UNIT 5 FOOD CONSTITUENTS – VITAMINS AND MINERALS

Structure

5.0 OBJECTIVES

After reading this unit, you should be able to:

- explain the chemistry and properties of different vitamins;
- their physiological functions and deficiency diseases;
- their dietary sources; and
- describe the importance of minerals in human nutrition.

5.1 INTRODUCTION

You have already learnt about the macronutrients viz. carbohydrate, protein and fat. Besides these macronutrients, the human body requires certain accessory factors called vitamins for maintaining the health and well being. The accessory factors were named vitamins because of their vital importance to health. Some of the vitamins are unstable to the adverse storage conditions of foods and also many processing conditions. Since the vitamins are present in foods only in minute concentrations, their protection during preservation and processing of foods is a major concern.

The human body requires several minerals also for maintaining normal health. Iron and iodine deficiencies among populations are well known. Due to various reasons, the foods consumed by sections of the populations are deficient in vitamins and minerals. Therefore, these are some times added to foods. Since vitamins and minerals are collectively termed 'micronutrients', the process of adding them to foods is called micronutrient fortification. You will be learning these aspects in this unit.

5.2 VITAMINS

Vitamins are organic substances of very diverse composition required by the body usually in very minute quantities. Some of them, especially the B-group vitamins, take an active part in enzymatic reactions as co-enzymes. You will be learning more on enzymes in another unit. Most of the vitamins are supplied

to the body by plants. Vitamins do not supply energy to the body or any structural units for bodybuilding. They, however, play a most important role in the energy transfer as well as in control of many metabolic processes. Some of the vitamins like vitamin A occur in plant foods as provitamins (e.g. β-carotene), compounds that are not vitamins but can be transformed by the body into vitamins.

Vitamins are generally classified into two groups: a) fat-soluble vitamins i.e., vitamins soluble in fats and fat-soluble solvents (like petroleum ether, chloroform, carbon tetrachloride etc.) but not soluble in water, and b) water soluble vitamins, i.e., vitamins soluble in water but insoluble in fats or fat-soluble solvents.

5.2.1 Fat Soluble Vitamins

Fat soluble vitamins include 1) Vitamin A and Carotene (Provitamins A), 2) Vitamin D, 3) Vitamin E and 4) Vitamin K.

Vitamin A (Retinol)

Osborne and Mendel (1913) and McCollum and Davis (1917) showed that a fat-soluble factor present in butter was essential for the growth of rats on synthetic diet. The latter workers called the factor as "fat-soluble A". Moore (1930) showed that when large amounts of carotene are fed to vitamin A deficient rats, vitamin A was found in large amounts in liver, indicating the conversion of carotene to vitamin A in the animal body.

Chemistry and properties: In 1931, Karrer determined the structure of vitamin A. In 1937, Kuhn and Morris announced a method of synthesis if vitamin.

Vitamin A contains a β-ionone ring and a highly unsaturated side chain. Due to the unsaturated side chain, vitamin A is destroyed easily by oxidation. Being an alcohol, it forms esters such as acetate, succinate, palmitate etc. Vitamin A is stable to heat (100^{o}C) for short periods in the absence of oxygen. Vitamin A is slowly destroyed when exposed to light.

A large number of carotenoid pigments occur in nature. You will be learning their structure and properties in a later section in this unit. Carotenes are converted into vitamin A in the body. Among the carotenes, β-carotene has maximum vitamin A activity.

Functions and deficiency diseases/syndromes: Vitamin A has various functions in the human body. It is essential for the maintenance of normal vision, building and growth of skeletal cells and provides resistance power to the body. Dietary retinoids, especially carotenoid compounds have been found to suppress carcinogenesis (development of cancer).

The most important effect of deficiency of this vitamin in the diet is night blindness. In early stages of vitamin A deficiency, one cannot see well in dim light. In advanced deficiency, the subject cannot see objects in dim light. Night blindness is very common in regions where vitamin A intake is inadequate.

Dietary sources: Vitamin A is present 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. Among the plant foods, green leafy vegetables, carrot, mango and other yellow coloured fruits are good sources of carotenes.

