A series on
Food Science and Technology

Lecture on
Fruits – Classification and Composition

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1.0 Introduction

In botanical terms a "fruit" is a part of a flowering plant that derives from specific tissues of the flower, mainly one or more ovaries. Often the botanical fruit is only part of the common fruit, or is merely adjacent to it. On the other hand, the botanical sense includes many structures that are not commonly called "fruits", such as bean pods, corn kernels, wheat grains, tomatoes, the section of a fungus that produces spores (1), and many more. However, there are several variants of the biological definition of fruit that emphasize different aspects of the enormous variety that is found among plant fruits (2).

Fruits are the means by which many plants disseminate seeds. Most plants bearing edible fruits, in particular, coevolved with animals in a symbiotic relationship as a means for seed dispersal and nutrition, respectively; in fact, many animals (including humans to some extent) have become dependent on fruits as a source of food (3). Fruits account for a substantial fraction of world's agricultural output, and some (such as the apple and the pomegranate) have acquired extensive cultural and symbolic meanings.

Culinary fruits

Many fruits that, in a botanical sense, are true fruits are actually treated as vegetables in cooking and food preparation, because they are not particularly sweet. These culinary vegetables include cucurbits (e.g., squash, pumpkin, and cucumber), tomatoes, peas, beans, corn, eggplant, and sweet pepper. In addition, some spices, such as allspice and chilies, are fruits, botanically speaking.[4] In contrast, occasionally a culinary "fruit" is not a true fruit in the botanical sense. For example, rhubarb is often referred to as a fruit, because it is used to make sweet desserts such as pies, though only the petiole of the rhubarb plant is edible.[5] In the culinary sense of these words, a fruitis usually any sweet-tasting plant product, especially those associated withseed(s), a vegetable is any savory or less sweet plant product, and a nut is any hard, oily, and shelled plant product.[6]

The quality of processed fruit products depends on their quality at the start of processing; therefor it is essential to understand how maturity at harvest, harvesting methods, and post-harvest handling procedures influence quality and its maintenance in fresh fruit between harvest and process initiation.

Quality attributes of the fresh include appearance, texture, flavor and nutritive value. Appearance factors include size, shape, colour and freedom from defects and decay. Texture

factors include firmness, crispness and juiciness. Flavour components incorporate sweetness, sourness (acidity), astringency, bitterness, and aroma and off flavor. Nutritional quality is determined by fruits content of vitamins, minerals, dietary fibers,carbohydrates, proteins and phytochemicals (carotenoids, flavonoids and other phenolic compounds). A safety factor that may influence the quality of fresh fruits includes residues of pesticides, presence of heavy metals,mycotoxins produced by certain species of fungi and microbial contamination.

Losses in fresh fruits between harvesting and processing, may be quantitative (e.g. water loss, physical injuries, physiological breakdown and decay. or qualitative (e.g. loss of acidity , flavor, colour and nutritive value.) many factors influence fruit quality and extent of post- harvest losses that can occur in the orchard during transportation and throughout the handling system(sorting, sizing, ripening , cooling and storage) the total time between and processing may also be important factor in maintaining the quality and freshness of fruit. Minimizing the delays throughout the post-harvest handling system greatly reduces quality loss, especially in highly perishable fruits such as strawberries, raspberries, apricots and cherries.

This episode deals with,

1. **Classification of fruit,**
2. **Contribution of fruits to human nutrition**
3. **Composition of fruit**
4. **Factors influencing composition and quality of fruits and**
5. **Key to successful handling of fresh fruits**

2.0Classification of Fruits

Fruits are mainly classified by their growing regions such as Tropical, Sub –tropical and temperate and growing regions and environmental conditions specific to each region significantly affect fruit quality(7). Some examples of fruits grown in different regions are listed below.

2.1Tropical fruits

a) **Major tropical fruits :** Mango, banana, Pineapple and Papaya
b) **Minor tropical fruits :** Cashew apple, guava, lychee, mangosteen, sapota, passion fruit , tamarind, durain, rambutan, Jackfruit

2.2 Subtropical fruits

a) **Citrus fruits :** grapefruit, lemon, lime, orange, pummelo, tangerine and mandarin
b) **Non citrus fruits** : avocado, cherimoya ,fig, kiwifruit, olive, pomegranate

2.3 Temperate fruits :

a) Pome fruits : apple, pear, quince
b) Stone fruits : apricot, cherry, peach and plum
c) Small fruits and berries : grapes, strawberry, raspberry, blueberry, blackberry, cranberry

Many vegetables are botanical fruits, including tomato, bell pepper, eggplant, okra, squash, pumpkin green bean, cucumber and Zucchini.

