UNIT 9 VITAMINS AND MINERALS

Structure

9.0 OBJECTIVES

After studying this unit you should be able to:

- define vitamins and minerals and classify them into various groups,
- outline the physiological importance of vitamins and minerals,
- describe the applications of vitamins and minerals in food industry,
- state the diseases associated with the deficiencies of vitamins and minerals,
- explain the effect of food processing on vitamins and minerals in the food,
- define metal toxicity, state its sources and ill effects,
- describe different food applications of vitamins and minerals, and
- explain the importance of fortification of food.

9.1 INTRODUCTION

In this block, you have so far learnt about the chemistry and the applications of the food constituents occurring in large amounts in different foods. In this unit we deal with the constituents that are present in very small amounts, yet are essential components of food. These include vitamins and minerals and are called micronutrients. One very important aspect of vitamins and minerals is that except for a very few vitamins, these cannot be synthesized in our body and food is their prime source.

The vitamins are involved in a number of physiological functions in our body and their deficiency causes disorders leading to diseases. It is, therefore, pertinent to learn about the basic structure, characteristics and physiological functions of these compounds so as to appreciate their importance in the food.

Since vitamins are present in foods in minute amounts, their protection during preservation and processing of foods is a major concern. An understanding of the effects of food processing on these and the means employed to retain them in the food is equally important.

Similar to vitamins, minerals like iron, calcium, iodine etc. present in food are also important for maintaining normal health. The consequences of their deficiencies are well known. However, some of the minerals like heavy metals are toxic if consumed in excess. Further, certain sections of the population consume foods that are deficient in vitamins and minerals. In such cases, it becomes desirable to use foods supplemented with both the components.

In the light of the above, this unit deals with various vitamins and minerals in terms of their occurrence, classification, physiological role, deficiency diseases, the effect of food processing on them and their food applications.

9.2 CLASSIFICATION OF VITAMINS

Vitamins are a group of organic compounds having diverse structures. These vital components of the food were earlier believed to be amines in their nature and behaviour and hence the name; derived from *'**vital amine**'*. The vitamins do not supply energy to the body but play an important role in the energy transfer as well as in control of many metabolic processes. Vitamins help in converting food into useable energy. Besides, they assist in the manufacture of blood cells, hormones, and the chemicals of the nervous system. Most of the vitamins are generally synthesised by the plants and found in animals as a result of food intake. Some of the vitamins like vitamin A occur in plant foods as **provitamins** e.g., **β-carotene.** However, some organisms can synthesise a few vitamins e.g., rat can synthesise vitamin C and human beings can synthesise vitamin D and niacin.

In the year 1880, Sir, Frederick and Hopkins first reported the necessity of certain food factors. In 1912, Funk observed that diseases like beri-beri, scurvy and pellagra could be prevented by some specific components of food.

Provitamins are the compounds that are not vitamins but can be transformed by the body into vitamins.

All the known vitamins can be classified into two groups, depending on their solubility. These are the **water soluble vitamins** and the **fat soluble vitamins**. The former group comprises of the B group vitamins and vitamin C, where as the fat soluble group includes vitamins A, D, E and K. Most of the water soluble vitamins have well identified coenzyme functions. The fat soluble vitamins, on the other hand, are not known to have any such properties.

We will discuss the chemistry and food applications of the fat soluble vitamins first.

9.3 FAT SOLUBLE VITAMINS

These vitamins are non-polar, hydrophobic molecules which are not soluble in water but readily dissolve in fats. Fat soluble vitamins include vitamin A and carotene (provitamin A), vitamin D, vitamin E and vitamin K. These are fairly stable and are not destroyed by heat and are normally not lost in the cooking process. The fat soluble vitamins are isoprene derivatives and are absorbed along with the normal fats in human beings. They are transported by lipoproteins or with the help of other specific binding proteins in the blood. The body is able to store excess of fat soluble vitamins in the liver and other fat storage sites and are made available when one is on a vitamin deficient diet. However, an overdose of these vitamins may have toxic effects leading to

hypervitaminosis. Therefore addition of fat soluble vitamins to the food or taking vitamin supplements must be carefully controlled.

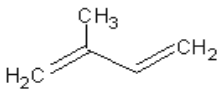
9.3.1 Physiological Importance of Fat Soluble Vitamins

The fat soluble vitamins perform a range of functions in the body. These are found both in plant and animal food sources. The dietary sources, physiological role, deficiency diseases and the hypervitaminosis symptoms of all the fat soluble vitamins are compiled in Table 9.1.

The toxic effect of accumulation of large amounts of a vitamin in the body is called **hypervitaminosis.**

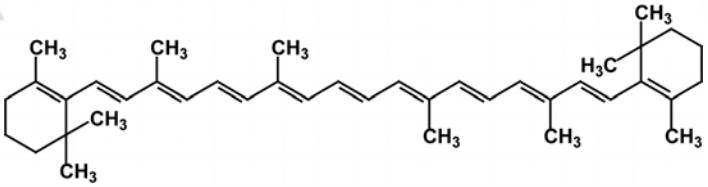
9.3.2 Food Applications of Fat Soluble Vitamins

Vitamin A (Retinol)



Isoprene

Structurally vitamin A is an isoprene derivative related to carotenoid pigments, α, β and γ carotene, found in plants. These carotenoid pigments are precursors of vitamin A and are known as **provitamin A.** β-carotene has a symmetrical structure and it gives rise to two molecules of vitamin A by enzymatically catalysed symmetrical oxidative cleavage.



β-carotene

Vitamin A finds use in food industry in two forms- as ***dry powder*** and in ***water soluble*** form. Vitamin A dry powder is used in the manufacture of dry mixtures, which find applications in dry formulations like coated tablets and capsules. It is also a preferred choice in animal feed industry. The stability of vitamin A in the dry powder is enhanced by matrix coating of the vitamin A esters with gelatine, which protects them from direct oxidation.

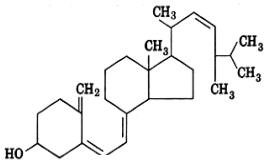
In the water soluble form, vitamin A is a yellowish green, slightly turbid, fluorescent liquid with a faint characteristic odour. Water soluble vitamin A finds extensive use in the manufacture of solutions for oral administration. It contains the palmitate ester of vitamin A which is made miscible with water and aqueous liquids by a solubilizer. In addition, a stabiliser is added to the preparation so as to delay a possible loss of activity by atmospheric oxidation.

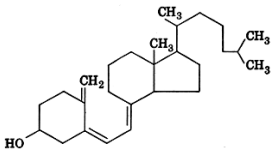
Vitamin D

Vitamin D is a group of compounds related to sterols. Sterols are polyaromatic alcohols. This vitamin occurs in several forms, the two most important are vitamin D_2 or ergocalciferol and vitamin D_3 or cholecalciferol. Vitamin D_2 is produced by the UV irradiation of ergosterol, present in yeast and moulds. **Vitamin D_3** is produced by the UV irradiation of 7-dehydrocholesterol, present in the skin.

Table 9.1: Dietary Sources, Physiological Functions, Deficiency Diseases and Hyper-vitaminosis Symptoms of Fat-soluble Vitamins

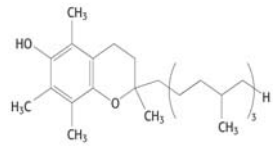
	Name of the Vitamin	Dietary Sources	Physiological Functions	Deficiency Diseases	Hyper-vitaminosis
1	Vitamin A (Retinol)	• Only in fish liver oil and foods of animal origin such as liver, eggs, milk and fatty fish • Plant foods contain only carotenoids (the precursor of vitamin A) and include green leafy vegetables, tomato, carrot, mango and other yellow coloured fruits	• Maintenance of normal vision • Building and growth of skeletal cells and provides immunity to the body • Dietary retinoids, especially carotenoid compounds have been found to suppress carcinogenesis (development of cancer)	• Night blindness • In early stages of vitamin A deficiency, one cannot see well in dim light • In advanced deficiency, the person cannot see objects in dim light • cessation of growth and keratinization of the epithelium in various parts of the body, such as the respiratory, alimentary, reproductive and genitor-urinary tracts, • defects in the teeth, • disturbances in bone growth	• Mild: nausea, irritability, blurring of vision • Severe: growth retardation, enlargement of liver and spleen, hair loss, increased skull pressure
2	Vitamin D	• Vitamin D_2 occurs in small amounts in fish liver oils • Vitamin D_3 is widely distributed in eggs, milk, butter and cheese but large amounts occur only in fish liver oils	• Essential for bone formation • Promotes absorption of calcium and phosphorous and deposition in bone • Involved in the formation of teeth	• Calcification (calcium deposition) of bone does not take place • Result in the disease called rickets in infants and children leading to bowleg, enlargement of ankles and wrists and deformities of the chest bones called 'pigeon breast', osteomalaeia in older people.	• Mild: nausea, weight loss, irritability • Severe: mental and physical growth retardation, kidney damage
3	Vitamin E	• Delta tocopherols were isolated from soybean oil as the richest natural sources • Cereal germ oils like wheat germ oil and corn germ oils, soybean oil • Cottonseed oil contains alpha, beta, and gamma tocopherols	• Essential for normal reproduction in several species of animals and also in human beings	• Reproductive failure • Liver necrosis (damage) • Muscular dystrophy, etc. The cardiac and smooth muscles as well as the skeletal muscles are affected.	• Severe: nausea, digestive tract disorders
4	Vitamin K	• Occurs widely in plant foods, especially in leafy vegetables like spinach, cabbage, alfa-alfa • Almost 50% of the vitamin requirement is derived from intestinal micro-organisms	• Essential for blood clotting by increasing the prothrombin levels in blood	• Inadequate intake or inadequate intestinal absorption of vitamin K • Inadequate intestinal absorption can occur due to disease of the liver or diarrhoea • Deficiency leads to increased blood clotting time. This may lead to haemorrhage conditions	• No significant consequence reported, however, in severe cases the liver may get damaged





Vitamin D_2 (Calciferol) **Vitamin D_3 (Cholecalciferol)**

Vitamin D_2 is primarily used in the preparation of various drug formulations. A mineral stable dry powder under the name of vitamin D_2 is commercially available in the animal feed industry. In many countries, milk and milk roducts, margarine and vegetable oils fortified with vitamin D serve as a ıajor dietary source of vitamin.



Vitamin E (α-tocopherol)

Vitamin E

Vitamin E belongs to a group of compounds called tocopherols are soluble in nonpolar solvents and are insoluble in water. The storage stability of unrefined vegetable oils is attributed to the tocopherols present in them.

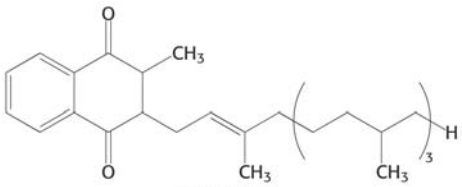
Vitamin E has excellent antioxidant properties and is destroyed by oxidising agents and UV light; however, it is fairly resistant to heat. As an antioxidant, vitamin E protects vitamins A and C, red blood cells and essential fatty acids from destruction. Regular consumption of antioxidant-rich fruits and vegetables is claimed to be associated with lowering risk for heart disease, cancer and several other diseases. Since alpha tocopherols have the highest biological activity, its content is taken for calculating the human requirements.

DL-α-tocopherol is mainly used as an antioxidant in stabilising edible oils, fats and fat-containing food commodities, pharmaceutical preparations and cosmetics.

Vitamin K

Its deficiency cannot occur easily in animals. Animal foods like egg yolk, milk, and butter contain little vitamin K.

