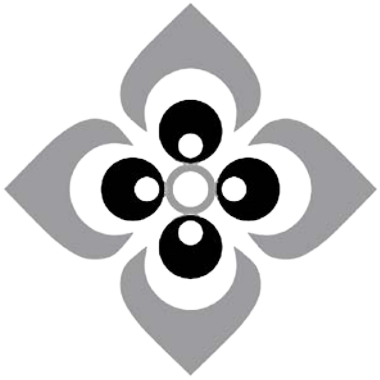

Consortium for Educational Communication

Module
on
Fruits

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TEXT

Although most of us have a good idea what fruits and vegetables are when we eat them, it would be difficult to provide a definition for someone of just what makes one food a vegetable and another a fruit. For a botanist, the definitions are easier; a fruit is a reproductive structure of an angiosperm which develops from the ovary and accessory tissue, which surrounds and protects the seed. Fruits are important in seed dispersal. In culinary sense a fruit is usually any sweet-tasting plant product, especially those associated with seeds.

Botanical Classification of fruits

All fruits may be classified into three major groups on the basis of the number of ovaries and the number of flowers involved in their formation. The following outline includes most of the common types of fruits.

A. Simple fruits

Simple fruits develop from a single matured ovary in a single flower. Accessory fruits have some other flower part united with the ovary.

1. Fleshy fruits- pericarp fleshy at maturity.

a) Berry, consisting of one or more carpels with one or more seeds, the ovary wall fleshy.

- Pepo (an accessory fruit)- a berry with a hard rind, the receptacle partially or completely enclosing the ovary.
- Hesperidium- a specialized berry with a leathery rind.

b) Drupe, a stone fruit, derived from a single carpel and containing (usually) one seed. Exocarp a thin skin.

c) Pome (an accessory fruit), derived from several carpels, receptacle and outer portion. of pericarp fleshy, inner portion of pericarp papery or cartilaginous, forming a core

d) Hip (an accessory fruit), several separate carpels enclosed within the fleshy or semi-fleshy receptacle

2. Dry fruits- pericarp dry at maturity.

a. Dehiscent fruits- those which dehisce or split open when fully mature.

(i) Follicle-composed of one carpel and splitting along a single suture

(ii) Legume-composed of a single carpel and splitting along two sutures

(iii) Capsule, composed of several carpels and opening at maturity in one of four ways:

- Along the line of carpel union (septicidal dehiscence).
- Along the middle of each carpel (loculicidal dehiscence).
- By pores at the top of each carpel (poricidal dehiscence).
- Along a circular, horizontal line (circumscissle dehiscence)

(iv) Silique- composed of two carpels which separate at maturity, leaving a persistent partition between them

b. Indehiscent fruits- those which do not split open at maturity.

(i) Achene or akene, a one-seeded fruit with the seed attached to the fruit at one point only.

(ii) Caryopsis or grain, a one-seeded fruit in which the seed is firmly attached to the fruit at all possible points.

(iii) Samara, a one- or two-seeded fruit with the pericarp bearing a wing like outgrowth.

(iv) Schizocarp, consisting of two carpels which at maturity separate along the midline into two one-seeded halves, each of which is indehiscent.

(v) Loment, having several seeds, breaking into one-seeded segments at maturity

(vi) Nut, a hard, one-seeded fruit, generally formed from a compound ovary, with the pericarp hard throughout

B. Aggregate fruits

Aggregate fruits consist of a number of matured ovaries formed in a single flower and arranged over the surface of a single receptacle. Individual ovaries are called fruitlets.

C. Multiple fruits

Multiple fruits consist of the matured ovaries of several to many flowers more or less united into a mass. Multiple fruits are almost invariably accessory fruits.