Vitamin A levels are frequently expressed in International Units (I.U.). One I.U. equals 0.3 μg of crystalline vitamin A alcohol (retinol) or 0.6 μg β-carotene.

Vitamin D

Mellanby (1919) discovered that cod liver oil can cure or prevent experimentally produced rickets in dogs. McCollum and co-workers (1922) established experimentally that the antirachitic vitamin was different from vitamin A and called the factor vitamin D.

Chemistry and properties: Vitamin D is a group of compounds related to sterols. This vitamin occurs in several forms, the two most important are vitamin D_2 or ergocalciferol and vitamin D_3 or cholecalciferol.

Vitamin D is fairly heat stable. It is unstable on exposure to ultra-violet light. It is soluble in fat solvents.

Functions and deficiency diseases/syndromes: Vitamin D is essential for bone formation. It promotes absorption of calcium and phosphorus and deposition in bones.

In vitamin D deficiency, calcification (calcium deposition) of bone does not take place. This results in the disease called rickets in infants and children. The manifestations of the disease are: bowleg, enlargement of ankles and wrists and deformities of the chest bones called 'pigeon breast'. Exposure of children suffering from rickets to sunlight has a curative effect. Therefore, vitamin D is also called the sunshine vitamin.

Dietary sources: 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.

One international unit (I.U.) of vitamin D is equivalent to the activity of 0.025 μg of pure crystalline vitamin D_2.

Vitamin E

Evans and Bishop (1922) discovered that for normal reproduction in rats, a fat-soluble factor present in crude vegetable oils was essential. They termed it vitamin E. Evans and co-workers (1936) isolated two compounds α and β-tocopherols possessing vitamin E activity.

Chemistry and properties: Tocopherols are derivatives of 6-hydroxy chroman with a phytyl side chain. Tocopherols are soluble in fat solvents and insoluble in water. Tocopherols have excellent antioxidant properties. The storage stability of unrefined vegetable oils is due to the tocopherols. They are slowly

destroyed in alkaline medium and the vitamin activity is destroyed by oxidation.

Functions and deficiency diseases/syndromes: Vitamin E is essential for normal reproduction in several species of animals and also in man. Its deficiency causes several disorders such as reproductive failure, liver necrosis (damage), muscular dystrophy, etc.

Dietary sources: Cereal germ oils like wheat germ oil and corn germ oils are the richest natural sources of the vitamin. Soybean oil is also a good source of tocopherols. Cottonseed oil is found to contain alpha, beta, and gamma tocopherols. Delta tocopherols were isolated from soybean oil. Since alpha tocopherols have the highest biological activity, its content is taken for calculating the human requirements.

One international unit (I.U.) of vitamin E is equal to the activity of 1 mg of synthetic α- tocopherols.

Vitamin K

As early as 1934, Dam and Schonheyder found that chicks fed on purified diets containing all vitamins known at that time developed haemorrhagic condition, which was cured by Lucerne (alfalfa) leaves. They named it vitamin K (Koagulations-vitamin) meaning vitamin responsible for blood coagulation.

Chemistry and properties: 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 2-methyl 3-phytyl- 1,4-napthoquinone. It is the only vitamin K found in plants.

The commercially available vitaminK_1 is prepared synthetically from isophytol and a derivative of menadione. Vitamin K is also a fat-soluble vitamin.

Functions and deficiency diseases/syndromes: Vitamin K is essential for blood clotting by increasing the prothrombin levels in blood. Vitamin K deficiency leads to increased blood clotting time. This may lead to haemorrhage conditions. The deficiency can occur either due to inadequate intake or inadequate intestinal absorption of vitamin K. Inadequate intestinal absorption can occur due to disease of the liver or diarrhoea.

Dietary sources: Vitamin K occurs widely in plant foods, especially in leafy vegetables and also synthesised by the intestinal micro flora. It is assumed that almost 50% of the vitamin requirement is derived from intestinal micro organisms. Animal foods contain little vitamin K.

Check Your Progress Exercise 1

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

1. What is the difference between fat-soluble and water soluble vitamins? Name four fat-soluble vitamins.

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2. Which vitamin is required for normal vision? Why beta-carotene is called pro-vitamins A? List a few foods rich in beta-carotene.