3.0 Contribution of fruits to Human nutrition

Fruits are not only colourful and flavourful components of our diet , but they also serve as a source of energy, vitamins, minerals and dietary fibers. Recent studies have emphasizes the consumption of five servings of fruits and vegetables. In some countries, consumers are encouraged to eat up to ten servings of fruits.(8)

Apart from being a source of carbohydrates, they also contribute towards the recommended dietary intake of minerals especially Zinc and selenium.

They also contain a group of antioxidants commonly referred to as Phytochemicals

3.1 Energy (calories)

Carbohydrates: Banana, breadfruit, jackfruit, plantain, dates raisin

Proteins and amino acids : Nuts, dried apricot and figs

Fats: Avocado, olive and nuts

3.2 Vitamins

Fresh fruits contribute about 91 % of vitamin C, 48 % vitamin A, 27% of vitamin B6, 17% of Thiamin and 15 % niacin to the human diet.

The following fruits are the important contributors to the supply of vitamins

Vitamin A : orange, mango, papaya, pineapple, watermelon, apricot, peach , cherry

Vitamin C : Strawberry, orange, grapefruit, kiwifruit, pineapple, amla (Indian gooseberry)

Niacin : banana, apricot, orange

Riboflavin: banana, peach, avocado, apple, orange

Thiamin : orange, banana, grapefruit, apple

3.3 Minerals

Fresh fruits contribute about 26% of magnesium, and 19% of iron to the human diet.

The following fruits are the important contributors to the supply of indicated minerals

Potassium : Banana, peach, orange, apple

Phosphorus : Banana, orange, peach, fig, raisin

Calcium : Tangerine, grapefruit and orange

Iron : Strawberry, banana, apple, orange

3.4 Dietary fiber

All fruits contribute to the dietary fiber. Dietary fiber consists of cellulose, hemicellulose, lignin and pectic substances, which are mainly derived from fruit cell walls and skin. The dietary fiber content of the fruits ranges from 0.5 to 1.5 % (Fresh weight basis). Dietary fiber plays an important role in relieving constipation. Its consumption is also linked to the decreased incidence of cardio vascular disease and colon cancer.

3.5 Antioxidants

Fruits in their daily diet have been strongly associated with reduced risk of certain forms of cancer, heart disease, stroke andother chronic diseases. This is attributed due to the presence of antioxidants collectively referred to as Phytochemicals.

Fruits such as apricot, mango, nectarines orange, papaya, peach, plum, raspberry,strawberry which have red, blue or purple colour are the rich source of flavonoids and other phenolic compoundswhich has positive antioxidant capacity of the fruit.

Orange colour fruits such as apricot, mango, orange, papaya, peach and pineapple and some red flesh fruits such as tomato, watermelonand pink grapefruit are good source of carotenoids.

4.0 Composition of fruits

Fruits are generally high in fiber, water, vitamin C and sugars, although this latter varies widely from traces as in lime, to 61% of the fresh weight of the date.[9] Fruits also contain various phytochemicals that do not yet have an RDA/RDI listing under most nutritional factsheets, and which research indicates are required for proper long-term cellular health and disease prevention. Regular consumption of fruit is associated with reduced risks of cancer, cardiovascular disease (especially coronary heart disease), stroke, Alzheimer disease, cataracts, and some of the functional declines associated with aging [10]

Diets that include a sufficient amount of potassium from fruits and vegetables also help reduce the chance of developing kidney stones and may help reduce the effects of bone-loss. Fruits are also low in calories which would help lower one's calorie intake as part of a weight-loss diet.[11]

4.1 Carbohydrates

Fresh fruits vary widely in their carbohydrate content generally ranging from 10-25 %.Texture, taste, food value and structural framework of the fresh fruit is related to the carbohydrate content. Sugar composition of the selected fruits is shown in Table 1.

Table 1: Sugar composition of some fruits.

	Sugar (g/100ml of juice)		
Fruit	**Sucrose**	**Glucose**	**Fructose**
Apple	0.082	2.14	5.31
Grape	0.29	9.59	10.53
Peach	5.68	0.67	0.49
Pear	0.55	1.68	8.12
Kiwifruit	1.81	6.94	8.24
Strawberry	0.17	1.80	2.18

Source :Ref 12

4.2 Proteins

Fruit contains less than 1 % of the protein.