Classification on the basis of growing region

Fruits are commonly classified by growing region as temperate-zone, sub-tropical, and tropical. Growing region and environmental conditions specific to each region scientifically affect fruit quality. Examples of fruit grown in each region are listed below.

a) Temperate-Zone Fruits

- Pome fruits: apple, Asian pear, European pear, Quince.
- Stone fruits: apricot, cherry, nectarine, peach, plum.
- Small fruits and berries: grape (European and American types), strawberry, raspberry, blueberry, blackberry, cranberry.

b) Subtropical Fruits

1) Citrus Fruits: grapefruit, lemon, lime, orange, pummelo, tangerine, and mandarin

2) Non-citrus Fruits: avocado, cherimoya, fig, kiwi fruit, olive, pomegranate.

c) Tropical Fruits

- Major tropical fruits: banana, mango, papaya, pineapple.
- Minor tropical fruits: carambola, cashew apple, durian, guava, longan, lychee, mangosteen, passion fruit, rambutan, sapota, tamarind.

Chemical composition and nutritional significance of fruits

Fruits are wonderful natural medicines wrapped with vitamins, minerals, fibers and phyto-chemicals, the latter being responsible in part for the anti-oxidant properties of fruits and foods of fruit origin. They could be best feast to humans not just because of their VIBGYOR colors and fantastic aromas but their absolute nutritional profile that help us to stay healthy. Fruits are low in fat and calories. In general, vitamins, minerals, water, and fibers are considered to be the main nutrients contributed to

fruits to balanced diet but now the trend is changing and attention is now giving to the nutraceutical properties of fruits. The composition of fruits is strongly influenced by the variety and ripeness. As the fruit approaches maturity, sugar content increases while starch, acid, and tannin content decreases. In addition to that there starts development of certain volatile compounds which give the fruit its characteristic aroma. There is also degradation of chlorophyll and development of anthocyanins and carotenoids during ripening. The major constituents in fruits are sugar, polysaccharides, and organic acids, while N- compounds and lipids are present in lesser amounts. Minor constituents include pigments and aroma substances of importance to sensory quality, and vitamins and minerals of nutritional importance. Nuts are highly variable in composition. Their moisture content is below 10%, N-compounds are about 20%, and lipids are as high as 50%.

1. **Carbohydrates**

Carbohydrates are the most abundant and widely distributed food components derived from plants. Fresh fruits vary greatly in their carbohydrate content, with the general range between 10 to 25%. The structural framework, texture, taste, and food value of a fresh fruit is related to its carbohydrate content. Sucrose, glucose, and fructose are the primary sugars found in fruits and their relative importance varies among commodities.

Monosaccharides

In addition to glucose and fructose, the ratios of which vary greatly in various fruit, other monosaccharides occur only in trace amounts. For example, arabinose and xylose have been found in several fruits. An exceptional case is avocado, in which a number of higher sugars are present at from 0.2% to 5.0% of the fresh weight (D-manno-heptulose, D-talo-heptulose, D-glycero-D-galacto-heptose, D-glycero-D-manno-octulose, D-glycero-L-galacto-octulose, D-erythro-L-gluco-nonulose, and D-erythro-L galactononulose). Small amounts of heptuloses have been found in the flesh of apples, peaches, and strawberries, and in the peel of grapefruit, peaches, and grapes.

Oligosaccharides

Saccharose (sucrose) is the dominant oligosaccharide. Other disaccharides do not have quantitative importance. Maltose occurs in small amounts in grapes, bananas, and guava (Myrtaceae). Melibiose, raffinose, and stachyose have also been detected in grapes. In ripe bananas, 6-Kestose has been identified. The study of monosaccharide and oligosaccharide composition may be useful in detection of adulteration of fruit juices. Other oligosaccharides occur only in trace amounts. The proportion of reducing sugars to sucrose can vary greatly. Some fruit have no saccharose (e.g., cherries, grapes, and figs), while in some the saccharose content is significantly higher than the reducing sugar content (e.g., apricots, peaches, and pineapples). Among sugar derivatives, D-sorbitol is abundant in Rosaceae fruits (pomme fruits, stone fruits). For example, its concentration is 300 mg/100 ml to 800 mg/100 ml in apple juice. Because fruits such as berries, citrus fruits, pineapples, or bananas do not contain sorbitol, its detection is of analytical importance in the evaluation of wine and other fruit products. Meso-inositol also occurs in fruit; in orange juice it ranges from 130 mg/100 ml to 170 mg/100 ml.

