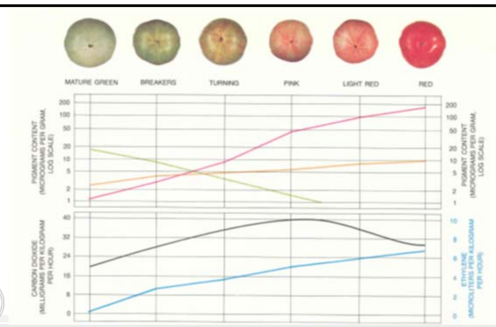

Rick, 1978

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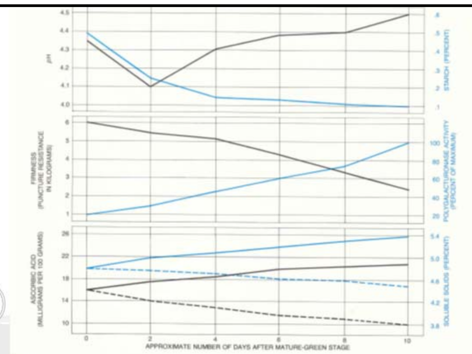

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Effects of delaying cooling for 6 hours at 30C on composition of strawberries after storage for 1 week at 1C plus 1 day at 20C

Treatment 'Cultivar'	pH	Titratable acidity (%)	SSC (%)	Ascorbic acid (mg/100 g)	Sugars Fruc	Gluc (g/100 g)	Suc
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	**3.46A**	**6.05A**	**55.12A**	**474.0A**	**11.79A**	**7.97A**	**2.49A**
6 h delay to cooling							
'Sweet Charlie'	3.51 a	5.16 b	48.86 ab	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	**3.47A**	**5.18B**	**47.05B**	**401.2B**	**7.99B**	**5.87A**	**1.54A**

Nunes et al., 1995

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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

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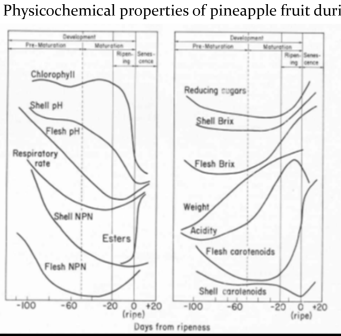
Physicochemical properties of pineapple fruit during development



Gortner et al., 1967

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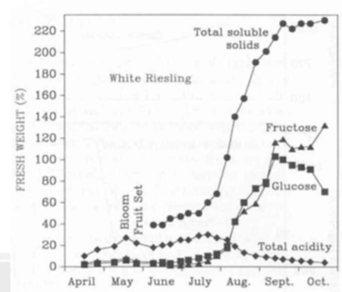
Sugar accumulation during grape ripening on the vine



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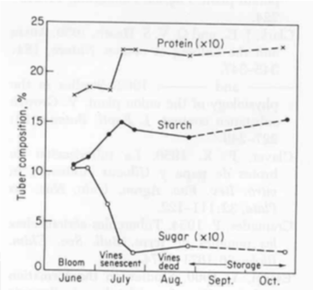
Potato tuber compositional changes associated with vine senescence



Appleman and Miller, 1926

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End of Composition: *Part I*

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