



FOOD CHEMISTRY

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Vegetables and Fruits

BINITA RANI
ASSOCIATE PROFESSOR (DAIRY CHEMISTRY)
FACULTY OF DAIRY TECHNOLOGY
S.G.I.D.T., BVC CAMPUS,
P.O.- BVC, DIST.-PATNA-800014



Vegetables and Fruits



- **Vegetables** => fresh parts of plants => consumed as such or cooked.
- ten thousand plant species => as vegetables in the world.
- provides => essential nutrition => minerals, dietary fibers, fats, vitamins, proteins, carbohydrates and energy.
- **Fruits** of perennial trees => **not** considered to be vegetables.
- **Ripe seeds** are also **excluded** (peas, beans, cereal grains).

- **Fruits** include **true fruits** and **spurious fruits**, as well as **seeds** of cultivated and wild perennial plants.

Commonly classified as:

- pomaceous fruits,
- stone fruits,
- berries,
- tropical and subtropical fruits,
- hard-shelled dry fruits and
- wild fruits.

GENERAL CLASSIFICATION OF VEGETABLES

classified in different groups:

1. Mushrooms:

Fungi => nutritious.

Button, milky, oyster, Flats, Truffle, Wood ear =>

Steamed, fried, dried, pickled or salted

2. Algae (seaweed):

1. Sea lettuce => Eaten raw - salad, cooked - soups

2. Sweet tangle => Eaten raw - salads, cooked - vegetable

3. Rooty vegetables: usually a long or round-shaped taproot.

1. **Beetroot** - salad - raw or cooked

2. **Carrot** - salad - raw or cooked

3. **Radish** - salad - raw or cooked

4. **White (Irish) potato** – cooked - fried or deep fried in many forms

4. Tuberos (rhizomatic) vegetables: grow underground on the root of a plant.

1. **Sweet potatoes** - Cooked, fried or baked

2. **Cassava** - Cooked or roasted

5. Bulbous Rooty vegetables: grow just below the surface of the ground and produce a **fleshy, leafy shoot** above ground. Bulbs usually consist of **layers** or **clustered segments**.

1. **Garlic** - Consumed raw, cooked as seasoning

2. **Onion** - Consumed raw, fried as seasoning, cooked as a vegetable

6. Stem (shoot) vegetables: edible stalks of plants

1. **Bamboo shoots** - Cooked for salads

Classification based on edible parts :

1. Leafy vegetables: edible leaves of plants

1. Cabbage - eaten raw in **salads**, cooked as a vegetable
2. Spinach - Cooked as a **vegetable**

2. Flower head vegetables: edible flowers of certain vegetables

1. Cauliflower - Cooked as a **vegetable** or used in **salads**
2. Broccoli - cooked as a **vegetable**

3. Seed vegetables: also known => legumes => usually obtained from pods => pod is sometimes eaten along with the seed.

1. Green beans - cooked as a vegetable, steamed or cooked for salads
2. Green peas - cooked as a vegetable, steamed or pickled for salads

4. Fruity vegetables: Vegetable fruit => fleshy and contain seeds.

1. Capsicum - cooked as a vegetable
2. Pumpkin - cooked as a vegetable
3. Cucumber – Consumed in salads, cooked as a vegetable or pickled
4. Tomato - eaten raw => salads, cooked => vegetable, used as a paste or seasoned puree, immature green tomatoes are pickled and then eaten as salad.

GENERAL COMPOSITION

- vary significantly depending => cultivar and origin
- **1.dry matter** => 10-20%
- Some tubers and seed vegetables => **high starch** content
- => so **higher dry matter** content.
- **2. N-compounds** => 1-3%
- of this **35-80%** is protein and
- rest is **amino acids, peptides and other compounds.**

- protein fraction consists of => **enzymes** => may have either **beneficial** or **detrimental** effect on processing
- may contribute => **typical flavor** or to formation of **undesirable flavor** , **tissue softening** and **discoloration**.
- **Enzymes** of all the main groups => **present** in vegetables.

3. **carbohydrate** => 3-20%.

- predominant sugars => **glucose, fructose and sucrose**.
- Starch => as **storage** carbohydrate and is present in large amounts in some **roots and tuber** vegetables.
- other polysaccharides – **cellulose, hemi-cellulose** and **pectin** are there.
- **pectin** fraction has a distinct role in **tissue firmness** of vegetables.

4. **lipid** => low (0.1- 0.9%) => **triacylglycerols, glycolipids** and **phospholipids** are present.

- **Carotenoids** => occasionally found in large amount.

5. Organic acids :

- malic and citric acids.
- content of free titratable acids \Rightarrow 0.2 - 0.4 g/100 g fresh tissues.
- pH is 5.5-6.5.

6. Mineral :

- 1% \Rightarrow Potassium followed by Ca, Na and Mg.
- major anions \Rightarrow phosphates ,chlorides and carbonates.

7. Secondary constituents:

- Vitamins, flavoring compounds and dietary fibers.
- Plant pigments other than carotenoids and anthocyanins viz. chlorophyll and betalains \Rightarrow great importance in vegetables.