Polysaccharides

All fruit contain cellulose, hemicellulose, pentosans, and pectins. The building blocks of these polysaccharides are glucose, galactose, mannose, arabinose, xylose, rhamnose, fructose, and galacturonic and glucuronic acid. The pectin fractions of fruits are particularly affected by ripening, with a decrease in the insoluble pectin fraction. The total pectin content can also decrease. Starch is present primarily in unripe fruits, and its content decreases to a negligible level as ripening proceeds. Exceptions are bananas, in which the starch content can be 3% or more even in ripe bananas, and in various nuts such as cashews and Brazil nuts.

The recommended dietary allowance (RDA) for carbohydrates is 130 g/day, except in the cases of pregnancy (175 g/day) and lactation 210 g/day). Carbohydrates should represent 45-65% of the total energy consumed per day. (IM, 2002).

2. FATS

Most fruits are naturally low in fat, sodium, and calories. None have cholesterol. Fats are used in body as carrier for fat soluble vitamins and some of the phytonutrients

like carotenoids and phytoestrogens that are lyophilic in nature. There are some fatty acids which are essential and can be ingested only from fat. These essential fatty acids are needed to make cell structures and act as prostaglandin precursors.

Fats can occur in two different forms viz. saturated and unsaturated. Among these two unsaturated fatty acids are beneficial and have many uses in the body. Unsaturated fatty acids are of two types. Monounsaturated fatty acids (MUFA's) which include oleic and palmitoleic acid and polyunsaturated fatty acids (PUFA's) which include linoleic, linolenic and arachdanoic acid. They are needed to build and repair cell structures, such as cell membrane and nervous tissues. Fruits in general are poor in fat content, however, avocado (16-20%) and cherimoya (1%) have higher lipid level. Avocado is rich in oleic, linoleic, linolenic, stearic, and palmitoleic acid, but their amount may vary with the variety, maturity, processing and storage condition (Ansorena-Arteida,2000).

Fats should represent 20- 35% of the total energy consumed per day in order to reduce the risk of chronic heart diseases. This fat should include 10-14g/day of linoleic acid and 1.2-1.6g/day of linolenic acid.

3. PROTEINS

Along with the carbohydrates and fats our body also needs proteins which are made of essential, non essential amino acid, and conditional amino acids, for good health. Proteins are essential nutrients for the human body (Hermann, Janice R). Essential amino acids are not synthesized by the body and are essentially taken in diet, non essential amino acids are not necessarily taken in diet as the body is capable of synthesizing them and conditional amino acids are usually not essential, except in times of illness.

Essential amino acids are leucine, isoleucine, valine, lysine, threonine, tryptophan, methionine, phenylalanine and histidine. Non-essential amino acids include alanine, asparagine, aspartic acid and glutamic acid. Conditional amino acids include arginine, cysteine, glutamine, glycine, proline, serine, and tyrosine.

Proteins are made of long chain of amino acids. They have primary, secondary, tertiary and quaternary structures. Proteins are essential structural components of all cells and are needed to build and repair tissues by the human body, for the synthesis of enzymes, hormones, etc. Proteins play both regulatory and plastic role in the body as

they also play a role in the immune system and coagulation.

4. **ORGANIC ACIDS**

Organic acids are important intermedia products of metabolism. The 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 . These are metabolized into many constituents, including amino acids, which are the building blocks of proteins. Most fresh fruits are acidic in nature with a pH range of 3-5. Some citrus fruits like lemon and limes, contain as much as 2-3% of their total fresh weight as acid. Acid content usually decreases during ripening due to utilization of organic acids during respiration or their conversion to sugars. Malic and citric acids are the most abundant in fruits, except grapes and kiwi fruit where tartaric and quinic acid, respectively are most abundant.

5. **PIGMENTS**

Pigments are the constituents which give fruits their fabulous colors and make them more appealing and attractive. These are the color imparting agents to the flesh and skin of fruits. These pigments undergo number of changes during the maturation and ripening of fruits. These include the following:

i) Loss of chlorophyll (green color), which is influenced by pH changes, oxidative conditions, and chlorophyllase activity.

ii) Synthesis and revelation of carotenoids (yellow and orange colors).

iii) Development of anthocyanins (red, blue, and purple colors), which are fruit specific.