4.3 Lipids

Lipids constitute only 0.1to 0.2 % of the most fruits except avocado (butter fruit and olives). Lipids are very important because they make up the surface wax that contributes to the fruit appearance and cuticle that protects fruit against water loss and pathogens. Lipids are also important constituents of cell membrane.

4.4 Organic acids

Organic acids in living cell provide the energy required for the maintenance of the cell integrity and are the important products of metabolism. The Krebs (TCA) cycle is the main channel for the oxidation of organic acids.

Most fresh fruits are acidic with pH range of 3 to 5. Some fruits such as lime and lemons contain as much as 2-3% of their fresh weight as acid. Organic acids of selected fruits are presented in Table 2.

Table 2: Organic acid composition of some fruits.

	Organic acids (mg / 100ml of juice)		
Fruit	**Citric**	**Ascorbic**	**Malic**
Apple	N.D.	tr	518
Grape	tr	tr	285
Peach	109	tr	358
Pear	ND	tr	371

Kiwifruit	730	114	774
Strawberry	207	56	199

Source :Ref 12.

4.5 Pigments

Pigments are the chemical compounds responsible for skin and flesh colour, undergo many changes during the maturation and ripening of fruits. These includes the following

1. Loss of chlorophylls(greencolour) , which is influenced by pH changes, oxidative conditions and chlorophyllase activity.
2. Synthesis and revelation of carotenoids. (yellow and orange colour)
3. Delopment of anthocynins (red, blue and purple colours) , which are fruit specific

β-Carotene is a precursor of Vitamin A and thus is important in terms of nutritional quality. Carotenoids are very stable and remain intact in fruit tissue even after extensive senescence has occurred. Anthocyanins occur as a glycoside in cell sap. Anthocyanins of selected fruits are presentedThey are water soluble, unstable and are readily hydrolyzed by enzymes to free anthocyanin which may be oxidized to give brown oxidizing products.(Table3).

Table 3: Anthocyanins of selected fruits

Fruit	Anthocyanins
Apple	Cyanidin 3-arabinoside Cyanidin 3 –galactoside Cyanidin 3 –glucoside
Grape	Cyanidin 3 –glucoside Cyanidin 3 –rutinoside
Peach	Cyanidin 3 –glucoside
Strawberry	Cyanidin 3 –glucoside Pelargonidin 3-glucoside

Source :Ref 12.

4.6 Phenolic compounds

Total phenolic content is higher in immature fruit thanin mature fruits and typically ranges from 0.1 and 2 g/ 100g fresh weight. Fruit phenolic includes chlorogenicacid,catechin, epicatechin, leucoanthocyanidins, favonols, cinnamic acid derivatives and simple phnolics. Chlorogenic acid occurs widely in fruits and is the main substrate involved in enzymatic browning of cut or otherwise damaged fruit tissue when exposed to air.

4.7 Volatiles

Volatiles are responsible for the characteristic aroma of the fruits. They are present in extremely small concentration in the fruit as less as ppm and ppb range. The major volatile formed in climacteric fruit is ethylene. Ethylene does not have strong aroma and does not contribute to the typical fruit aroma.

Volatiles compounds are largely esters, carbonyls, alcohols, aldehydes and ketones and acids. Very large number of volatile compounds has been identified in fruits and more are identified as advances in separation and detection techniques and gas chromatography methods are made.However, only a few key volatile compounds impart a chractristic flavour to a particular fruit such as Amyl acetate in Banana.

4.8 Vitamins

The water soluble vitamins include Vit C, thiamin, riboflavin, niacin, VitB6 ,Vit $B_{12,}$ biotin and pantothenic acid, Fat soluble vitamins include vitamins A, D E and K. Fat soluble vitamins are less susceptible to post -harvest losses.

Ascorbic acid is the most sensitive to destruction since when the commodity is subjected to advance handling and storage conditions. Losses are enhances by extended storage, higher temperature, low relative humidity, physical damage and chilling injury. Post-harvest losses in Vitamins A and B are usually much smaller than losses in Vitamin C. They are, however, susceptible to degradation to higher temperatures in the presence of oxygen.