Vitamin K belongs to the group of compounds called quinones. Vitamin K_1 is called phylloquinone and K_2 is called menaquinone. Vitamin K_1 is the only vitamin K found in plants. Vitamin K_3 is menadione and is synthetic in nature.



Menadione is used in the preparation of drug formulations and vitamin K supplementation of feed mixes and infant formula foods.

Before proceeding the water soluble vitamins try to answer the following exercise.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

Match the statements given in column 1 with the terms given in column 2.

Column 1	Column 2
a) Precursor to vitamin A	i) Vitamin D
b) Deficiency leads to bow legs	ii) Carotenoids
c) Used as an antioxidant	iii) Vitamin K
d) Essential for blood clotting	iv) Vitamin E

2. β-Carotene is called provitamin A because:
   i) it favours absorption of vitamin A.
   ii) it gets converted to vitamin A in the body.
   iii) it is one of the components of vitamin A structure.
   iv) it catalyses the synthesis of A in the body.

9.4 WATER SOLUBLE VITAMINS

As mentioned earlier, these vitamins are readily soluble in water and include a group of vitamins called vitamin B and vitamin C. Due to their solubility in water these vitamins get regularly eliminated from the body through urine. The body, therefore, requires a regular intake of these vitamins and these must be present in our daily diet. These vitamins are destroyed by prolonged heat and there is an appreciable loss of vitamin activity during the cooking process.

9.4.1 Physiological Importance of Water Soluble Vitamins

Let us read about the physiological and chemical significance and the food applications of water soluble vitamins in the following sub-sections. You will find the dietary sources, physiological functions and deficiency diseases of the water soluble vitamins in Table 9.2. As mentioned above, these vitamins are water soluble, any excess amount in the body is eliminated through urine etc. Therefore unlike fat soluble vitamins these do not get accumulated in the body. Fruits and vegetables are a good source of water soluble vitamins.

Table 9.2: Dietary sources, physiological functions and deficiency diseases of water soluble vitamins

Name of the Vitamin	Dietary sources	Physiological functions	Deficiency diseases
Vitamin B_1 (Thiamine)	• Whole cereals, pulses (legumes), oilseeds, eggs, pork and nuts	• Functions in carbohydrate metabolism. • Free thiamine is readily absorbable by small intestine • Necessary for nerve function, appetite and normal digestion	Mild deficiency leads to loss of appetite, fatigue, depression, irritability gastrointestinal disturbances, oedema, muscular incordination and heart failure resulting from an abnormal enlargement of the heart. • Beriberi disease
Vitamin B_2 (Riboflavin)	• Liver, dried yeast, white bread, egg powder, whole and skim milk	• Concerned in the regulatory function of insulin. • The retina	• Causes oral and facial, scrotal, vulval, and also ocular lesions. • Itching and burning of

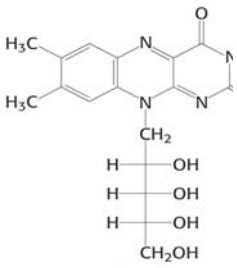
Name of the Vitamin	Dietary sources	Physiological functions	Deficiency diseases
	powder are excellent sources • Milk, cheese, eggs, whole grain and green leafy vegetables are also good sources.	contains riboflavin, which is converted by light to a compound involved in stimulation of the optic nerve • Forms a part of enzyme systems involved in the metabolism of carbohydrates, fats and proteins.	the eyes, microssed sensitivity to light dimness of vision at a distance and vascularization and opacity of the cornea • Severe deficiency in animals leads to cessation of growth and eventual death.
Vitamin B_5 (Pantothenic acid)	• Widely distributed in foods. • Dried yeasts, liver, rice polishing, wheat germs, fleshy foods, eggs, fish etc. are good sources.	• Important role in the metabolism of Co-enzyme A • Indirectly it has a role in the utilization of carbohydrates and fats	• Deficiency disease symptoms are headache, fatigue, weakness, sleeplessness, nausea etc. • Often not observed in humans • deficiency in chicks causes keratitis, dermatitis degenerative changes in the spinal cord, fatty livers and involutions of the thymus. • Rat deficient in the vitamin fail to grow normally
Vitamin B_6 (Pyridoxine hydrochloride)	• Both plant and animal foods • Dried yeast, rice polishing, wheat germ and liver are excellent sources • Whole cereals, legumes, oil seeds, nuts, egg, milk, meat and fish and leafy vegetables are good sources	• Essential for growth of infants • Important roles in amino acid and lipid metabolism • Pyridoxal phosphate acts as a coenzyme for a number of enzyme systems, removes carbon dioxide from the acid groups of certain amino acids and transfer amine groups from one compound to another. • Pyridoxal phosphate helps in transamination reactions, poryphyrin synthesis etc.	• Degeneration of the nerves • Has also some influence on the functioning of hormones. • In rat, deficiency cause decreases growth rate, dermatitis, anemia and convulsions
Niacin (Nicotinic Acid)	Yeast, liver, meat, poultry, whole grains, fresh pork	Nicotinic acid is essential for the normal functioning if	• Deficiency of Niacin leads to a disease known as pellagra. In

Name of the Vitamin	Dietary sources	Physiological functions	Deficiency diseases
	are excellent sources of niacin. Good proteins like milk protein are associated with niacin because tryptophan, an amino acid, present in the proteins is converted into niacin in the body.	the skin, intestinal tract and the nervous system	pellagra disease dermatitis, **glossitis** and **stomatitis** occur. Dermatitis disappears wherever that part of the body is exposed to sunlight. • The other symptoms are irritability, mental anxiety and depression, which can develop to delirium and dementia.
Biotin	• Peanuts, chocolates, egg yolk, liver, kidney, peas, cauliflower, dry yeast, milk products, cereals etc. are good sources • Royal jelly from honeybee is the richest source of biotin (400 μg / 100 g) • Produced by intestinal bacteria	• Essential for the activity of many enzyme systems • Helps in maintaining the skin structure and is necessary for normal gestation and lactation in animals • Required for fatty acid metabolism	• Biotin deficiency does not occur in humans frequently. • Experimental deficiency in animals has shown skin scaling, dermatitis, muscle pains, anorexia (lack of appetite) and slight anaemia.
Folic Acid (Pteroylglutamic acid)	• Dried yeast, green leafy vegetables, dry beans, cabbage, soybean, yeast, kidney and liver	• Essential for the maturation of Red Blood Cells (RBC); Acts as co-enzyme in the transfer of single carbon groups such as methyl or form, • Essential for reproduction in animals • Also helps in the hair growth and health of skin.	• Causes **megaloblastic anaemia,** which is also called macrocytic anaemia, mainly occurs in pregnant women, and is due to accumulation of immature RBCs in bone marrow • Inadequate supply of vitamin causes glossitis (red sore tongue), diarrhoea, and anaemia
Vitamin B_{12} (Cyanocobalamin)	• Present only in foods of animal origin. • Kidney and liver, egg, cheese, milk, fish etc. are good sources	• Promotes the maturation of Red Blood Cells (RBC); Essential for the normal function of bone marrow and the nervous system. • Takes part in many enzymatic reactions, is essential for the absorption of calcium and phosphorus.	• Causes **pernicious anaemia** life span of RBCs comes down and shape and size of RBCs also change • Other symptoms are skin lesions, reduction in gastric secretion, effect on spinal cord, tingling, numbness, loss of sense of limbs, depression etc.

Name of the Vitamin	Dietary sources	Physiological functions	Deficiency diseases
		• Aids in providing energy to the central nervous system • Also helps in the increase of white blood cells and blood platelet count.	
Vitamin C (Ascorbic Acid)	• Widely distributed in the plant kingdom. • Many fruits and vegetables like amla, orange, lemon, guava, cabbage, etc. are good sources	• Essential for the formation of collagen and osteoblasts • For carbohydrate and cholesterol metabolism, • Oxidation of phenylalanine to tyrosine, for the absorption of iron, • Rapid healing of wounds.	• Severe deficiency results in the development of the disease called **scurvy.** The disease is characterised by general weakness, spongy bleeding gums, loose tooth swollen joints and haemorrhages in various tissues.

9.4.2 Food Applications of Water Soluble Vitamins

Vitamin B_1 (Thiamine)



Vitamin B_2 (Riboflavin)

It is a white crystalline powder. Its chemical structure was established by Williams and co-workers in 1936 and was shown to be thiamine hydrochloride, containing a pyrimidine ring and substituted thiazole ring joined by a methylene bridge. It is stable to heat in acid foods but it is less stable in neutral foods. Baking of cereal products shows considerable loss in thiamine content and it is destroyed by alkali also. Due to its solubility in water thiamine is leached out during wet processing of food.

The steady increase in the consumption of white flours that are low in vitamin content is exposing large sections of the population to the risk of vitamin B_1 deficiency. Therefore, the white flours are extensively being fortified with chemically pure vitamins of the B group. Vitamin B_1 hydrochloride find a common application in the preparation of drug formulation of all types, especially of oral drop solutions, drops, tablets and others and also for the vitamin fortification of foods. As sulphur dioxide destroys the vitamin activity of thiamine, sulphites should not be added as a preservative to foods rich in thiamine.

Vitamin B_2 (Riboflavin)

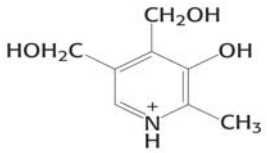
Riboflavin is made up of a yellow pigment called flavin (isoalloxazine) and a pentose alcohol called ribitol. Flavin adenine dinucleotide (FAD) and flavin mono nucleotide (FMN) are the coenzymic forms also found in some foods. Riboflavin is slightly soluble in water and ethyl alcohol. The solution when exposed to ultra-violet light emits a strong greenish yellow fluorescence. It is stable in acid or neutral medium but is destroyed in alkaline medium especially on heating.

Vitamin B_2 is used as a colour and nutrient in various food commodities such as baked foods, noodles and macaroni products, ice creams and soup mixes.

Vitamin B_5 (Pantothenic acid)

Pantothenic acid is an unstable viscous oil soluble in water. Structurally it is an amide of pantoic acid and β-alanine-an amino acid. Pantothenic acid is stable to heat but destroyed by acid and alkali. It is readily absorbed from small intestines.

As calcium pantothenate, vitamin B_5 is used in drug formulations and the vitamin fortification of animal feeds.

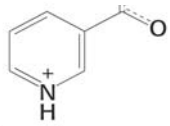


Vitamin B_6 (Pyridoxine)

Vitamin B_6 (Pyridoxine hydrochloride)

Pyridoxine is a naturally occurring pyridine derivative. Pyridoxine hydrochloride is a white crystalline powder that is almost colourless. It is easily soluble in water and insoluble in 95% ethanol. On prolonged exposure to the sunlight and UV light it changes gradually. The active form of this vitamin is pyridoxal and a related compound is pyridoxamine.

Sterilization of milk done by heating it at high temperature results in the loss of vitamin B_6. It is interesting to know that the vitamin B_6 hydrochloride added to milk or milk preparation is more resistant to thermal sterilization than the vitamin B_6 naturally present in the milk. Loss of vitamin B_6 due to thermal sterilization of milk based preparation may thus be compensated by external addition of vitamin B_6 hydrochloride.



Vitamin B_3 (Niacin)

Vitamin B_3 (Niacin)

Niacin is the nontoxic derivative of the toxic tobacco alkaloid, nicotine. There are two forms of this vitamin, i.e. nicotinic acid and nicotinamide. These are collectively called ***niacin***. On heating, the acid or alkaline solutions of nicotinic acid are converted to nicotinamide. Niacin is one of the most stable of the vitamins. It is stable to acids, bases, oxidising agents, heat and light. However, it is destroyed by autoclaving at 120°C for 20 minutes. It is sparingly soluble in cold water, but soluble in hot water and alcohol. Nicotinamide exists almost exclusively as a constituent of coenzymes NAD (nicotinamide adenine dinucleotide and NADP (nicotinamide adenine dinucleotide phosphate).