Beta carotene is a precursor to vitamin A and thus is important in terms of nutritional quality. Carotenoids are very stable and remain intact in fruit tissues even when excessive senescence has occurred. Carotenoids are red, orange, or yellow tetraterpenoids. They function as accessory pigments in plants, helping to fuel photosynthesis by gathering wavelengths of light not readily absorbed by chlorophyll. The most familiar carotenoids are carotene (an orange pigment found in carrots), lutein (a yellow pigment found in fruits and vegetables), and lycopene (the red pigment responsible for the color of tomatoes). Carotenoids have been shown to act as antioxidants and to promote healthy eyesight in humans. Anthocyanins occur as

glycosides in the cell sap. They are water soluble, unstable and are readily hydrolysed by enzymes to free anthocyanins , which may be oxidized by phenol oxidases to give brown oxidation products.

6. PHENOLIC COMPOUNDS

Phenolic compounds occur in all fruits as a diverse group of secondary metabolites. Fruit phenolics include chlorogenic acid, catechin, epicatechin , leucoanthocyanidins, flavonols , cinnamic acid derivatives and simple phenols. Chlorogenic acid occurs widely in fruits and is the main substrate involved in enzymatic browning of cut or otherwise damaged fruit tissues when exposed to air. Enzymatic browning occurs due to the oxidation of phenolic compounds and is mediated, in the presence of oxygen, by the enzyme polyphenol oxidase. The initial product of oxidation is usually O-quonone, which is highly unstable and undergoes polymerization to yield brown pigments of higher molecular weight. Astringency is directly related to phenolic content and it usually decreases with fruit ripening because of conversion of astringent phenolic compounds from the soluble to insoluble non astringent form. There is a strong positive relationship between phenolic content and anti oxidant capacity of fruits and their products.

7. VOLATILES

In fruits, the volatiles representing their characteristic flavor are generally esters, aldehydes, alcohol, terpenes or their derivatives. Volatiles are present in very minute quantities less than 100 micro gram per gram of fresh weight. The major volatile formed in climacteric fruits is ethylene, and does not have a strong aroma and does not contribute to typical fruit aromas. Very large number of volatiles have been identified in fruits and more are identified as advances in separation and detection techniques and gas chromatographic methods are made. But only a few volatiles are important for the particular aroma of a given fruit. Their relative importance depends upon threshold concentration, potency and interaction with other compounds.

8. WATER

The human body can sustain for weeks without food but can hardly survive for days without water. Water forms the basis of almost all metabolic processes in human body and as the human body can’t store water it regularly needs fresh supplies to make up

losses from lungs, skin, urine and feaces.

Water plays two fundamental roles as a nutrient: (1) protective and regulatory, by being a substrate of biological reactions or acting as the matrix or vehicle in which those reactions take place, and (2) an essential role as the temperature and pH regulator in the human body. Other functions include maintenance the health and integrity of every cell in the body, help in removal of byproducts from the body, lubricate and cushion joints, keep mucous membranes moist, serve as a shock absorber inside the eyes, spinal cord and in the amniotic sac surrounding the fetus during pregnancy, and aid digestion and prevent constipation. Fruits have a high percentage of water that ranges 70% to 90% of the edible part of the fruit. For this reason they are a good source of water in the diet among the solid foods. Water content of fruits varies with maturation, therefore optimum maturation stage should be chosen for fruit consumption.

9. **FIBER**

Dietary fiber consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants. Functional fiber consists of isolated, nondigestible carbohydrates that have beneficial physiologic effects. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.