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3. What is the chemical nature of vitamin K? List the physiological functions of the vitamin.

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4. Which vitamin is required for normal reproduction? List a few foods rich in the vitamin.

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5.2.2 Water Soluble Vitamins

Water soluble vitamins are classified into two groups viz.1) vitamins of the B group to which most of the water soluble vitamins belong and 2) vitamin C.

Vitamin B_1 (Thiamine)

Vitamin B_1 was the first of the B-vitamins discovered. A Dutch doctor, Eijkman, demonstrated in 1897 that a very common disease, beriberi, which prevailed at that time in the Dutch East Indians, was caused through feeding

only polished rice. Jansen and Donath (1926) isolated vitamin B_1 in crystalline form from rice polishings. This vitamin is also called thiamine.

Chemistry and properties: Williams and co-workers established the chemical structure of thiamine in 1936. Thiamine contains a pyrimidine ring and thiazole ring. It is a white crystalline powder. Sulphur dioxide destroys the vitamin activity of thiamine. Therefore, sulphites shoud not be added as a preservative to foods rich in thiamine. Thiamine is stable to heat in acid foods but it is less stable in neutral foods. It is destroyed by alkali. During wet processing, thiamine is leached out. Baking of cereal products shows considerable loss in thiamine content.

Functions and deficiency diseases/syndromes: Thiamine functions in carbohydrate metabolism. Free thiamine is readily absorbable by small intestine. It is necessary for nerve function, appetite and normal digestion.

Mild deficiency of the vitamin leads to loss of appetite, fatigue, depression and irritability. Severe deficiency causes a disease called Beriberi. There are three types of beriberi occurring in human beings viz. wet, dry and infantile beriberi.

Wet beriberi produces three general symptoms: a) Polyneuritis (inflammation of nerves), b) Oedema (swelling), and c) Disturbances of the heart. Muscle soreness and loss of reflex of the knee take place. The body tissues swell and oedema develops and it is noticed in the legs and thigh of the patient. Breathing becomes difficult and the heart becomes weak. Death occurs due to heart failure.

Dry beriberi affects the nerves of legs and arms. Calf muscles become tender and swollen. Toes and ankles get numb. The emaciated subject needs the help of sticks to stand and walk and finally becomes bedridden.

Infantile beriberi affects infants below 6 months. Two types of infentile beriberi are known. They are a) cardiovascular type, and 2) neuritic type.

Dietary sources: Whole cereals, pulses (legumes), oilseeds and nuts are good sources of thiamine.

Vitamin B_2 (Riboflavin)

In 1926, Goldberger and co-workers showed that pellagra was cured by autoclaved yeast, which was devoid of thiamine. This factor was called vitamon B_2. However, later studies showed that the vitamin so defined was a complex of several vitamins and riboflavin was one of them. Riboflavin does not cure pellagra.

Chemistry and properties: Riboflavin has a cyclic iso alloxazine nucleus and has a side chain containing a pentose sugar (ribose).

Riboflavin is slightly soluble in water and ethyl alcohol. The solution when exposed to ultra-violet light emits a strong greenish yellow fluorescence. Riboflavin is stable in acid or neutral medium but is destroyed in alkaline medium especially on heating.

Functions and deficiency diseases/syndromes: Riboflavin is concerned in the regulatory function of insulin. The retina contains riboflavin, which is converted by light to a compound involved in stimulation of the optic nerve. It forms a part of enzyme systems involved in the metabolism of carbohydrates, fats and proteins. Flavin Adenine Dinucleotide (FAD) and Flavin Mono Nucleotide (FMN) are formed from riboflavin.

Deficiency of riboflavin in the diet causes oral and facial, scrotal, vulval, and also ocular lesions.

Dietary sources: Liver, dried yeast, egg powder, whole and skim milk powder are excellent sources of riboflavin. Milk, cheese, eggs, whole grain and green leafy vegetables are also good sources.

Niacin (Nicotinic Acid)

The discovery of niacin was also associated with yeast extract as in the case of thiamine and riboflavin. It was isolated from liver and found that it can cure 'pellagra' in man and 'black tongue' in dogs. Niacin (nicotinic acid) is also called vitamin B_3.