It has been estimated that 60 mg of tryptophan yield 1 mg of niacin.

Nicotinic acid mainly used in the vitamin fortification of flour, macaroni and noodle products. Besides the vitamin efficacy, nicotinic acid is sometimes used in combination with ascorbic acid in the meat industry, to retain the colour in minced and unpickled meats.

Biotin

Structurally biotin is an imidazole derivative. It is sparingly soluble in cold water and is freely soluble in hot water. It is stable to heat but sensitive to acid, alkali and oxidising agents. It forms salts with alkali hydroxides. The protein avidin present in raw egg white very strongly binds biotin thereby reducing its availability and leads to the symptoms of deficiency of this vitamin.

Biotin is mainly used in the preparation of injection, and also in the manufacture of vitamin B complex and multi-vitamin preparations. In addition, biotin also finds application in the manufacture of baking yeasts.

Folic Acid (Pteroylglutamic acid)

Folic acid is also called pteroylglutamic acid as it is mainly composed of substituted pteridine, *p*-aminobenzoic acid and glutamic acid. It is widely distributed in nature. It is produced by many bacteria and is a yellow crystalline compound moderately soluble in hot water and stable to heat.

Folic acid is mainly used in the manufacture of dry drug formulations and also in the vitamin fortification of animal feeds.

Vitamin B_{12} (Cyanocobalamin)

Cyanocobalamin has a complicated chemical structure in which cobalt (III) atom is bound to four nitrogen atoms of a corrin ring as shown in the figure. Vitamin B_{12} is a water-soluble dark red crystalline compound which is not stable to acids and alkali. It gets partially destroyed on exposure to sunlight.

Cyanocobalamin is used in the preparation of liquid and dry drug formulations of all kinds. Cobalamin concentrates are being used in the animal feed industry.

Vitamin C (Ascorbic acid)

Scurvy is known to the mankind since centuries. The sailors on long voyage were found to be suffering from this disease. This was due to the non-availability of fresh fruits and vegetables to sailors in their long journey. Szent-Gyorgy (1928) isolated an acid with intense reducing properties from cabbage, orange and adrenal glands. Subsequently, it was named ascorbic acid due to its antiscorbutic properties. Vitamin-C is a water soluble white crystalline compound stable in acid solution but sensitive to oxidation. It is sensitive to high temperature also. It is only water soluble vitamin without a coenzymic activity.

Vitamin C has a simple structure that resembles a monosaccharide to some extent. It is an ene-diol of a hexose sugar acid, and is a naturally occurring lactone. Due to the presence of a dienolic structure it has strong reducing properties. Dehydroascorbic acid is the oxidized form of vitamin A.

Antiscorbutic: having a property of curing scurvy

Ascorbic acid is used for the preparation of various drug formulations and for the vitamin fortification of foods and beverages.

Vitamin C is used in the prevention of browning and discolouration in vegetables and fruit products as an antioxidant in fats, fish colour in meat as an improver of flour, as an agent in wine partially replacing SO_2 and as an added nutrient.

Try to check your understanding of the water soluble vitamins by answering the following questions:

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Fill in the blanks spaces with appropriate words:

   i) Some good sources of vitamin B_1 include ……, ……, ……. etc.

ii) Vitamin …….emits a strong greenish yellow fluorescence when exposed to ……. light.
iii) Vitamin ……finds food application in vitamin fortification of animal feeds.
iv) Deficiency of pyridoxine hydrochloride causes .

2. Tick mark (√) the correct answer for the statement given below

The only water soluble vitamin not associated with coenzyme activity is:

i) vitamin B_1
ii) vitamin B_6
iii) vitamin C
iv) vitamin B_{12}

9.5 CLASSIFICATION OF MINERALS

In addition to the organic components like proteins, carbohydrates, fats and vitamins etc. our food also contains small amounts of inorganic species called mineral elements. These minerals play key functional roles in health and nutrition of humans. In the context of food and nutrition the minerals may be defined as the elements other than carbon, hydrogen, oxygen and nitrogen that are present in food. These are present in relatively low concentrations in the food. About 25 of the elements occurring naturally on the earth's crust are known to be essential to life and are present in living cells. Further, since our food is derived from living plants or animals, these elements are expected to be present in our food.

The mineral elements can be divided into two groups on the basis of their amounts in the body. The **major minerals** are found in bulk concentrations in the body while the microminerals or the **trace elements** are present in very small concentrations. In terms of their biological roles, the mineral elements are divided into **essential elements** having known biological roles **non-essential elements** with unknown functions, and **toxic elements**. Sodium, potassium, phosphorous, iron, calcium, zinc, selenium, magnesium, copper, tin, cobalt, manganese and fluorine etc. are the examples of essential elements. These function as electrolytes, as enzyme constituents and as building materials in bones and teeth. Boron, aluminium, mercury, lead and cadmium are non essential elements. Of these boron and aluminium are non-nutritive and non-toxic whereas the rest are and non- nutritive, toxic elements.

In addition to their nutritional and physiological role, minerals contribute to food flavour and texture. They activate or inhibit the enzyme catalyzed and other reactions. Even though minerals are present in low concentrations, they often affect the physical and chemical properties of food because of their interactions with other food components.

9.5.1 Macrominerals: Physiological Importance and Food Applications

As the name suggests, these minerals are required in relatively larger amounts in the diet, generally greater than 100 mg/day. It follows that they are also present in greater amounts in the body. Table 9.3 gives the food sources, physiological roles and food applications of macro-minerals.

Calcium magnesium and phosphorus play an important role in the stability of fluid milk products such as liquid milk, concentrated milk, lassi etc and control the texture of semisolid products like cheese, ice-cream, *chhana*, *paneer*, *khoa* etc. While calcium and magnesium, the two divalent cations impart hard texture to cheese, ice cream, *chhana*, *paneer* and *khoa*, the divalent anions like phosphate and citrate import soft texture characteristie to these products. Concentrations of minerals in the food may also effect its digestability.

Table 9.3: Food sources, physiological roles and food applications of macro-minerals

Minerals	Food sources	Physiological roles	Food applications
Calcium	• All the dairy product, green leafy vegetables and fish bones contain calcium.	• Calcium has important structural or mechanical role • Component of blood, lymph and soft tissues • Blood clotting process • Muscle contraction and nerve impulse transmission, mediator of hormone action, enzymes and proteins regulation Deficiency leads to osteoporosis in later life.	Forms gel with some macromolecules as texture modifier and firms canned vegetables.
Phosphorous	• Foods such as nuts, oil seeds, pulses and cereals	• Involved with the formation of bones and teeth • Constituent of various physiologically important molecules and nucleic acids, DNA and RNA, a variety of coenzymes – NAD^+, $NADP^+$, FMN, FAD. influences the acid-base balance of blood	As phosphates as acidulant in soft drinks for moisture retention in meats and aids in emulsification.
Magnesium	• Whole grains, nuts, legumes and green leafy vegetables	• Forms part of the bone tissue and along with calcium and some other cations affects fluidity and permeability of the membrane,	Colour modifier in foods removal of magnesium from chlorophyll changes colour from green to olive-green.
Sodium and potassium	• All foods, fruits and vegetables are rich sources.	• Maintenance of osmotic pressure, cell volume and membrane potential.	Potassium as potassium acid tartarate as leavening agent Potassium chloride as salt substituent Sodium chloride may be used as a preservative and lowers the water activity in food Some of the sodium salts used as leavening agents.
Sulphur	• Sulphur is widely distributed in nature	• Sulphur is antimicrobial in nature and is widely used in wine making.	Sulphur dioxide and sulphites as browning inhibitors

9.5.2 Trace Elements: Physiological Importance and Food Applications

Microminerals occur in living tissues in minute amounts. In fact early workers who were unable to measure their precise concentrations with the methods then available, frequently referred to them as occurring in 'traces'. For this reason they came to be known as 'trace elements'. Other popular names used include 'minor elements' or 'oligo-elements' (from the Greek 'oligos' meaning scantly). The micro-minerals are required in amounts less than 100 mg/day.

The trace elements may be subdivided into 3 groups:

Essential trace elements – These have been shown to be dietary essentials as these are vital to the enzymatic processes of the living cell. Iron, copper, iodine, zinc, manganese, cobalt, molybdenum, selenium and chromium belong to this category.

Possibly essential trace elements – These exhibit some metabolic activity, revealed by both in vivo and in vitro studies and likely to be essential. Nickel, tin, vanadium, cadmium, silicon, barium and strontium belong to this category

Non-essential trace elements – The essentiality of these elements have not been established. Aluminium, boron, lead, mercury, fluorine and arsenic are the examples of this category.

The food sources, physiological role and food applications of some microminerals are given in Table 9.4.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

Mark (√) for the correct and (×) for the wrong statements in the following.

i) The minerals are not very important as they are required in very small amounts by the body.
ii) Iron is important for oxygen transport by haemoglobin.
iii) Function of iodine is associated with the thyroid hormone; however it does not form a part of this hormone.
iv) Cobalt and manganese are classified as ultra trace elements.

Table 9.4: Food sources, physiological and food applications of some trace elements

Minerals	Food Sources	Physiological role	Food application
Iron	• Green leafy vegetables, cereals, legumes, meat etc. are good sources • Also food cooked in iron utensils also provides iron.	• Oxygen transport by haemoglobin • To ensure availability, of oxygen in muscle cells oxygen is stored combined with iron-containing muscle protein, myoglobin • Constituent of enzymes peroxidase and catalase which catalyze oxidation-reduction reactions	Catalyze lipid peroxidation in foods Colour modifier in foods Cofactor to many enzymes like cytochromes, hypoxygenase etc.

Minerals	Food Sources	Physiological role	Food application
Iodine	• Available in iodized salt, sea food, plants and animals grown in areas where soil iodine is not depleted.	• An integral part of thyroid hormone • Insufficient quantities of iodine in the diet results in the disease goitre. • Thyroid deficiency during the prenatal period results in serious detriment in both mental and physical development in the growing child.	Potassium iodate improves baking quality of wheat flour Therefore, it is used as a dough improver.
Selenium	• Sea foods, organ meats, cereals	• Present in amino acids as constituents of proteins, • Selenocysteine occurs at the active site of several enzymes and functions as enzymes cofactor	
Copper	• Organ meats, sea foods, nuts and seeds.	• A part of a number of proteins including many important enzymes. Some of these are: copper-binding proteins, metallothionein, albumin, blood clotting factor V, amine oxidases, ferroxidases, cytochrome C oxidase, superoxide dismutase, tyrosinase, C18, Δ9 desaturase.	As a catalyst; Colour modifier; Enzyme cofactor; Texture stabilizer
Cobalt and Manganese	• Green leafy vegetables, especially spinach are the richest source • Dairy products and cereals are the poorest.	• Cobalt is a constituent of vitamin B_{12}, functions as a coenzyme • Manganese as Mn^{2+} activates a number of plant and animal enzymes including oxidoreductases, lyases, ligases, hydrolases, kinases, transferases and various decarboxylases.	Manganese as enzyme cofactor e.g. pyruvate carboxylase, superoxide dismutase.

9.6 EFFECT OF FOOD PROCESSING ON VITAMINS AND MINERALS

The freshness, appearance, and nutritive value of foods changes when they are stored for long time. People in food industry work for procedures which make the foods retain their nutritive value even after a long time. The conversion of raw food materials into the acceptable food product by a variety of means in referred to as **food processing**. The techniques followed include, dehydration, freezing, heating at high temperatures, exposure to radiation (i.e. irradiation), fermentation, chemical preservation etc. We all believe in consuming fresh foods and avoid the processed and the preserved one. Do you think it's a correct belief?