Chemically, dietary fiber consists of non-starch polysaccharides such as arabinoxylans, cellulose, and many other plant components such as resistant starch, resistant dextrins, inulin, lignin, waxes, chitins, pectins, beta-glucans, and oligosaccharides (Food and nutrition board,2005) . A novel position has been adopted by the US Department of Agriculture to include functional fibers as isolated fiber sources that may be included in the diet.(Anderson JW, Baird P, Davis RH et al. (2009). Dietary fibers have three primary mechanisms: bulking, viscosity and fermentation.[Gallaher, Daniel D. (2006). Dietary fibers can change the nature of the contents of the gastrointestinal tract, and to change how other nutrients and chemicals are absorbed through bulking and viscosity (Eastwood M, Kritchevsky D 2005). Some types of soluble fibers bind to bile acids in the small intestine, making them less likely to enter the body; this in turn lowers cholesterol levels in the blood. Viscous soluble fibers may also attenuate the absorption of sugar, reduces sugar response after eating, normalizes blood lipid

levels and, once fermented in the colon, produce short-chain fatty acids as byproducts with wide-ranging physiological activities. Insoluble fiber is associated with reduced diabetes risk, but the mechanism by which this occurs is unknown (Weickert M. O, 2008). One type of insoluble dietary fiber, resistant starch has been shown to directly increase insulin sensitivity in healthy people, (Weickert M. O, 2008), in type 2 diabetics,[Zhang, 2007) in individuals with insulin resistance, (M. Denise, 2003), possibly contributing to reduced risk of type 2 diabetes(Johnston, K L, 2010) (Maki, Kevin C, 2012; Robertson, M, 2012).

Different fiber-associated substances are found in fruits which may attribute to nutrition of the fruits. Among them are phylates, saponins, tannins, lectins, and enzyme inhibitors. Saponins, which are mainly present in some tropical fruits, may enhance the binding of bile acids to fiber and reduce cholesterol.

Dietary fiber is present in fruits in very high amount and within fibers celluloses, hemicelluloses, and pectins are most common components. The RDA for fiber is 25-30 g/ day, depending on age and sex, except in children where it's 19g/day.

10.**VITAMINS**

Vitamin is an organic compound required by an organism as a vital nutrient in limited amounts. Vitamins cannot be synthesized in sufficient quantities by an organism, and must be obtained from the diet. Fruits are enriched with many important vitamins, indispensable for a number of vital activities within the human body.

Vitamin C or Ascorbic acid: Vitamin C refers to a number of vitamers that have vitamin C activity in animals, including ascorbic acid and its salts, and some oxidized forms of the molecule like dehydroascorbic acid. It is the most effective and least toxic naturally occurring antioxidant. It is important for the formation of collagen, cartilage, blood vessels and muscles. It also facilitates the absorption of iron and reduces the risk of cardiovascular diseases and can't be synthesized in body. This vitamin is abundantly found in apple, banana, pear, orange, lemon, plum, strawberry, raspberry, blackberry, grapes, mango and watermelon.

Vitamin A or Retinol: This vitamin is essential for cell reproduction, formation of hormones, stimulation of immune system and improvement of vision and hair growth. It also helps in proper growth and development of teeth and bones. It plays a role in

a variety of functions throughout the body, such as:Vision,Gene transcription,Immune function,Embryonic development and reproduction, Bone metabolism, Haematopoiesis, Skin and cellular health and Antioxidant activity. Vitamin A deficiency can lead to night blindness, dryness of skin, weak bones and teeth. Orange, watermelon, blackberry, peach, kiwi and apple are some of the fruits rich in vitamin A.

Vitamin B complex

Vitamin B_1: Vitamin B_1, also known as thiamine, is not present abundantly in fruits. It's active compound, thiamine diphosphate serves as a cofactor for several enzymes in carbohydrate metabolism where pyruvate is converted to acetyl Coenzyme A (CoA). It is also important for ensuring normal functioning of heart, nervous system and muscles (IM,1998; ASNS! 2004; Lusaki, 2004). It is involved in RNA and DNA production. Chronic thiamine deficiency can also cause Korsakoff's syndrome, an irreversible psychosis characterized by amnesia and confabulation. Thiamine is found in banana, pear, lemon, raspberry, orange, mango, grapefruit and pineapple.