4.9 Minerals

Important fruit minerals includes Ca, Mg, Na, K, P, Cl and S. Minerals present in micro quantities include Fe, Cu, Co, Mn, Zn, I and MO

Potassium is the most abundant mineral found in the fruits. It most often occurs in combination with organic acid. High potassium content is often associated with increased acidity and improved colour of the fruit.

Calcium is the second most important mineral constituent and is associated primarily with the cell wall. High calcium content reduce CO_2 and C_2H_2production rate , delay ripening , reduce incidence of physiological disorders such as bitter pit of apples.

Magnesium is a component of chlorophyll molecule which is responsible for the intensity of the green colour in fresh fruit. Phosphorous is a constituent of cytoplasmic and nuclear protein play a major role in carbohydrate metabolism and energy transfer.High phosphrous content may result in decrease acidity in some fruits.

5.0 Factors influencing composition and quality of fruits

5.1Pre-harvest factors

a) Genetic : Selection of cultivars, rootstocks are important because there are often differences in raw fruit composition , post- harvest life potential and response to processing.

b) **Climate**: Climatic factors such as temperature, light, wind may have strong influence on nutritional quality of the fruit. Light intensity significantly affects vitamin concentration and temperature influences transpiration rate which affects mineral uptake and metabolism

c) **Cultural practices**: includes soil type, soil nutrient and water supply, pruning and thinning. Fertilizer addition may significantly affect the mineral content of the fruit. While other cultural practices such as pruning and thinning may influence nutritional composition by changing fruit crop load and size.

5.2Maturity at harvest and harvesting methods

Maturity at harvest is one of the primary factors affecting fruit composition, quality and storage life. Although most fruits reach peak eating quality when harvested fully ripe, they are usually picked mature, but not ripe to decrease mechanical damage during post-harvest handling. Harvesting may also mechanically damaged fruits: therefore, choice of harvest method should allow for maintenance of the quality.

5.3 Post –harvest factors

a)Environmental temperature, relative humidity, atmospheric composition. Temperature management is the most important tool for extension of shelf life and maintenance of quality of fresh fruit. Relative humidity influences water loss, decay development and incidence of physiological disorders and uniformity of fruit ripening. Optimal relative humidity for storage of fruit is 85-90%. Finally atmospheric composition (O_2, CO_2 and C_2H_2 in particular) can greatly influence respiration rate and storage life.

b) Handling methods: post- harvest handling systems involve the channels through which harvested fruit reaches the processing facility or consumer. Handling methods should be chosen such that they maintain fruit quality and avoid delays

c) Time period between harvesting and consumption: delays between harvesting and cooling or processing may result in direct losses (due to water loss and decay) and indirect losses (decrease in flavor and nutritional quality)

Key to successful handling of fresh fruits

Maturity and quality

1. Harvest at proper stage of maturity that will result in the best eating quality
2. Eliminate fruits with defects in orchard or soon after delivery to the processing plant

Temperature and humidity management procedure

1. Harvest during the cool part of the day

2. Keep in the shade while accumulating fruits in the orchard

3. Transport fruits to the processing plant as soon as possible after harvest and use refrigerated transport vehicles for distances that require more than two hours.

4. Avoid delays at the processing plant. If delay cannot be avoided, cool and hold fruits at or near their optimum storage temperature until processed.

5. Maintain proper temperature and relative humidity during ripening of fruits requiring such treatment (with or without added ethylene).

Physical damage

1. Handle fruits with care during harvesting,hauling to the processing plant, and during the handling operations within the plant.

2. Avoid drops, impact, vibrations, and surface injuries of fruits throughout the handling system.

3. use containers that will provide adequate protection of commodity from physical injuries when stacked during temporary storage.

Sanitation procedure

1. Sort out and properly discard the decayed fruits

2. Clean harvest containers, processing plant machinery, cooling and storage facilities, and transit vehicles periodically with water, soap and disinfectant.

Expedited handling

1. Reduce the time between the harvest and cooling of the fruit.
2. Avoid exceeding the fruits storage life, based on flavor quality, before processing

Wide varieties of fruits are cultivated in India, and are available in abundance in the season. Some of the minor fruits of our country such as amla, Jamun, jackfruit, cashew, apple, sapota etc. are not grown in many countries. Therefore, marketing these fruits as fresh commodity or in the form of various value added products will pave the way for the effective utilization of these fruits. In addition, development of fruit varieties which can withstand the various processing conditions should be the ultimate goal of the Scientists.