Processing of food has advantages and disadvantages both. We know that it results into desirable changes like enhancement of flavours, improvement of texture, and increase in shelf life etc. However, it may lead to some undesirable changes too. These include changes in colour, flavour, nutritional properties and development of toxicity. This affects, to some extent, all the components of food. Let us read what is the effect of food processing on vitamins?

9.6.1 Effect of Food Processing on Vitamins

Dehydration i.e. removal of water under controlled conditions is one of the ways of lowering water activity and preserving foods. However, dehydration results in decrease of vitamin levels. In fruits, β-carotene and B-group vitamins do not get altered significantly but vitamins C is lost to a good extent. However, pickling of vegetables leads to acidic pH which stabilizes vitamin C. Freezing fruits and vegetables also do not result in a substantial loss of vitamin A and β-carotene. The B-group vitamins also remain unaffected.

Heating at high temperatures, another important food process, results into a number of changes. For example, the heating process employed in industry for the sterilization of milk-based formulations greatly reduces their vitamin B_6 content, thiamin may be lost to the extent of 30-50%. Baking of cereals and cereal products also cause loss of B-group vitamins to different extent. For example, the baking of white bread may result in thiamin loss of about 20%. The vitamin B_{12} on the other hand is not destroyed to a great extent by cooking, unless boiled in alkaline solution. The vitamin like vitamin A, vitamin B, thiamin, riboflavin, pantothenic acid and nicotinic acid do not get affected by frying of egg.

The heat treatment and leaching are the factors affecting vitamin C destruction during processing. Further, the rate of destruction of vitamin C is increased by the action of metals especially Cu and Fe and also by the action of enzymes. Considerable vitamin C is lost by cooking, preservation, drying and storage of the foods commodities.

On irradiation the nutrients in meats and poultry are also affected. It has been found that thermal processing and radiation sterilization of pork have comparable losses of thiamine. Blanching of vegetables and cooking of meat do not cause folic acid losses.

Vitamin A is relatively stable to heat in the absence of oxygen. Vitamin A and carotenoids have good stability during various food processing operations. Losses may occur at high temperatures in the presence of oxygen.

Vitamin D is extremely stable and little or no loss is experienced in processing and storage. Vitamin D in milk is not affected by pasteurization, boiling or sterilization. Frozen storage of milk or butter also had little or no effect on vitamin D levels.

Substantial **tocopherol** losses may occur on processing and storage of foods. Baking of white bread results in a loss of ~50% of the tocopherols in the crumb.

9.6.2 Effect of Food Processing on Minerals

Minerals are comparatively stable under food processing conditions such as heat, light, use of oxidizing agents and extremes in pH. Therefore processing does not usually reduce the mineral contents. However, these minerals can be removed from foods by leaching or by physical separation. Cooking in water would result in some losses of minerals since many minerals have significant solubility in water. In general, boiling the vegetables in water causes greater loss of minerals from them as against steaming them. Canned foods such as

fruit juices may take up metals from the container-tin and iron from the tin plate and tin and lead from the soldering.

During cooking sodium may be lost but the other minerals are well retained. Many selenium compounds are volatile and can be lost by cooking or processing. Further, it has been found that milling of cereals cause considerable loss of minerals. Since minerals are mainly concentrated in the bran layers and in the germ, during milling after removal of bran and germ, only pure endosperm remains, which is poor in minerals. For example, when wheat is milled to obtain refined flour, the losses in mineral content are to the extent of 76% in case of iron, 78% in zinc, 86% in manganese, 68% for copper, and 16% for selenium. Similar losses occur during milling of rice and other cereals.

As mentioned above, the minerals are quite stable to heat and pH during processing. However change in temperature, pH and concentration or dehydration may lead to the change in the status in food system. For example in milk 1/3rd 1/4th of the calcium and phosphorous is associated with casein while 66 to 80% are present as dissolved calcium and phosphorous. On heating these minerals change from the dissolved to the colloidal state. On the other hand, cooling of milk shift the colloidal calcium and phosphorous to the dissolved state. Decrease in pH from the normal value towards isoelectric side (pH 4.6) will caused the solubilization of these minerals while an increase in pH will causes a shift of colloidal calcium, magnesium and phosphorus to the dissolved state.

The minerals in meat products are in the non-fatty portions, when liquid is lost from meat, the maximum loss is of sodium and calcium, phosphorus and potassium are lost to a lesser extent. During cooking also, sodium is lost but other minerals are well retained. In fact, cooking dissolves some calcium from bone and enriches the meat with this mineral.

Check Your Progress Exercise 4

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

Fill in the blanks spaces with appropriate words

i) Food processing is done in order to decrease ……and increase the …….. of foods.
ii) A lot of vitamin ……. is lost during cooking and preservation of foods.
iii) Drying of fruits does not cause a large loss of ……and ……vitamins.
iv) ……. in water causes more loss of minerals from vegetable as against …… .

9.7 TOXIC METALS: SOURCES AND SYMPTOMS

You have read that the minerals though required in small amounts, have very important physiological roles to play. You would be able to appreciate the fact that as they are required in small amounts, taking them in high doses may prove harmful to the extent of being toxic. The mineral elements causing toxicity are generally the heavy metals like, arsenic, cadmium, lead, mercury,

chromium and beryllium. These heavy metals can be present in foods, drinking water and the exhaust of automobiles and industries. The sources and the symptoms of the exposure to toxic metals are compiled in Table 9.5.

Table 9.5: Toxic Metals: Sources and Symptoms

Toxic metal	Sources	Symptoms
Aluminum	Cookware, cans, tap water, baking powders, antacids, processed cheese, some medications and physical exposure etc.	Alzheimer's disease, anaemia and other blood disorders, colic, fatigue, dental caries, kidney and liver dysfunctions, neuromuscular disorders, Parkinson's disease, etc.
Arsenic	Pesticides, beer, tap water, paints, pigments, cosmetics, fungicides, insecticides, contaminated food, etc.	Abdominal pain, anorexia, dermatitis, diarrhoea, oedema, goitre, headache, herpes, impaired healing, jaundice, kidney and liver damage, muscle spasms, vasodilation, vertigo, weakness, etc.
Beryllium	Polluted air (burning fossil fuels), plastics, electronics, steel alloys, etc.	Arthritis, depression, fatigue, osteoporosis and symptoms of slow metabolism, etc.
Cadmium	Cigarettes, processed and refined foods, fish, tap water, auto exhaust, galvanized pipes, air pollution from incineration and physical exposure, etc.	Hypertension, arthritis, diabetes, anaemia, arteriosclerosis, cancer, cardiovascular disease, reduced fertility, hypoglycemia, headaches, osteoporosis, kidney disease, etc.
Copper	Copper water pipes, tap water, pesticides, swimming pools, intra-uterine devices, dental amalgams, occupational exposure, etc.	Allergies, hair loss, anaemia, anxiety, arthritis, autism, cancer, depression, elevated cholesterol, cystic fibrosis, diabetes, dyslexia, inflammation, kidney and liver dysfunctions, tooth decay, etc.
Lead	Tap water, cigarette smoke, hair dyes, paints, pesticide and in batteries, industries, etc.	Abdominal pain, anaemia, arthritis, arteriosclerosis, blindness, cancer, depression, diabetes, epilepsy, fatigue, gout, infertility, inflammation, kidney dysfunction, etc.
Mercury	Dental amalgams, fish, medications, air pollution, adhesives, fabric softeners, waxes, etc.	Depression, dermatitis, fatigue, headaches, hearing loss, hyperactivity, memory loss, mood swings, nervousness, pain in limbs, thyroid, muscle weakness, etc.
Nickel	Hydrogenated oils (margarine, commercial peanut butter and shortening), shellfish, air pollution, etc.	Cancer (oral and intestinal), depression, heart attack, hemorrhages, kidney dysfunction, low blood pressure, paralysis, nausea, skin problems and vomiting

9.7.1 Metal Uptake from Canned Foods

You might be buying a number of canned foods like, *rasagullahs*, pine apple in sugar syrup, fruit juices, etc. you know that these are the preserved foods available in the market. You have studied that one way of preservation is to heat the food material so that the enzymes get deactivated and the bacteria can not thrive on that food easily. In canning process also the same method is used and the food is stored in metallic containers, containers made up of glass, ceramic and plastics.

The metals from equipment or from packing materials, especially tin cans can cause contamination of food products. Tin gets into most of the canned food in the absence of oxygen. Examples of such foods are spinach, green beans, tomatoes, vegetable soups and some fruits juices like grape fruits juice. Foods rich in sulphur containing amino acids like pork, fish and peas undergo **sulphide staining** in tin cans. These stains are due to the formation of tin

sulphide on heating. The nickel found in milk comes almost exclusively from stainless steel in the processing equipments. Similarly, on storing acidic foods, e.g. fruits juices in galvanized containers, enough zinc may get dissolved to cause poisoning.

9.8 FORTIFICATION: NEED AND TYPES

The practice of supplementing nutrients to the foods had been prevalent almost since 400BC.

You have read in the previous subsection that a number of vitamins and minerals are lost in the processing of food and its preservation. A good amount of these is lost in the cooking of food itself. The loss of nutrients in food is implicated to be responsible for malnutrition and number of diseases. For example the deficiencies of iron and iodine leading to anemia and goiter have been known quite well. Similarly number of cases due to the deficiencies of vitamin A and B are known. A lot of awareness is being generated in this regard. Is it possible to make up for the losses?

The answer is in affirmative. A number of interventions are in practice that makes up for the loss of nutrients in the food. These are in terms of supplementing the food for the lost components. Nutrient supplements are added in order to:

- Maintain the nutritional availability of foods
- Provide the adequate level of nutrients in the food
- Impart additional nutritional value to the food

Nutrient supplementation obviously means adding nutrients to the food. It is generally achieved in two ways.

In 1997, Parliament passed law making sale of iodized salt mandatory.

1. **Enrichment**: refers to adding nutrients in the food so as to maintain the amount that was present in food before its processing i.e., equal to the loss incurred during processing or preservation.
2. **Fortification:** According to FAO/WHO, Food fortification has been defined as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups.

Vitamins and minerals are most commonly used for fortification. You are quite familiar with the governments campaign for using iodised salt i.e., common salt fortified with essential iodine. Some of the foods and the fortifying agent used are given in Table 9.6

Table 9.6: Some foods and the fortifying agents

S.No.	Name	Fortifying agent
1	Salt	Iodine, iron
2	Flours, bread, rice	Vitamin B_1, B_2, niacin, iron
3	Milk, margarine	Vitamins A and D iron and calcium
4	Sugar, monosodium glutamate, tea	Vitamin A
5	Infant formulas, cookies	Iron, Vitamin D, E
6	Vegetable mixtures, proteins	Vitamins, minerals

S.No.	Name	Fortifying agent
7	Soy milk, orange juice	Calcium
8	Ready-to-eat cereals	Vitamins, minerals
9	Edible oils and sugar	Vitamin A

Food fortification is especially useful for the people who generally belong to low income groups and face malnutrition. Food fortification has been very successful in eradicating diseases like goitre, rickets, beriberi and pellagra. Many important aspects must be borne in mind while carrying fortification at a large scale. Some of these are as follows:

- The food selected for fortification should be the staple food of the target groups so as to make it affordable.
- The fortified nutrient should have favorable physico-chemical and bio-availability characteristics. The former takes care of the colour, taste, odour and appearance of the food while the later is important from the stability point of view. For example iron and fatty acids may react in the fortified food and produce free radicals which are not good for the quality of food.
- It should be economically viable i.e., it should not be an expensive process.
- A number of factors like the solubility and stability of the fortifying agent affect fortification. The stability depends upon pH, light and temperature besides presence of oxygen. These must be considered while attempting fortification.