Chemistry and properties: Acid or alkaline solutions of nicotinic acid on heating is converted to nicotinamide. It is one of the most stable of the vitamins. It is stable to acids, bases, oxidizing agents, heat and light. However, it is destroyed by autoclaving at 120^0C 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).

Functions and deficiency diseases/syndromes: Nicotinic acid is essential for the normal functioning if the skin, intestinal tract and the nervous system. Deficiency of Niacin leads to a disease known as pellagra. In pellagra disease dermatitis, glossitis and stomatitis occur. Dermatitis is appears 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.

Dietary sources: Yeast, liver, meat, poultry, wholegrains, fresh pork are excellent sources of niacin. Good proteins like milk protein are associated with niacin because triptophan, an amino acid, present in the proteins is converted into niacin in the body. It has been estimated that 60 mg of triptophan yield 1 mg of niacin.

Vitamin B_6 (Pyridoxin)

Pyridoxine is one of the vitamins of the B group, which prevents dermatitis. It was isolated in 1938 in pure form by different groups of workers. Pyridoxine is also called vitamin B_6.

Chemistry and properties: Pyridoxine does not belong to only one class of compound. It consists of three related substances namely pyridoxine, pyridoxal and pyridoxamine.

Pyridoxine contains a pyridine nucleus, two primary alcoholic groups and one phenolic hydroxyl group. Pyridoxal contains an aldehyde group in place of one primary alcoholic group and pyridoxal amine contains a primary amine side chain in place of a primary alcohol group. Pyridoxine is readily soluble in water and alcohol. It slowly gets destroyed when exposed to sunlight. Neutral or alkaline solutions of pyridoxine are heat labile. Oxidising substances like potassium permanganate and hydrogen peroxide also destroy it.

Functions and deficiency diseases/syndromes: Pyridoxine is essential for growth of infants. Its deficiency produces degeneration of the nerves. It has also some influence on the functioning of hormones. Besides pyridoxine play important roles in amino acid and lipid metabolism. Pyridoxal phosphate acts as a coenzyme for a number of enzyme systems. It removes carbon dioxide from the acid groups of certain amino acids and transfer amine groups from one compound to another. Pyridotal phosphate helps in transamination reactions, poryphyrin synthesis etc.

Dietary sources: Pyridoxine is widely distributed in 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 of this vitamin.

Pantothenic Acid

Pantothenic acid is one of the B group vitamins. In 1933, Williams reported that a factor present in yeast could prevent a specific type of pellagra (chick pellagra). This factor was named pantothenic acid.

Chemistry and properties: Pantothenic acid is an unstable, viscous oil. It is soluble in water. It contains an amino acid namely alanine. It is stable to heat but destroyed by acid and alkali. It is readily absorbed from small intestines.

Functions and deficiency diseases/syndromes: Pantothenic acid has an important role in the metabolism of Co-enzyme A. Therefore, indirectly pantothenic acid has a role in the utilization of carbohydrates and fats. Deficiency diseases of the vitamin are not often observed in man. However some of the deficiency disease symptoms are headache, fatigue, weakness, sleeplessness, nausea etc.

Dietary sources: It is widely distributed in foods. Dried yeasts, liver, rice polishing, wheat germs, fleshy foods, eggs, fish etc. are good sources of pantothenic acid.

Biotin

In 1916, Bateman showed that when rats were fed with uncooked egg white, they developed the peculiar skin disease. This condition was called egg-white injury. This was due to a toxic component called avidin. Gyorgi in 1931 isolated an anti-egg white injury factor from yeasts and named it as vitamin H. Later this factor was found in egg yolk and it was called Biotin.

Chemistry and properties: Biotin is sparingly soluble in cold water and freely soluble in hot water. It is stable to heat but sensitive to acid, alkali and oxidizing agents. It forms salts with alkali hydroxides.

Functions and deficiency diseases/syndromes: Biotin is essential for the activity of many enzyme systems. It helps in maintaining the skin structure and is necessary for normal gestation and lactation in animals. It is also 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.