STORAGE OF VEGETABLES

- varies greatly and depends mostly on **type and quality**.
- **leafy vegetables** => lettuce and spinach as well as beans, peas, cauliflower, cucumbers, asparagus and tomatoes => **limited storage time**
- **root and tuber vegetables** => carrots, potatoes, kohlrabi, turnips, red table beets, celery, onions and late cabbage cultivars => stored for **months** => **cold storage at high air humidity** (80–95%) => weight loss => 2–10%.
- Ascorbic acid and carotene contents => **decrease** with storage.
- Starch and protein => **degradation** occurs and
- **free acid content** of vegetables - cauliflower, lettuce and spinach => **rise**

GENERAL CLASSIFICATION OF FRUITS

1. Pomme fruits

1. Apple - Fresh, dried, purée, jelly, juice, apple cider, brandy
2. Pear - Fresh, dried, brandy, Jelly

2. Stone fruits

1. Apricot - Fresh, dried, jam, juice, brandy
2. Peach - Fresh, juice, brandy

3. Berry fruits

1. Blackberry - Fresh, jam, jelly, juice, wine, liqueur
2. Strawberry - Fresh, jam, brandy
3. Raspberry - Fresh, jam, brandy
4. Gooseberry - Fresh, jam, juice
5. Grapes - Fresh, dried (raisins) juice, wine, brandy

4. Citrus fruits

1. Orange - Fresh, juice, marmalade
2. Grapefruit - Fresh, juice
3. Lemon – Juice

5. Other tropical/ subtropical fruits

1. Pineapple – Fresh, compote, jam, juice
2. Banana – Fresh, dried, cooked, baked
3. Avocado – Fresh
4. Date – Fresh, dried
5. Guava – Fresh, juice
6. Mango – Fresh, juice
7. Watermelon – Fresh
8. Papaya - Fresh, juice

6. Shell(nut) fruits

1. Cashew nut – Roasted
2. Peanut – Roasted salted
3. Almond - Baked and confectionary products
4. Pistachio - Fresh, salted, sausage flavoring, decoration of baked products
5. Walnut - Fresh, baked and confectionary products, unripe fruits in vinegar and sugar-containing preserves

7. Wild fruits

1. Rose hips - Jam, wine
2. Sea buckthorn - Jam, juice
3. Elderberry - Juice, jam

GENERAL COMPOSITION

strongly influenced by its variety and ripeness

1. Dry matter => 10-20%

- Major constituents => sugar, polysaccharides and organic acids, while Nitrogen-compounds and lipids => present in fewer amounts.
- Minor constituents => pigments and aroma substances (organoleptic quality), vitamins and minerals(nutritional importance).

2. Nitrogenous Compounds => 0.1-1.5% of which 35-75% is protein.

- protein fraction varies widely => fruit variety and ripeness. This fraction => primarily **enzymes**.
- **Free amino acids** => widely distributed and are on an average **50%** of the soluble N-content.
- A number of **aliphatic and aromatic amines** are found => various fruits.

3. **Sugars:** Glucose and fructose => in varying ratios in fruits.

- Sucrose => **dominant oligosaccharide**.
- fruits => cherry, grape and figs => **no sucrose**.
- D-sorbitol => the sugar alcohol => is most **abundant** => pomme and stone fruits but **absent** => berries, citrus fruits, pineapple and banana.
- All fruits have => **cellulose, hemicellulose** and **pectins**.
- Pectin fractions of fruits are especially **affected by ripening**.
- **Starch** is present mainly => **unripe** fruits and generally its content **decreases** to a negligible level as **ripening proceeds**, with the **exception of bananas**.

4. **Lipid:** generally low (0.1-0.5%) => exception of nuts.

- fraction consists of => TAGs, glyco- and phospholipids, carotenoids, triterpenoids and waxes.
- presence of **carotenoids** is => widespread in **many fruits** and in
- citrus fruits and peaches => main factor determining => **colour**.
- presence of carotenoids => forms the basis of fruit **classification**.
- triterpenoid fraction contains => bitter compounds, viz. **Limonoids and cucurbitacins**.
- **fruit peel** is often coated with => **waxy layer**.

5. Organic Acids:

- L-Malic acid and citric acid are the major organic acids in fruits.
- Malic acid is predominant => pomme and stone fruits, while
- Citric acid is abundant => berries, citrus and tropical fruits.
- Tartaric acid occurs only => grapes.

6. Phenolic compounds:

- Phenolic compounds occur => most fruits and most of them contribute => colour and taste.
- They can => form complexes during processing => resulting in discolouration of fruit pulp.

7. Vitamins:

- Many fruits are important sources => **vitamin C**
- **Pantothenic acid** and **biotin** are present => Citrus fruits, figs, black currant
- **Vitamin B12**, **Vitamin D** and **tocopherols** are => found in trace amounts

8. Minerals:

- most important cation => **K⁺**, and
- most important inorganic anions => **PO₄³⁻**

Physico - chemical changes during RIPENING OF FRUITS

- fruits continue to => undergo **chemical changes** after harvest until **finally spoilage** occurs.
- Ripening of fruits involves => highly **complex changes** in => **chemical** and **physical properties**.
- There are quite a number of **intricate changes** taking place in => complex **bio-chemical system**.