In addition, a proper monitoring is essential while carrying out food fortification for fruitful results.

9.9 LET US SUM UP

Vitamins and minerals are very important from nutrition point of view and are important to food scientists also. These are not required in large amounts in the body and are not energy giving in nature.

Vitamins are the organic compounds classified on the basis of their solubility in fats and water. Accordingly these are called fat soluble vitamins and water soluble vitamins. The fat soluble vitamins include vitamin A, vitamin D, vitamin E, and vitamin K. The water soluble vitamins include a group of vitamin B comprising of vitamin B_1 , B_2, B_5, B_6, B_{12} , niacin, biotin and folic acid and vitamin C. All the vitamins have some or the other important physiological role to play. They are the coenzyme parts of many enzymes except vitamin C. the deficiency of each of these vitamins leads to a disease. Fruits, vegetables, milk, meat, egg, fish etc. are good sources of these vitamins.

Minerals are actually inorganic elements which are required in very small amount but carry a lot of importance. The minerals are classified into two broad types depending upon the amount required by the body. These are major elements having a requirement of more than 100 mg/day and the trace elements. The first type has elements like calcium, magnesium, sodium, potassium, phosphorus and sulphur. The later type includes iron, iodine, zinc, cobalt, selenium, copper, and manganese. Some of the minerals are part of structure and mechanical support while others have important roles in various metabolic processes. Green leafy vegetables, milk, fruits, whole grains, meat, egg, fish, nuts etc. are good sources of minerals.

Some of the metals are hazardous for human health if taken in large amounts. They come from various sources like the contaminated water and food, cookware, medications, etc. These lead to various types of diseases and should be avoided.

Vitamins and minerals both act affected by various food processes like, freezing, drying, heating etc. carried out during preservation and storage of foods. As a result the foods lose a number of these nutrients. In order to compensate for the loss, the foods need to be properly supplemented and fortified.

9.10 KEY WORDS

Beri-beri : Beriberi is a vitamin deficiency disease in which the body does not have enough thiamine (vitamin B_1). Symptoms of dry beriberi include: Pain, Tingling, Loss of feeling (sensation) in hands and feet, Muscle damage with loss of muscle function or paralysis of the lower legs, vomiting and even coma and death.

Dementia : Severe impairment or loss of intellectual capacity and personality integration, due to the loss of or damage to neurons in the brain.

Diarrhoea : Diarrhoea is an intestinal disorder characterized by abnormal fluidity and frequency of fecal evacuations, generally the result of increased motility in the colon; may be an important symptom of such underlying disorders as dysenteric diseases, lactose intolerance, GI tumors, and inflammatory bowel disease. Diarrhoea is the passage of watery stools, usually at least three times in a 24 hour period.

Enrichment : The process of replenishing nutrients lost during food processing.

Fortification : The process whereby nutrients (vitamins and minerals) are added to food. This normally happens during or directly after manufacturing.
Food products may be enriched for the following reasons: to replace nutrients removed during processing (e.g. when flour is milled, thereby removing bran and germ) and to supplement a diet lacking essential nutrients.

Goitre : Disease due to enlargement of thyroid gland seen as a swelling in the neck, commonly due to deficiency of iodine in the diet or to the presence of goitrogens in foods. In such cases there is commonly underproduction of the thyroid hormones, i.e. hypothyroid goitre.

Oedema : Swelling from effusion of watery fluid in the cellular tissue beneath the skin or mucous membrane; dropsy of the subcutaneous cellular tissue.

Rickets : A disorder primarily caused by lack of vitamin D, calcium, or phosphate, which leads to softening and weakening of the bones.

9.10 TERMINAL QUESTIONS

1) Differentiate between fat soluble and water soluble vitamins. Give two examples for each type.
2) Which vitamin is responsible for normal reproduction? Give its chemical nature and two sources.
3) Give the role of the following vitamins in food industry.

   Vitamin A, Vitamin K, Vitamin B_6 and Vitamin E.
4) Differentiate between macrominerals and microminerals. Give two examples for each of these.
5) Why are the trace elements named so? What are their major subgroups?
6) Write in brief the effect of food processing on vitamins and minerals.

9.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) a) ii)
   b) i)
   c) iv)
   d) iii)
2) ii)

Check Your Progress Exercise 2

1) i) pulses, oil seeds, eggs
   ii) ultra-violet
   iii) B_5
   iv) pernicious anemia.
2) iii)

Check Your Progress Exercise 3

1) a) (×) b) (√) c) (×) d) (√)

Check Your Progress Exercise 4

1) i) spoilage, shelf-life
   ii) C
   iii) β-carotene, B-group
   iv) Boiling, steaming.

9.12 ANSWERS TO TERMINAL QUESTIONS

1) Fat soluble vitamins are water insoluble. They require fat absorption in the body as the lipoproteins and some other proteins help in their transportation. Two examples are vitamin A and D. Water soluble vitamins dissolve in water easily and for this reason they get eliminated

in urine. They need to be supplemented regularly. Two examples are vitamin B_1, i.e. thiamine and vitamin C.

2) Vitamin E is essential for normal reproduction this vitamin belongs to a group of organic compounds called tocopherols which have good antioxidant properties. Wheat germ oil and corn germ oil are the richest sources of this vitamin.

3) Refer to Sec 9.3 and 9.4.

4) Macrominerals are the inorganic elements required in more than 100mg/day quantity while the microminerals are required in much smaller amounts i.e. less than 100mg/day. Calcium and phosphorous are two examples of former while iron and iodine are two examples of the later type.

5) The trace elements are required in traces by the body that is why they are named so. They are divided into three subgroups.

6) Refer to Sec 9.7.

9.13 SOME USEFUL BOOKS

Meyer, L.H. (1969). Food Chemistry Van Nostrand Reinhold Company, NewYork.

deMan (1980). Principles of Food Chemistry, The AVI publishing Company Inc.

Swaminathan M. (1999). Essentials of Food and Nutrition, vol. I The Bangalore Printing and Publishing Co. Ltd., Bangalore

Braverman, J.B.S. (1963). Introduction to the Biochemistry of Foods, Elsevier Publishing Company, Amsterdam, London, New York.

PIGMENTS

Normal constituents of cells or tissues which are synthesized and accumulated in or excreted from, living cells that impart colour are called pigments.

NON CERTIFIED COLOURS :

No need for certificate to sell or use most are from natural sources so also called as natural colours

CERTIFIED COLOURS:

A food colorant is synthetically made absorbed on the surface of an inert carrier and added to the processed foods reffered to as certified colours

VEGETABLE PIGMENTS:

WATER INSOLUBLE : CAROTINOIDS AND CHLOROPHYLL

WATER SOLUBLE : ANTHOCYANINS, BETALAINS, ANTHOXANTHINS

1.CHLOROPHYL :

Chlorophyll green pigments involved in photosynthesis in plants there are number of chlorophylls such as chlorophyll a, b,c,d. Out of all types chlorophyll a and b are of particular interest in food coloration. Chlorophyll a is intense blue green in colour present in florets of blue green broccoli. chlorophyll b, is dull yellow green in colour present in green stalks.chlorophylls are mostly insoluble in water and dominant in unripe fruits.

- Effects of cooking on chlorophyll

All green leaves and green vegetables like beans and peas contain chlorophyll. The structure and conjugation of proteins makes chlorophyll to chemical chages in cooking and the pleasant green colour is difficult to retain .

*Effect of putting in hot water :when a green vegetable is put in boiling water the green colour becomes brighter.

*Solubility :Removal of the phutyl group from the molecule of chlorophyll is found in some vegetables . hydrolysis of the ester linkage yields a compound chlorophyllide produced during storage of certain green vegetables prior to cooing possibly accounts for the light green tint of the cooking water from them

*Effect of prolonged cooking :As the cooking process continues the colour of the green vegetables varies from bright green to olive green.

*Effect of acid: A pale greenish compound knon as *pheophytin-a* or an olive green *pheophytin-b* results no longer masked by the intense chlorophyll the yellow and orange pigments in green tissue now show along with the green. This combination together with pheophytin give the vegetable a muddy olive colour. Green vegetableswhich are lower in acid retain the higher pearcentage of chlorophyll when they are cooked than do more acid vegetables

*Effect of canning : vegetables like peas, beans, greens are sometimes canned. During canning, chlorophyll gets converted to pheophytin due to high temperature used.

Effect of calcium salt : Addition of a small amount of calcium acetate or other calcium salt prevents the mushiness by blocking the breakdown of the hemicelluloses.

Chlorophyll can be retained best : By initially cooking in an open pan

By using slight excess of wwater to dilute the acids or By starting with boiling water which in turn reduces the actual time required to tenderized vegetables shouldbe cooked less than 5 minutes as oheophytin forms between 5 and 7 minutes.

CAROTENOIDS

Carotenoids are group of lipid soluble hydrocarbon responsible for yellow, orange, and red colours of plants. And their oxygenated derivatives are called Xanthophylls.

Carotenoids pigments in food

Yellow corn contain cryptoxanthin,
Tomatoes contain Lycopene, beta carotene,
Red capsicum contain cryptoxanthin, capsorbin, beta carotene, violaxanthin and neoxanthin
Green capsicum contain lutein, betacarotene, violaxathin, and neoxanthin.
Carrots contain beta carotene, alpha carotene, gamma carotene, lycopene, xanthophylls.

Carotenes are oxygen free carotenoids which contain only carbon hydrogen . mostly found in carrots, apricots, and gives bright orange. Xanthophylls contain ne or more oxygen atoms. Dissolves best in methanol and ethanol. eg:lutein and zeaxanthin. They are associated primarily with eye health studies often donot separate lutein and zeaxanthin because they are they are the only carotenoids found in retina.
Bêta cryptoxanthin is a provitaminA it produces half as much as betacarotene.

Effect of cooking on carotenoids

*The colour is little affected by acid, alkaliand the volume of the water. The nutritive value is protected during cooking by the insolubility in water .
*The high degree of unsaturation of carotenoids makes them susceptible to oxidation with the resulting loss of colour after the foods containing them has been dried .
* The finer the vegetable divided or cut and higher temrature that are used and longer cooking process hasten the process of oxidation.
*Appreciable amounts and enough to affect the colour dissolve in ghee when carrot halwa or kheer is made.
*Blanching prior to dehydration is helpful in reducing the likelihood of oxidation. Blanching makes lipids free from proteins with which they are complexed as lipoproteins
* Steaming has constantly reduced carotene losses in leafy vegetables. Cutting of vegetables for salad resulted in 10-15 percent loss. Leafy vegetables enhanced the losses of carotene to 30-40 percent .leafy vegetables should be washed before cutting to retain more carotene. Cooking the vegetabes with oil showed grester retention of carotene as compared to other cooking procedures like boiling and steaming..

WATER SOLUBLE PIGMENTS :

ANTHOCYANINS :

Anthocyanins : These are coloured water soluble pigments belonging to the phenolic group . these are responsible for the colours red, purple, and blue. Which exist in cell sap juice i.e, flowers fruits and vegetable various berries, blue red grapes, pomegranates, and currants, radishes, and sweet potatoes achieve their colour appeal because of predominance of anthocyanins.

*Food sourses of Anthocyanins : blackberries, blue berries, purple pepper, purple cabbage, purple carrots, eggplant, purple grapes, plums and black currants are some sources from which we get anthocyanins pigments.

Effect of cooking on anthocyanins : pickles are usually low in P^H and anthocyanin change to deep crimson red in colour.