Dietary sources: Biotin occurs widely in foods of both vegetable and animal origin. 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).

Folic Acid

Wills (1934) showed that a vitamin present in autolysed yeast extract cured tropical macrocytic anaemia in humans. Mitchell, Snell and Williams (1941) reported the presence of this factor in spinach leaves essential for the growth of L-casei (a micro organism). They called this factor folic acid (*folium* meaning leaf).

Chemistry and properties: Folic acid is also called pteroyl glutamic acid. It is widely distributed in nature. It is a yellow crystalline compound moderately soluble in hot water and stable to heat. Many bacteria produce this vitamin.

Functions and deficiency diseases/syndromes: It is essential for the maturation of Red Blood Cells (RBC). It acts as co-enzyme in the transfer of single carbon groups such as methyl or formyl. It is essential for reproduction in animals. It also helps in the hair growth and health of skin.

Folic acid deficiency causes megaloblastic anaemia, which is also called macrocytic anaemia. This mainly occurs in pregnant women. This is due to accumulation of immature RBCs in bone marrow. Inadequate supply of folic acid causes glossitis (red sore tongue), diarrhoea, and anaemia.

Dietary sources: Dried yeast, green leafy vegetables, dry beans, cabbage, soybean, yeast, kidney and liver are good sources of this vitamin.

Vitamin B_{12}

In 1926, Minot and Murphy found that feeding liver in large quantities could control pernicious anaemia. In 1929, Castle also found that beef muscle is effective in controlling pernicious anaemia. Both these factors were responsible due to Vitamin B_{12}. It is also called Cyanocobalamin.

Chemistry and properties: Cyanocobalamin has a complicated chemical structure. It contains a porphyrin nucleus and a molecule of cobalt (4-5%).

Vitamin B_{12} is a water-soluble dark red crystalline compound not stable to acids and alkali. When it is exposed to sunlight it gets partially destroyed.

Functions and deficiency diseases/syndromes: Vitamin B_{12} promotes the maturation of Red Blood Cells (RBC). It is essential for the normal function of bone marrow and the nervous system. B_{12} takes part in many enzymatic reactions. It is essential for the absorption of Calcium and Phosphorus. It aids in providing energy to the central nervous system. It also helps in the increase of white blood cells and blood platelet count.

Deficiency of the vitamin causes pernicious anaemia. Life span of RBCs also comes down. The shape and size of RBCs also change. The other symptoms are skin lesions, reduction in gastric secretion, effect on spinal cord, tingling, numbness, loss of sense of limbs, depression etc.

Dietary sources: Vitamin B_{12} is present only in foods of animal origin. Kidney and liver, egg, cheese, milk, fish etc. are good sources of the vitamin.

Vitamin C (Ascorbic Acid)

Man knew the disease scurvy since centuries. It was found that sailors on long voyage were 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.

Chemistry and properties: Haworth and co-workers established the chemical structure of ascorbic acid in 1933. It is a six carbon mono basic acid present in its lactonised form. Its reducing property is due to the presence of a di-enolic configuration.Vitamin-C is a white water soluble crystalline compound stable in acid solution but sensitive to oxidation. Ascorbic acid has strong reducing property. It loses two hydrogen and forms dehydroascorbic acid. It is sensitive to high temperature. Vitamin-C is lost during food processing, storage and cooking.

Functions and deficiency diseases/syndromes: Vitamin C is essential for the formation of collagen and osteoblasts, for carbohydrate and cholesterol metabolism, for oxidation of phenylalanine to tyrosine, for the absorption of iron, and for rapid healing of wounds. Severe deficiency of the vitamin 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.

Dietary sources: Ascorbic acid is widely distributed in the plant kingdom. Many fruits and vegetables like amla, orange, lemon, guava, cabbage, etc. are good sources of the vitamin.

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. What is beriberi?

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2. What is the chemical nature of niacin? Which disease is caused by its deficiency?

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3. What are the roles of vitamin B_{12} in the human system? List a few dietary sources of the vitamin.

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4. What is the chemical nature of ascorbic acid? Why it has reducing property? List a few foods rich in ascorbic acid.