Vitamin B_2 or Riboflavin: Riboflavin is involved in the energy production for the electron transport chain, the citric acid cycle, as well as the catabolism of fatty acids (beta oxidation).Vitamin B2 or riboflavin plays a significant role in the production of red blood cells, growth and development of body and reproduction. It can be found in kiwi, though most fruits are not substantial sources of vitamin B2. Riboflavin is also required in carbohydrate metabolism. Its deficiency causes ariboflavinosis.

Niacin or nicotinic acid or Vitamin B_3: Nicotinamide is a precursor of nicotinamide adenine (NAD), nucleotide, and nicotinamide adenine dinucleotide phosphate(NADH), in which the nicotinamide moiety acts as electron acceptor or hydrogen donor, respectively, in many biological redox reactions. Vitamin B3 is found in banana, peach, watermelon, kiwi and cantaloupe, and is essential for the smooth operation of digestive and nervous systems. It is also important for a healthy skin and normal growth. Sufficient intake of vitamin B3 prevents the occurrence of the disease 'pellagra.

Vitamin B_6 or pyridoxine hydrochloride: Vitamin B_6 has another two forms pyridoxal, and pyridoximine. It is the most versatile enzyme cofactor as it acts as a cofactor for transferases, transaminases and decarboxylases, used in transformation of amino acids. Pyridoxine plays a very crucial role in the metabolism of carbohydrate, fat and

protein. It helps in the production of antibodies, and red blood cells and smooth operation of the nervous system. Vitamin B6 is mainly found in banana, and watermelon. Its deficiency may result in nausea, irritability, insomnia, dermatitis, asthma and allergies.

Folic acid or Vitamin B_9: The metabolic role of folate is an acceptor and donor of one carbon units in a variety of reaction in amino acid and nucleotide metabolism. Folic acid Deficiency results in a macrocytic anemia, and elevated levels of homocysteine. Deficiency in pregnant women can lead to birth defects hence its sufficient intake during pregnancy is very important. Its deficiency Masks B12 deficiency, which can lead to permanent neurological damage. Folate is also important for production of red blood cells, DNA and constituent parts of the nervous system. Strawberry, blackberry, kiwi, orange and banana are significant sources of vitamin B9.

Vitamin B_5 or Pantothenic acid: Pantothenic Acid is involved in the oxidation of fatty acids and carbohydrates. Coenzyme A, which can be synthesised from panothenic acid, is involved in the synthesis of amino acids, fatty acids, ketones, cholesterol,((phospholipids, steroid hormones, neurotransmitters (such as acetylcholine) and antibodies(Gropper, 2009).

Vitamin B_{12} or Cobalamin: Vitamin B_{12} is involved in the cellular metabolism of carbohydrates, proteins and lipids. It is essential in the production of blood cells in bone marrow, nerve sheaths and proteins (Vitamin B_{12} functions as a co-enzyme in intermediary metabolism for the methionine synthase reaction with methylcobalamin, and the methylmalonyl CoA mutase reaction with adenosylcobalamin. Vitamin B_{12} Deficiency results in a macrocytic anemia, elevated homocysteine, peripheral neuropathy, memory loss and other cognitive deficits. It is resent in fruits like kiwi, raspberry.

Vitamin E or Tocopherol: Vitamin E refers to a group of eight fat-soluble compounds that include four tocopherols and four tocotrienols. Vitamin E has many biological functions, the most important one is its antioxidant function. Other functions include enzymatic activities, gene expression and neurological function(s). It's also been suggested that the most important function of vitamin E is in cell signaling. Vegetable and fruits contain little amount of vitamin E (Bramley et al., 2000).

11. **MINERALS**

Minerals are elements that originate in the soil and cannot be created by living things, such as plants and animals. Yet plants, animals and humans need minerals in order to be healthy. For a high nutritional quality of the diet, an adequate intake of minerals is essential as they prevent from chronic nutrition related diseases.