Effects of method of cooking : anthocyanins are water soluble cell sap pigments which can be leached from a vegetable by the cookingwater. Cooking in a steamer or in a pressure pan which limit the contact of vegetable with water are better methods than boiling in water.. To retain the red colour in red cabbage, the cooking water should be acidified otherwise the pigment will change to a dull and unappetising blue.

Effects of alkali : addition of alkali gives the pigment a bluish green shade which is probably caused by the anthocyanins +anthoxanthins. On the addition of alkali the anthoxanthins turns yellow whereas anthocyanins turs blue and a mixture of two colours appear green. Such a colour can be seen in red cabbage.

Effect of acid : red cabbage exhibits unusually wild swings in colour with a change in ph because of the presence of more than four hydroxyl groups on the anthocyanins molecule. Red cabbage is frequently cooked with the addition of some slices of a tart apple to ensure that the ph is sufficiently acidic to avoid the development of a blue, highly unpalatable pigment colour.

BETALAINS :

Betalains are water soluble nitrogen containing pigments these group of pigments found in red beet and to some extent in cactus fruit, pokeberries and flowers like Bougainvillia. The pigments are red and yellow. Betacyanins and betaxanthins are together known as betalins. High ratio of betacyanin to betaxanthin lead to violet,

Medium to red and low to orange tuber colours the water soluble pigments present within the betacyanin group are betanidin and betanin. A somewhat yellowpigment is contributed by the betaxanthins.

Effects of cooking on betalains : betalains diffuse rapidly into the cooking water resulted in highly pigmented water.

Effects of p^H : betacyanins undergo colour changes parallel to anthocyanins. An acidic medium promotes reddish colour whereas a neutral or somewhat alkaline ph brings out brownish blue of the pigment.

ANTHOXANTHINS :

They are colourless or pale yellow pigments depending on the ph closely related to anthocyanins. They are water soluble occurring in the vacuoles of the plant cells. Anthocyanins give colour to cauliflower onions and spinach or other leafy vegetables (in green leafy vegetables the colour is masked is chlorophyll)

Effect of cooking on anthoxanthins

Effect of Ph : the colour of the vegetable will be whiter if little acid such as juice or vinegar is added during cooking if the water in which cauliflower is cooked is slightly alkaline, it will have a distinctly yellow colour to it. They turn yellow or orange in the presence of alkali.

Effect of metal : They cause the cooking water to turn a bit yellow when they are cooked in aluminium and form a flavones aluminiumchelate. Such reactions also takes in cast iron pans. Pears and white potatoes sometimes develop a pinkish colour in their cut surface.

PIGMENTS INDEGENOUS TO FOOD :

TANNINS: tannins are class of astringent polyphenolic biomolecules that bind to proteins and various other organic compounds. Tannins also known as tannic acid or gallotannic acid. Gaallnut contain 50-70 % of tannin. The nuts such as hazel nuts, walnuts, contain high amounts of tannins where almond have lower content. tannins are sometime used in fruit juice industry as a claryfing agent.apple juice, grape juice, and berryjuice are all high in tannins.

FLAVONOIDS:

Flavonoids plant pigments that are synthesized from phenylaline and are important for flower colouration producing yellow or red blue pigmentation in petals that attract pollinator animals. Flavonoids are naturally occurring phenolic substances or antioxidants present in the human diet. The major group of flavonoids found in nature is flavonol group consisting of kaempferol less common than flavonol are flavones. The flavanones are found mainly inn citrus fruits and they can be used as synthetic sweetner.

XANTHONES :

xanthones are group of yellow pigments one well known member is magneferin which occurs as a glucoside in mangoes.

QUINONES: A large group of pigments found in cell sap of flowering plants fungi, bacteria, and algae are derivatives of anthraquinone, naphthoquinone and benzoquinone. A number of synthetic dyes also are derivatives of quinines. The natural quinonens range in colour from pale yellow to almost black.

PECTINS

*pectins in general is a group of polysaccharides found in nature in the primary cell walls of all seed bearing plants and are invariably located in the middle lamella.

* It has been observed that these specific polysaccharides actually function in combination with both cellulose and hemicellulose as an intercellula cementing substance.

*One of theonate an L - arabinose richest sources of pectin is lemon or orange rind which contains about 30% of this polysaccharide .

*Evaluation and standardization of pectin is based on its ‘Gelly grade” that is , its setting capacity by the addition of sugar .

*Usually pectin have gelly grade of 100, 150, and 200 are recommended for medicinal and food usages.

Biological sources of pectin :

pectin is a purified polysaccharide substance obtained from the various plant sources

Such as inner peel of citrus fruits, apple, raw papaya, etc. Numbers of plants sources of pectin are Lemon, Orange, Apple, Papaya, Sunflower heads, Guava, Beets, Carrots, Mangoes.

Chemical constituents :

*pectins is a polysaccharide with a variable molecular weight from 20,000 to 4,00,000 depending on the number of carbohydrate linkages .

*The core of the molecule is formed by linked D-polygalacturonate and L-rhamnose residues.

*the neutral sugars, D-galactose, L-arabinose, D- xylose and L- fructose form side chains on the pectin molecule

*Once extracted pectin occurs as a coarse or fine yellowish powder that is highly water soluble and forms thick colloidal solutions.

*The parent compound propectin is insoluble, but is readily converted by hydrolysis into pectinic acids .

USES :

*pectin is used as an emulsifier gelling agent and also as a thicking agent.

*It is a major component of anti diarrhoel formulation.

*pectin is a protective colloid which assists absorption of toxin in the gastrointestinal tract.

*it is used as haemostatic in cases of haemorrhage. As a thickener.

GUMS

Natural gums are polysaccharides of natural origin, capable of causing a large increase in a solution’s viscosity, even at small concentration. In the food industry they are used as thickening agents, clarifying agents, gelling agents, emulsifying agents, and stabilizers. Most often these are botanical gums found in the woody elements of plants or in seed coatings.

Types of Gums:

*Agar : agar or agar-agar is a jelly like substances obtained from algae . melting point is 85 ^{o}c . solidifying range 30^{o}c - 40^{o}c. Agar is a natural vegetable gelatin counterpart. It is available as dried strips or in powdered form.

*Alginic acid : An anion polysaccharides distributed widely in the cell walls of brown algae, where through binding with water forms a viscous gum

*Carrageenans : These are a family of linear sulphated polysaccharides that are extracted from red edible seaweeds. They are widely use in food industry for their gelling thickening and stabilizing properties.

*Gum Arabic is a complex mixture of glycoproteins and polysaccharides.it is original source of the sugars arabinose and ribose. It the hardened sap of various species of the acacia tree.

*Karaya gum : A vegetable gum produced as an exudates by trees of genus sterculia. Gum karaya is an acid polysaccharide composed of the sugars galactose, rhamnose and galacturonic acid. It is used as thickener and emulsifier in food

*Xanthan gum: it is a powerful thickening agent and also used as a stabilizer to prevent ingredient from separating. It can be produced from a range of simple sugars using fermentation process. Its used in icecreams, sauces and etc

Health effects :

*Examination of the most common gum additives in food today indicates that in general they are safe for occational consumption by healthy persons with normal gut function.

*The exceptions to this are xanthan gum, which infants should not consume the worst of lot cellulose gum. It is best avoided by everyone.it is ultra cheap industrialized product.

*Guar gum, tara gum, gellen gum, and locust bean gum is all are safe in small amounts .

FOOD PIGMENT AND COLORANTS :-

look delicious, look tasty, attractive to consumes

Food Pigments: Pigments are the substance that impart color when it is added to food. They come in many forms consisting of (they may be) liquids, powders, gels & pastes. food colouring is used in both commerical food production & domestic cooking.

Difference in food Pigment & Colorant.

Colourants :- is a substance that is used to impart colour to matter. they are soluble in medium.
eg- indigo carmine, allura red

Pigment :- Pigment are the main forms of colourant they are insoluble in a medium.
eg- chlorophyll.

Natural pigments:

Definition: Natural Pigments are the pigments that are obtained naturally or occur naturally in Environment ie in the cell & tissue of plants. from plants or from animals

eg:- chlorophyll, carotenoids

Classification of Natural Pigment:

Natural Pigment

- Plants → specialized body protoplasm in Plastid
  [fruits, Vegetables, flowers]
  - ① Carotenoids
  - ② Anthocyanins
  - ③ Flavonoids
  - ④ Betalains
  - ⑤ Chlorophyll
- Micro-organisms
  (bacteria, fungi, A
  - Carotenoids
  - Chlorophyll
  - Prodigiosin →
  - Phycobiliproteins →

Nature
colour
occurance
chemical property
M.P
B.P
solubility
where used

① Chlorophyll: → fat Soluble pigment
→ Carotenoid

* Occurance: It is widely distributed as natural plant pigment. present in all green leafy vegeta
It is a green, oil soluble colour. It also occur in plant, algae & photosynthetic bacteria. they are located in inner membrane of chloroplast organelles which perform Photosynthesis.
Photosynthesis: absorb energy absorbed by chlorophyl to synthesize (food) carbohydrates. Imp for all Organism for food

Effect of Proce

* Chlorophyll pigment give green colour to vegetables & several fruits, they also used as additives is added to food products.

eg- Spinach, collard greens, Parsley, Broccoli, Green cabbage,

used in desserts, beverages, dairy product, ice cream, fruit preparation, soup, sauces, snacks, bakery product.

⟹ Benefits of chlorophyll : skin.

* Skin healing - reduce inflammation & bacterial growth in skin
* Blood builder
* Weight loss prevent
* prevent form detoxification & cancer

Anthocyanins :→ belong to flavonoids

* Anthocyanins are a group of naturally occuring pigments that are responsible for the red-blue color of many grains, fruits & vegetables.

also give purple, black

* Used in drinks, jams & sugar confectionery

Occurances :→ tissue of higher plants → leaves, stem, root, flower, fruit.

black berries	Red grapes
blue berries	pomengranate
Cherries	& others.
Cranberries	
egg plant	

* functional pigment of photosynthesis in green plants

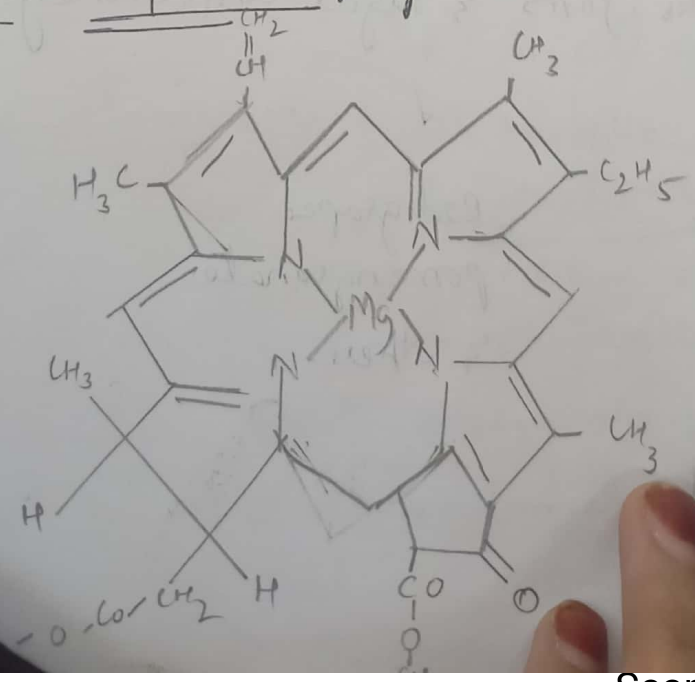
2 types

* chlorophyll a: intense blue-green in color
* chlorophyll b: intense yellow-green colour.