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5.3 MINERALS

Proteins, carbohydrates and fats belong to organic compounds whereas minerals are inorganic in nature. When a food material is completely burnt, we are left with ash. This ash is nothing but minerals. These minerals are very essential to our body and they are included under the category called micronutrients.

The body contains about 24 minerals, all of which must be supplied by the diet. These minerals are necessary for the following different functions: 1) as

constituents of bones and teeth e.g. Calcium, phosphorus and magnesium; 2) as constituents of body cells of soft tissues like muscles, liver etc. e.g. Phosphorous; 3) as soluble salts which give to the body fluids and cell contents, their composition and stability which are both essential for life, e.g., sodium, potassium, chloride, and phosphorous; 4) some minerals are required in small quantities for specific functions, e.g., iron and copper for formation of hemoglobin; iodine for formation of thyroxine; zinc a constituent of a co-enzyme; cobalt the constituent of vitamin B_{12} and some other elements are essential for the activity of various enzymes. Minerals are classified into macro-minerals and micro minerals. Macro minerals are required in higher quantities and micro minerals are required in much smaller quantities. Calcium, phosphorous, magnesium, sodium and potassium are generally classified as macro minerals while iron, iodine, fluorine, manganese, cobalt, selenium, cobalt etc are classified under micro minerals. The physiological functions and dietary sources of some minerals are given in the following table.

Physiological functions of some minerals

Sl. No.	Mineral	Functions	Sources
1.	Calcium	Essential for the formation of bones and teeth. Absorption of Vitamin B12 and contraction of heart and muscles.	Milk and milk products, green leafy vegetables, ragi, egg and fish, etc.
2.	Phosphorus	Essential for formation and growth of bones and teeth, metabolism and transport of lipids and maintenance of acid base balance.	Rice and wheat bran, cheese, milk, meat and fruits and vegetables, etc.
3.	Sodium	Essential for acid base balance, regulation of osmotic pressure in cell fluids, maintenance of blood pressure and regulation of heart beat.	Table salt, milk meat, shell fish, egg, cheese, leafy vegetables, etc.
4.	Potassium	Essential for acid base balance, conduction of nerve impulses, conversion of glucose to glycogen and growth and build-up for tissues.	Fruits, dry fruits, milk, beans, etc.
5.	Magnesium	Takes part in the activity of more than 300 enzymes, vital for the functions of nerves, bones and muscles and teeth, role in coagulation of blood.	Green vegetables. Nuts, cereals, milk, etc.
6.	Iron	Component of haemoglobin, transport and storage of oxygen, essential for cell respiration.	Cereals, sea foods, meat, egg, vegetables, etc.

7.	Iodine	Normal thyroid function, deficiency causes goiter, i.e. Swelling of the thyroid gland and decrease of thyroidal hormone production.	Drinking water, Iodized salt, marine foods, meat, milk, fruits and vegetables, cereals, etc.
8.	Fluorine	Essential for bone and teeth formation, prevents tooth decay. Deficiency causes dental caries. Excess chlorine causes dental fluorosis.	Drinking water, milk, sea foods, garlic, tea, etc.
9.	Manganese	Takes part in the activity of many enzymes, helps in the development of bones, role in the regulation of fats and carbohydrates	Cereals, pulses , oil seeds, milk, vegetables, etc.
10.	Copper	Helps in the absorption and utilization of iron, influence on the oxygen supply, formation of melanin and phospholipids, takes part in enzyme activity.	Seeds, nuts, mushrooms, etc.
11.	Zinc	Aids in carbohydrate and protein metabolism, role in production of insulin, takes part in enzyme activity.	Cheese, fish, meat, egg, oyster, cereals, etc.
12.	Chromium	Influence on carbohydrate metabolism, stabilization of blood sugar level, influence on appetite.	Poultry, meat, milk, potato, nuts, etc.
13.	Selenium	Component of various enzymes, acts as an antioxidant, has protective effect against cancer.	Soybean, meat, fish, etc.
14.	Cobalt	Component of vitamin B12, Role in carbohydrate and lipid metabolism, role in synthesis of proteins.	Animal foods especially liver

Micronutrient Fortification

As compared to the major nutrients viz. carbohydrate, protein and fat, the other essential nutrients like the vitamins and minerals are required by the human system only in minute quantities. Therefore, they are termed as 'micronutrients'. Due to lack of access to balanced foods, certain sections of the population suffers from severe micronutrient deficiency. To improve the quality of the diet, these nutrients are some times added to foods. This process is called 'micronutrient fortification'. For example, iodine is added to table salt to prevent goiter and iron is added to wheat flour to prevent anemia. Vitamin fortified foods are also not rare. During fortification, the following precautions have to be taken.