Iron: It is the mineral nutrient that has to be present in the diet as it forms the part of oxygen carrying proteins, hemoglobin in red blood cells and myoglobin in muscles. It is also an important component of various enzymes. Transferrin protein in the blood transports and delivers iron into cells. Plants are a source of non heme iron in the diet and its absorption is influenced by many dietary components, which bind iron in the intestinal lumen. There are both inhibitory as well as enhancers of iron in the diet. Inhibitors such as phytic acid is present in cereals and legumes and poly phenolic substances in coffee and tea. The enhancers are found in fruits and vegetables such as Ascorbic acid. Fruits rich in iron are, Boysenberries, Black currant, Blue berries, Avocado, Bread fruit, Black berries, Banana.

Calcium: Calcium is the most important and common mineral in the body is necessary for the growth and maintenance of strong teeth and bones, nerve signaling, muscle contraction, and secretion of certain hormones and enzymes. As a component in blood composition, calcium is essential for proper muscle and nerve function, and blood clotting. Deficiency may result in muscle spasms and cramps in the short term and osteoporosis. Fruits rich in calcium are Blackberries, Blackcurrant's, Dates, Grapefruit,Mulberries ,Orange ,Pomegranate ,Prickly Pears.

Phosphorus: Phosphorus is an essential mineral that is required for proper cell functioning, regulation of calcium, strong bones and teeth, and for making ATP, a molecule which provides energy to cells. The greatest amount of phosphorus can be found in bone and muscle. The mineral makes 1% of the total body weight. The nucleic acids- DNA and RNA are polymers based on phosphorus ester monomers. The metabolism of all major metabolic substrates depends on the functioning of phosphorus as a cofactor in a variety of enzymes and as the principal reservoir for metabolic energy. Fruits rich in phosphorus are Tamarinds, Purple passion-fruit, Currants, European black, Avocados, Currants, Ground-cherries, Guavas, Kiwifruit

Magnesium: It is the fourth most abundant cation in the body. It helps in formation of bones, relaxation of nerves and muscles. Magnesium and calcium act in conjunction

help to regulate nerve and muscle tone. Magnesium plays a role in over 300 different enzymes, its physiological functions are very extensive and include (but are certainly not limited to) being involved in protein, carbohydrate and fat metabolism, storage of energy in muscle cells and the proper functioning of genes. The digestive system, endocrine system, cardiovascular system, nervous system, muscles, kidney, liver and brain all rely upon magnesium to carry out their metabolic functions. Fruits containing magnesium include Banana, Blackberries, Raspberries, Dates, Avocado, Watermelon.

Potassium: Potassium cation is the most important essential cation of the cells. Potassium is needed to build proteins break down and use carbohydrates. Build muscles build normal body growth, control the electrical activity of the heart. Control the acid-base balance. Potassium is involved in nerve function, muscle control and blood pressure. Fruits that contain significant sources of potassium include citrus fruits, cantaloupe, bananas, kiwi, prunes, and apricots. Dried apricots contain more potassium than fresh apricots.

Sodium: Sodium is a mineral, an essential nutrient. It helps to maintain blood volume, regulate the balance of water in the cells, and keep nerves functioning. The kidneys control sodium balance by increasing or decreasing sodium in the urine. Sodium acts in consort with potassium to maintain proper body water distribution and blood pressure. Sodium is also important in maintaining the proper acid-base balance and in transmission of nerve impulse. Fruits rich in sodium are pomegranate, strawberry, apple, pear, orange, lemon, banana, etc.

Zinc: Zinc is an essential mineral and acts as a stabilizer of the structures of membranes and cellular components, with a wide variety of functions within the human body. Zinc is a component of over 300 enzymes needed to repair wounds, maintain fertility in adults and growth in children, synthesize protein, help cells reproduce, preserve vision, boost immunity, and protect against free radicals, among other functions. Fruits rich in zinc are Apricots, Peaches, Plums, Avocado, Figs, Black currant, etc

Selenium: It is an essential trace element that functions as a component of enzymes involved in anti oxidant protection and thyroid hormone metabolism (ASNS, 2004). It functions as cofactor for reduction of antioxidant enzymes, such as glutathione peroxidases and certain forms of thioredoxin reductase found in animals. Fruits rich in selenium are gooseberry, guava, papaya, jackfruit, lychee, mangoes etc.