→ chemical property: solubility M.P - 1032.1°C B.P -

* Both chlorophyll a & b are insoluble in water but sol. in ethanol, ether, pyridine
* The melting point of chlorophyll in ~~water but~~ is 152°C & for chlorophyll b is 125°C.
* Chlorophyll absorb light strongly in the blue & red b poorly in the green portions of the electromagn spectrum, hence the colour of chlorophyll contain tissue such as plant leaves.
* Chlorophyll does not participate in the hydrogen oxid reduction, while alone electron alteration & conju alteration participate in activity transfer.

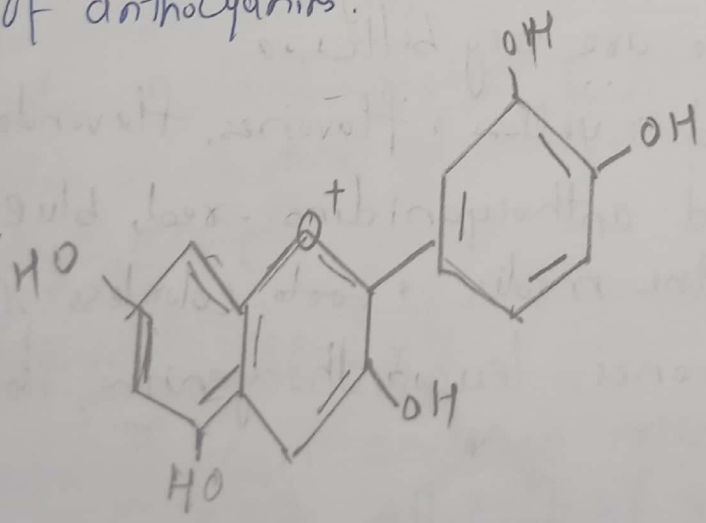
Structure of chlorophyll:



* These are contained in the vacuole of plant cells where their solubility in water makes them disperse freely
* As anthocyanin are water soluble cell sap pigment. which can be leached from vegetable by the cooking water.
* When anthocyanin contact with iron, aluminium, tin & copper ions colour ranges from green to state blue

Chemical properties: M.P
B.P
Solubility - water soluble

* Anthocyanins generally degraded at higher PH, however some anthocyanins, such as petanin are resistant to degradation at pH8 & may be used effectively as a food colorant.
* Many factors, such as pH, temperature, & light, presence of other phenolic compounds, enzymes, metal ions, sugars, ascorbic acid & oxygen have impact on the stability of anthocyanins.



function
antidiabetic,
anticancer,
anti-inflammatory,
antimicrobial &
anti-obesity
anti-
prevent cardiovascular disease

used in purple-colored jam, confectionaries & beverages..

Flavonoids:

* Flavanoids are diverse group of phytonutrients (plant) found in almost all fruits & vegetables. Along with Caroten they are responsible for the vivid colors in fruits & veg

M.P - 336.5°C
B.P - 352.4°F

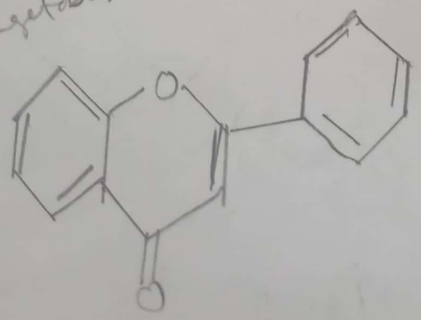
⟹ Sources / occurances

Onion, tea, strawberries, kale, grapes, Brussels sprouts, citrus fruits, parsley & many spices are just a few natural foods rich in flavonoids.

⟹ Chemical properties: formula. $C_{15}H_{10}O_2$

* Flavonoids are crystalline compounds.
* flavonoids glycosides are generally soluble in water & alcohol but insoluble in organic solvents, the aglycones are only sparingly soluble in water but soluble in ether, chloroform.
* Under the UV light flavonoids show fluorescence of different colors (yellow, orange, brown, red).
* Certain flavonoids also markedly affect the taste of foods. for ex- some are very bitter.
* They are Colored: yellow: flavones, flavonoles, chalcones, aurones, in acid anthocyanidins - red, blue: anthocyanidins in alkaline media, colorless: catechins, flavans, flavanones, leucoanthocyanidins, isoflavones.

used in fruit, vegetables, tea, cocoa & wine



Function
prevent free radical formation
prevent inflamation

Carotenoids :

* Carotenoid are also water insoluble pigment which is responsible for the - yellow, orange, colour of fruits & vegetables widely distributed in nature.

* Carotenoid are extracted from Annatto, saffron, Paprika, tomato etc

* In plants carotenoids are present as α-carotene, β-carotene, γ-carotene, xanthophyll & cryptoxanthin.

* of all carotenoids β-carotene is valuable in the synthesis of vit-A

* The colour of carotene is little affected by acid, alkali & wt of water.

chemical properties of carotenoids

(1) Solubility :

* Carotenoids are highly lipophilic. They are insoluble in water & soluble in varying degrees in organic solvents such as acetone, alcohol, ethyl ether, chloroform & ethyl acetate

(2) Chemical reactivity

* Carotenoids can undergo many reactions with a wide variety of chemical reagents, some of which might be similar to chemical found in biological systems.

* The process of that draws much attention in ... -cal system is the oxidation of carotenoids ... which time they may function as biological ... known for vit A -

(3) Protein binding. used in Alcoholic beverages. ...

* The best ex- of protein binding with β-Carote... the 15, 15'-dioxygenase of intestinal & other tissues ... pastry & ice-crea...

* This enzyme requires, carotenoids with at least ... unsubstituted O-ring which allows cleavage to ... a family of C, compounds known as retinoids. Betalain.

Microbial Pigments:

defn: The pigment found in micro-organisms wh... are used as food colorants is known as Microbial pigment

eg - prodigiosin, beta-carotene, melanin etc.

(1) Prodigiosin - M.P - 152°C B.P - 554°C dark red colour

Many strains of serratia marcescene, prod... ared pigment, which shows antibacterial, antifu... antibiotic & antineoplastic activity. It has been ... successfully applied as coloring agent in yog... milk & carbonated drinks. dairy products

drug used to treat gout immunosuppressant

* Its property of best known for its capacity to ... apoptosis of malignant cancer cells.

M.P-154°C B.P-633°C

② Beta-carotene:

A red orange colored organic pigment, mostly extracted from the beta-carotene rich algae, Dunaliella salina. Production of β-carotene through fermentation of Blakeslea trispora produces a pigment equivalent to pigments produced through a chemical process & is an acceptable coloring agent. It is used in variety of food items ranging from red to yellow in color.

③ Asthaxanthin: M.P-216°C B.P, 774°C powder form

Is a red-orange pigment, naturally found in basidiomycetous yeast, micro-algae, salmon & crustaceans, red shrimp, crayfish, feathers of some birds & is lipid soluble. It's an approved coloring agent used in fish & animal foods.

* Its property is it act as an antioxidant & reduce oxidative stress, thereby preventing protein & lipid oxidation & DNA damage

Molecular formula. $C_{40}H_{52}O_4$.

breaking of protein structure addition of oxygen

free radical formed during oxidation

④ Riboflavin :→ yellow-brown pigment

Water soluble vitamin B_2, is a yellow pigment & produced by various micro-orga... It is used in diary items, breakfast cereals, ... food, sauces, fruits drinks, & energy drinks, in ...

* It is heat stable in neutral & acid medic... but sensitive to light, unstable in alkaline so...
* Stands ordinary cooking & canning

B.P - 660°C M.P - 504°C

⑤ Lycopene :→ good for keeping healthy heart

Widely present & consumed in tomatoes, a brilliant red pigment in tomatoes, a brilliant consisting of carotenoid. It has been isolated fro... microbes like Fusarium, Sporotrichioides, & Blackeslea tripora & has the potential to attenuate ~~Persistant~~ fight against some disease, such as some types of cancer & coronary heart disease. It is used in meat Coloring in countries like the USA, Australia.

flavonoids [Anthoxanthins].

* type of flavonoid pigment is Anthoxanthin, water soluble pigment eg. cabbage, cauliflower, onion, potato.
* In acid medium became lighter
* " basic " slight yellowish
* prolonged heat → disappearance of colour

Change during processing of plant Pigments:

* Under neutral conditions, chlorophyll is a pigment that's insoluble in water & gives food a pleasant green color. When exposed to heat & acidic conditions, chlorophyll becomes a compound known as pheophythin, which gives food a dull olive brown color.

* The heat-labile factors can force anthocyanin (loss its property) destruction, which could be accelerated by endogenous enzymes in fruits that cause pigment destruction during juice processing

* temperature plays a critical role in anthocyanin storage i.e eight-hour storage of black chokeberry juice concentrate at 60°C resulted in purple reduction in anthocyanins by 31% & 35%, (half around) & antioxidant activity ↓ decreased by 26% g.

* Being highly unsaturated, carotenoids are susceptible to isomerization & ~~of trans carot~~ oxidation during processing & storage of foods. Isomerization of trans-carotenoids to cis-carotenoids, promoted by contact with acids, heat treatment & exposure to light, diminishes the color & the vit-A activity of carotenoids.

* The major loss of carotenoid is enzymatic & non-enzymatic reaction, which depend on availability of oxygen.

* Water soluble pigments leached from a vegetable by poor cooking techniques - eg- anthocyanin

* Special enamel linings of cans are used when canning anthocyanin containing fruits & vegetables but colour ranging from green to stable stable develop when anthocyanins contain iron, aluminum tin & copper ions.

Note
* The ascorbic acid with copper or Fe accelerate the oxidation & undesirable colors change of anthocyanin compounds.

⟹ Change during processing of Animal Pigment

* Prodiogiosin:
Color change due to temperature known as thermochromism, is a major cause issue faced by many producers. A pigment or dye's reaction to high temperature depends on its chemical properties & material. Too hot of temperature or long exposure to high temperature may completely degrade the color of an object.

* Astaxanthin:
When exposed to oxygen & heat, Osthaxanthin can degrade over time

* Beta - carotene:
B-Carotene is largely present in carrot. processing might negatively affect B-carotene stability as a result of isomerization & degradation

* due to negative effect β-carotene bioaccessibility increases.

Riboflavin:

Riboflavin are both stable to heat & atmospheric oxygen, especially in acidic medium. Riboflavin is sensitive to sunlight to slightly lesser extent. fluorescent

Effect of cooking on Pigments

Chlorophyll:

* In hot water dark green
* Chlorophyll on prolonged heating turn to olive green.
* Chlorophyll with citric acid convert a compound called pheophythin, which gives food a dull ~~olive~~ brown colour → fat soluble
* Chlorophyll insoluble in water give pleasent bright green colour. to dull gray green.