1. Only the required concentration of the nutrient should be added to foods.
2. Fortification should not affect the stability of the food product.
3. It should not affect the colour and taste of the end product.

Check Your Progress Exercise 3

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

1. Which minerals are required for the formation of bones and teeth? List a few dietary sources for the minerals.

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2. Which diseases are caused by the deficiency of iodine and fluorine?

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3. Enumerate the importance of iron and cobalt in human nutrition.

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5.4 LET US SUM UP

Vitamins are complex organic substances required by the human body for several vital and well-defined physiological functions. They are mostly derived from plant sources. Because there is no structural relationship among the different vitamins, their classification is practically not possible. However, based on their solubility characteristics they are classified into fat soluble (soluble in fat and fat solvents) and water soluble vitamins. Most of the water-soluble vitamins belong to the group of the B complex. Many of the B complex vitamins take part in various enzymatic reactions as coenzymes.

The human body also requires several minerals for its physiological functions. Many of the minerals are cofactors of enzyme systems. Deficiency of some minerals cause specific diseases like for example, deficiency of iodine causes ‘goitre’ and deficiency of fluorine causes ‘dental caries’.

Since all the vitamins and minerals are not present in sufficient quantities in the staple diets of sections of the population, their deficiencies are common. In order to alleviate the deficiency, some foods are fortified with these nutrients.

5.5 KEY WORDS

Vitamin	**:**	Of vital importance
Retinol	**:**	Vitamin A alcohol
Provitamin A	**:**	Carotenes, which are converted to vitamin A in the body.
Liver necrosis	**:**	Liver damage due to disease.
Prothrombin	**:**	Substance in blood responsible for normal blood clotting.
Beriberi	**:**	The disease caused by the deficiency of vitamin B_1.
FAD	**:**	Flavin adenine dinucleotide.
FMN	**:**	Flavin mono nucleotide.
Pellagra	**:**	The disease caused by the deficiency of niacin.
Scurvy	**:**	The disease caused by deficiency of vitamin C.
Goitre	**:**	The disease caused by deficiency of iodine.
Dental caries	**:**	The disease caused by deficiency of fluorine.
Micro nutrients	**:**	Vitamins and minerals.

5.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include the following points:

   - Solubility in fat and fat-soluble solvents and water.
   - Vitamin A, D, E and K

2. Your answer should include the following points:

   - Vitamin A.
   - Beta carotene gets converted to vitamin A in the human body.
   - Green leafy vegetables, yellow fruits and vegetables like mango, papaya, carrot.

3. Your answer should include the following points:

- Quinone
- Blood clotting

4. Your answer should include the following points:

- Vitamin E
- Cereal germ oils, soybean oil, cottonseed oil

Check Your Progress Exercise 2

1. Your answer should include the following points:

- Deficiency of vitamin B_1

2. Your answer should include the following points:

- Nicotinic acid, nicotinamide
- Pellagra

3. Your answer should include the following points:

- RBC
- Pernicious anaemia
- Absorption of Ca, P
- Animal foods eg. liver

4. Your answer should include the following points:

- Six carbon monobasic acid
- Di-enol
- Citrus fruits, amla, guava

Check Your Progress Exercise 3

1. Your answer should include the following points:

- Ca, P
- Milk, ragi, leafy vegetables, rice and wheat bran, fish

2. Your answer should include the following points:

- Goitre
- Dental caries

3. Your answer should include the following points:

- Haemoglobin
- Anaemia
- Oxygen transport
- Vitamin B_{12}
- Carbohydrate and lipid metabolism

5.7 SOME USEFUL BOOKS

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