The most striking changes related to ripening are:

1. **cell-wall** constituents are => **profoundly modified** during ripening leading => **softening**.
2. build-up of **other cell constituents** => **starch** and **sugar** are affected along with the **disappearances of astringent compounds**, which ultimately lead => **increase in sweetness**.
3. **formation** => **flavour and aroma compounds** as well as **changes in color** due to breakdown of green chlorophyll pigment, whereby the yellowish color pigment of the shows up.

The changes taking place are:

1. Changes in respiration rate

- respiration rate is affected by => **development stage** of fruits.
- A **rise in respiration** occurs with => growth.
- This is followed by => a **slow decrease** in respiration rate until the fruit is fully ripe.
- In a number of fruits => **ripening** is associated with a **renewed rise in respiration rate** soon after picking => until it reaches a climax (**climacteric respiration**) => followed by a steady **decrease in respiration** rate i.e. senescence.
- Depending on fruit => this can occur before/after harvesting.
- **Maximum CO₂** production occurs => in **climacteric stage**.

Climacteric rise is so specific that fruits can be classified into:

a) Climacteric fruits: apples, banana, pears, mango, papaya, tomato

b) Non-climacteric fruits: pineapple, oranges, strawberry, grapes and lemon.

non-climacteric fruits generally **ripen on plants** and contain **no starch**.

2. Changes in metabolic pathways:

- Metabolic shift may occur in **several fruits => during ripening**
- e.g. during ripening of **banana**, it appears that
- **Embden-Meyerhoff Pathway** (Glycolysis) becomes **dominant** and **Pentose Phosphate Pathway** is **suppressed** during ripening.

3. Change in individual constituents of fruits :

Carbohydrates:

- During ripening => significant changes => in **carbohydrate fraction**.
- green fruits => have abundant starch and less soluble sugars.
- On ripening => starch decreases => while sugar content increases => gives the ripe fruit its sweetness.
- It has been assumed that => sugars are produced at the expense of starch and other sugars => available for conversion.
- A decrease in hemi-cellulose (during the ripening of banana) => suggests => they can be a possible source of sugars.
- Additionally, organic acids may also be => possible source.

- Another change in fruits is => **alteration of texture.**
- **softening** of fruit tissue => associated with changes in **pectin fraction.**
- **Insoluble protopectin**(associated with **cellulose** in the cell wall matrix) is transformed => **soluble forms** => decreases **rigidity** of the matrix.
- Additionally a **decrease** in **degree of methylation** (from ~80% to ~40%) and **degree of polymerization** of pectin => observed in fruits => bananas, citrus fruits, mango, melons.
- **All these together** contribute => an **increase in softness** of ripe fruit.
- **soluble pectin** bind => **polyphenols** and thereby quench their astringent effect and => contribute to **mild taste of ripe fruits.**

Proteins:

- During ripening of some fruits => although total nitrogen content is constant => an **increase in protein** content is observed => mainly due to **biosynthesis of enzymes**.
- During ripening => a **shift** also occurs in **amino acid** and the **amine fraction**.
- These shifts are => **not uniform** and are affected by **type** and **ripening stage** of fruits.

Lipids:

- Little is known => changes in lipids.
- Changes have been found in => **composition** and **quantity** of lipids, esp. in **phospholipid** fraction.

Acids:

- There is a **decrease** in **acid content** of fruits => during ripening (exception - lemon).
- There can be changes in => **proportion** of various acids.
- in ripe apples => **malic acid** is major acid, while
- **in unripe ones** => **quinnic acid** is major one.
- In many fruits => synthesis of **ascorbic acid** takes place during ripening.

Pigments:

- Ripening of fruits is accompanied by \Rightarrow a decrease in colour.
- transformation from green \Rightarrow other colours is due to the degradation of chlorophyll and the consequent appearance of the concealed pigments.
- In some fruits \Rightarrow the change is more due to synthesis of other pigments \Rightarrow lycopene content of tomatoes greatly increases during ripening.

Aroma compounds:

- Formation of **typical aroma compounds** occurs => during ripening.
- In bananas => noticeable amounts of **volatile compounds** are formed 24 hrs after climacteric stage has passed.
- Aroma build up is affected by => **external factors** => **temperature** and **day-night variations**.

Water:

- Living parts constantly transfer $H_2O \Rightarrow$ the surroundings.
- This loss of water results \Rightarrow in **visible shriveling**
- when fruit is plucked $\Rightarrow H_2O$ flow into fruits is discontinued, even though **H_2O loss** continues.
- This **loss** is **high** \Rightarrow **high temperature** and **dry atmosphere**.
- This H_2O given off **through physiological forces** that remain active even after harvesting is called **transpiration**.
- Water is **also formed** \Rightarrow due to **respiration** \Rightarrow most of this water \Rightarrow **removed** through **evaporation** along with **readily accessible surface water**.
- some fruits have \Rightarrow **waxy layer** on the skin \Rightarrow check the loss of H_2O .



THANKS