Raw vegetable - light green

Anthocyanins:

* Anthocyanin in acidic condition become more red or pink
* Anthocyanin react with base become more blue or green or colourless.

alkaline

* → Alkali test Gives Green colour
* effect of freezing - better retent colour remain as it is
* effect of sodium bicarbonate gives a bright green - water soluble chlorophyllin

Colour formed

alkaline test - brownish gray colour

⇒ Carotenoids:

Carrot contain - β-carotene

Green capsicum - β-carotene, Lutein

Tomatoes - Lycopene - β-carotene

** Colour is little affected by acid : alkali & by
* While cooking using of covering lid enchance the Carotenoid colour.

* on heating of prolonged colour is retained
* In alkaline medium colour is retained
* In acid medium colour is reduced. no colour change only lightning or brightening of colours
* Nutritive value is protected during cooking by the insolubility in water → fat soluble

⇒ Betalain: → red colour

* Betacyanins & betaxanthins are togethes known as betalins. → Beetroot
* Water soluble source: Betacyanin - Amaranth
* Acidic medium - reddish color .00 neutral
* alkaline " - brownish tolne of the pigment
* prolonged heating lightens the colour.
* dark in raw state
* High ratio of betacyanin to betaxanthin lead to violet, medium to red & low to orange tuber colour

Synthetic food colourants :-

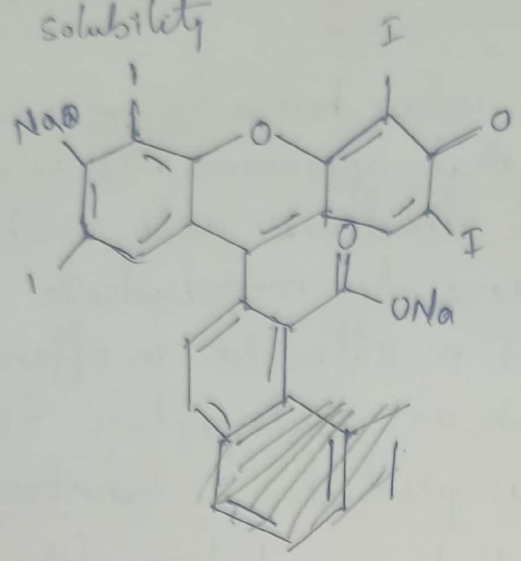
Erythrosine :

Erythrosine food colour has a brown-colored powder or granules type physical appearance. It is a xanthene dye, which comprises disodium salts such as a salt of the 2-benzoate monohydrate & subsidiary coloring matters. It is effective in offering a red color to fruits such as watermelon & can be applied for coloring various products in industries like pharmaceuticals, baking industries, like pharmaceutical baking industries, breakfast cereal manufacturing industries, confectionary products manufacturing industries, & into the areas the require erythrosin for decoration in baking, dressing & drinks, frosting & icing, & manifold. With the wide industrial experience in food colour manufacturing industries, we have attained a reliable knowledge in framing erythrosine food colour.

Erythrosine is an artificial red or cherry pink food colouring made from coal tar. Erythrosine is predominantly used as a food colours. It is used to colour products like canned fruit, candy, pistachios, popsicles, maraschino cherries, cake decorating gels, & toothpaste.

chemical formula	$C_{20}H_6I_4Na_2O_5$
Molar mass	879.86 g/mol
Melting point	142 to 144°C
boiling point	628.3°C

Water solubility



Soluble in water

Carmoisine Food colour :-

to maroon powder

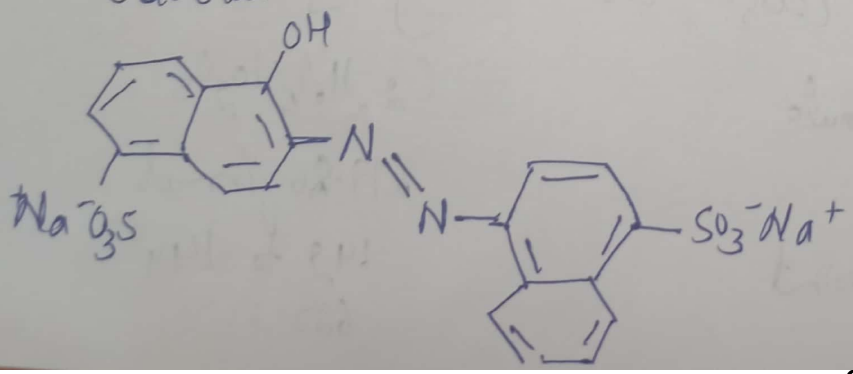
→ Carmoisine Colour also known as food red 3 or Azorubin S is a synthetic red food dye from the azo dye d group. It is used for the purposes where food is heat-treated after fermentation. Used in certain foods & beverages like cheeses, dried fruits & some alcoholic beverages. melting point >300°C. yoghurts, bread crumbs. It is synthetic food. It is used colour Amaranth

Effects increased hyperactivity in children.

Water insoluble

Chemical formula: $C_{20}H_{12}N_2Na_2O_7S_2$.

Odorless



Allura Red:

Allura red occurs as a red brown powder or granule. It is monoazo dye, consisting mainly of disodium 6-hydroxy-5-(2-methoxy-5-methyl-4-sulfonato-phenylazo)-2-naphthalene-sulforlate & subsidiary coloring matter together with sodium chloride & /sodium sulfates as the principal uncolored components & may be converted to the corresponding aluminum lake.

Allura red can be used for coloring food, drugs & cosmetics, including beverages, frozen treats, powder mixes, gelatin products, candies, icings, jellies, spices, dressings, sauces, baked goods & dairy products.

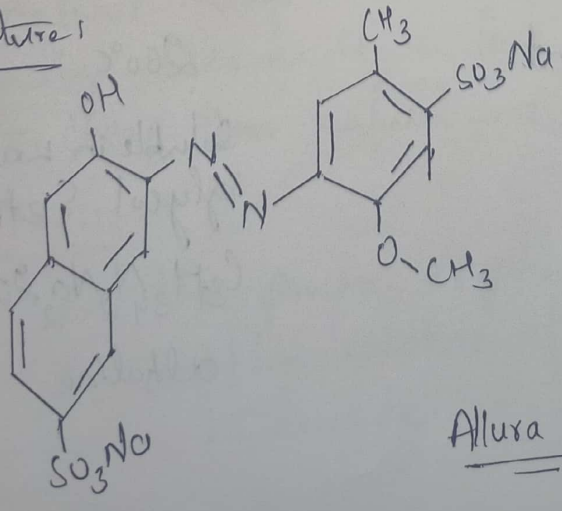
Melting point → 300

Boiling point - 325.16°

chemical formula - $C_{18}H_{14}N_2Na_2O_8S_2$

Molar Mass - 476.45.

Structure:



Allura Red

⟹ Fast Green :-

Fast Green is recommended as a replacement of Light Green SF yellowish. Masson's trichrome, as its colour is more brilliant & less likely to fade. It is used as a quantitative stain for histones at alkaline pH after acid extraction of DNA. It is also used as a protein stain in electrophoresis. Its absorption maximum at 625 nm.

Fast Green is poorly absorbed by the intestine. Its use as a food dye is prohibited. & It can be used for tinned green peas & other vegetables, jellies, sauces, fish, desserts & dry bakery mixes at level of up to 100 mg/kg.

Uses:

Common uses:

Fast Green is used for coloring cosmetics, drugs & food, including dietary supplements, breakfast cereals, cakes & cupcakes, drinks mixes & frozen treats.

Chemical properties:

Melting point	290°C
Boiling point	280°C
Solubility	Soluble in water, glycerin, glycol & ethanol.
formula	$C_{37}H_{34}N_2Na_2O_{10}S_3$.
PH	alkaline

...ical properties:

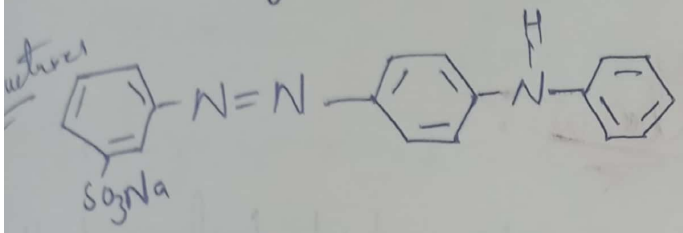
Melting point >250°c

Solubility - soluble in water, & less soluble in organic solvent (benzene, ether), acetone

pH - 1.2 & 3.2

Boiling point - 325°c

Density - 0.488



⟹ Indigo :-

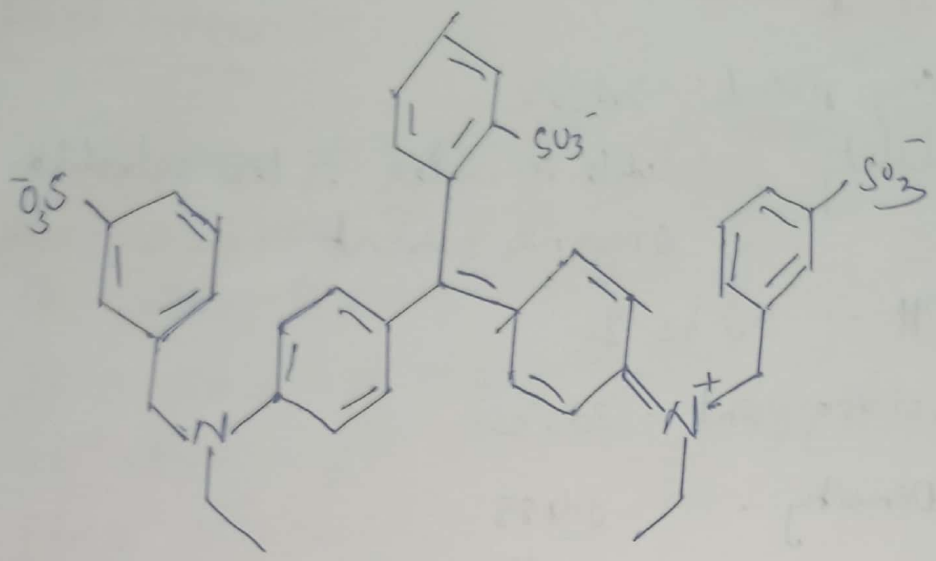
Indigo is a group of carbonyl compounds, one of the oldest known dyes in term of natural blue dye derived from the "indigofera tinctoria plant". Here in synthetic version of plant based indigo that is Blue No:2 or indigotine dt color is used.

Compared to natural, synthetic is pure & natural indigo has less yield than synthetic indigo because it is less pure. Synthetic indigo is cheap than natural one

Synthesis:

In this process, N-phenylglycine is treated with a molten mixture of sodium hydroxide, potassium hydroxide & sodamide. This is

Structure:



Metanil Yellow :-

Metanil yellow is adye which belongs to the azo compounds. It is used as a pH indicators as it changes color from red to yellow betn pH 1.2 & 2.3. It is unpermitted food dye because of its toxic effects but it is still used in turmeric powder & arhar dal (Pigeonpea) as it imparts a bright yellow color to the food so it is known to be food toxicants used for adulteration in turmeric powder, ladoo & besan.

effects:

Because of its genetoxic & Carcinogenic nature (having the potential to cause cancer) has been classified as a non-permitted food color. It consumption for a long time may cause degerative changes in the Stomach living kidney & liver.

ghly sensitive melt produces indoxyl, which is subsequently oxidized to in air to form indigo.

Chemical properties:

Density - 1.199 g/cm³.

M.P - 390 to 392°C

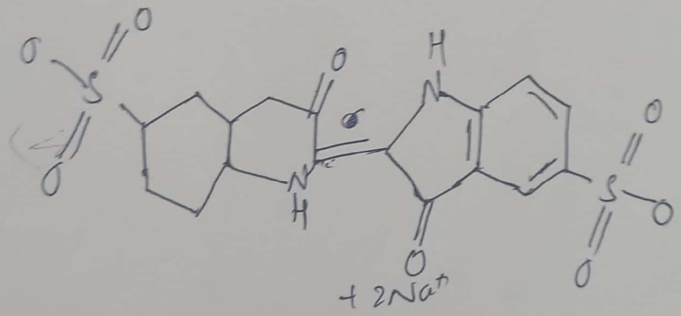
B.P - decomposes.

Appearance - dark blue crystalline powder

Indigo carmine - synthetic food colour.

formula - $C_{16}H_8N_2O_2$.

Structure:



Name: disodium - 3-oxo - 2(2-oxo-5-sulfonato-2,3-dihydro-1H-indol-2-ylidene)-2,3-dihydro-1H-indole-5-sulfonate