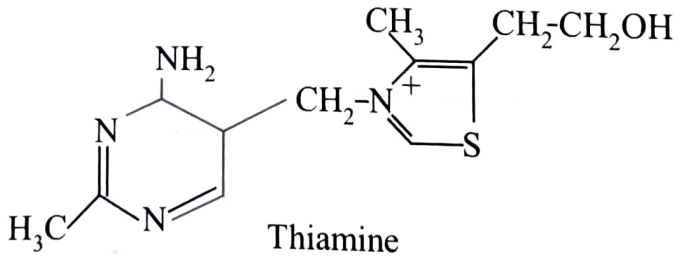
5.2 Water-Soluble Vitamins

Water-soluble vitamins are not normally stored to any extent in the body and the ingested vitamins in excess of requirement are excreted through the kidney. For the body to carry out its normal functions the daily supply of these vitamins is necessary. Most of the water-soluble vitamins are components of essential enzymes. These vitamins are extensively lost by leaching during the cooking operations. The principal food sources of the B complex vitamins are liver, yeast and bran of cereal grains. Some vitamins of the B group result from bacterial activity in the small intestine. Many are easily synthesized and used as food additives.

B complex vitamins: One important reason for grouping the B vitamins together is that they all occur together in nature. Therefore, a diet lacking in one B complex vitamin usually lacks in others of the group. As a result, single discrete deficiency of a B group vitamin is seldom seen. Deficiency diseases involving the vitamins are multiple in nature, although the signs and symptoms of the deficiency of a particular member of the group may predominate. In general, the B group vitamins function as coenzymes and thus they play an essential role in the metabolic processes of all living cells.

5.2.1 Thiamine (Vitamin B-1)

This vitamin is widely distributed throughout the plant and animal kingdoms. The best sources of this vitamin are cereal grain (particularly wheat) germ layers. Polished cereal grains and refined wheat flour are deficient in the vitamin. The vitamin is present in good quantity in pulses (peas, beans) and in nuts. Liver, lean meats, poultry, egg-yolk and fish are also good sources of the vitamin. Thiamine can exist in foods in a number of forms including free thiamine, the pyrophosphate ester, and bound to respective apoenzymes (see Sec. 10.1).



Thiamine

Thiamine is readily soluble in water and insoluble in fat solvents. The dry vitamin is fairly stable but solutions of it are unstable in the presence of heat or alkali. Temperature is an important factor in thiamine stability. Thermal destruction of thiamine results in many degradation products and leads to the formation of a characteristic odour which is involved in the development of "meaty" flavour in cooked foods. Thermal destruction is pH dependent. In acidic of pH, the vitamin is heat stable, but the coenzyme form of the vitamin is more sensitive to pH than thiamine. Starch and/or the protein components of cereal products exert a protective action against the destruction of the vitamin in some pH ranges.

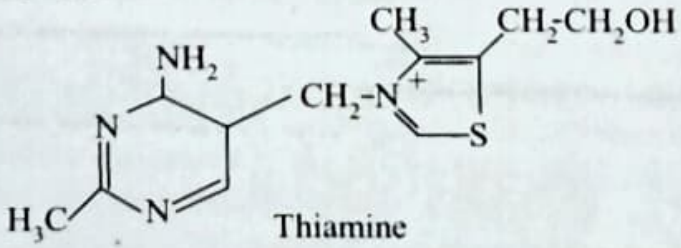
Thiamine is also destroyed by oxidation and reduction. It is particularly sensitive to sulphur dioxide and sulphite, and so these should not be used to preserve thiamine-containing foods. Loss of thiamine can occur in raw fishery products because of thiaminase activity. This does not seem to be a significant human problem.

excess of requirement are excreted through the kidney. For the body to carry out its normal functions the daily supply of these vitamins is necessary. Most of the water-soluble vitamins are components of essential enzymes. These vitamins are extensively lost by leaching during the cooking operations. The principal food sources of the B complex vitamins are liver, yeast and bran of cereal grains. Some vitamins of the B group result from bacterial activity in the small intestine. Many are easily synthesized and used as food additives.

B complex vitamins: One important reason for grouping the B vitamins together is that they all occur together in nature. Therefore, a diet lacking in one B complex vitamin usually lacks in others of the group. As a result, single discrete deficiency of a B group vitamin is seldom seen. Deficiency diseases involving the vitamins are multiple in nature, although the signs and symptoms of the deficiency of a particular member of the group may predominate. In general, the B group vitamins function as coenzymes and thus they play an essential role in the metabolic processes of all living cells.

5.2.1 Thiamine (Vitamin B-1)

This vitamin is widely distributed throughout the plant and animal kingdoms. The best sources of this vitamin are cereal grain (particularly wheat) germ layers. Polished cereal grains and refined wheat flour are deficient in the vitamin. The vitamin is present in good quantity in pulses (peas, beans) and in nuts. Liver, lean meats, poultry, egg-yolk and fish are also good sources of the vitamin. Thiamine can exist in foods in a number of forms including free thiamine, the pyrophosphate ester, and bound to respective apoenzymes (see Sec. 10.1).



Thiamine

Thiamine is readily soluble in water and insoluble in fat solvents. The dry vitamin is fairly stable but solutions of it are unstable in the presence of heat or alkali. Temperature is an important factor in thiamine stability. Thermal destruction of thiamine results in many degradation products and leads to the formation of a characteristic odour which is involved in the development of "meaty" flavour in cooked foods. Thermal destruction is pH dependent. In acidic of pH, the vitamin is heat stable, but the coenzyme form of the vitamin is more sensitive to pH than thiamine. Starch and/or the protein components of cereal products exert a protective action against the destruction of the vitamin in some pH ranges.

Thiamine is also destroyed by oxidation and reduction. It is particularly sensitive to sulphur

ystems and of the gastrointestinal tract. Thiamine deficiency occurs most frequently in areas where
e diet consists of unenriched white rice and white flour. Thiamine deficiency occurs among
coholics. Decreased consumption, increased requirement and decreased absorption all appear to play
role in the development of the deficiency in alcoholics. Individuals consuming large amounts of tea,
hich contains a thiamine antagonist (a compound whose structure is similar to the specific nutrient),
ay have an increased risk of developing a deficiency.

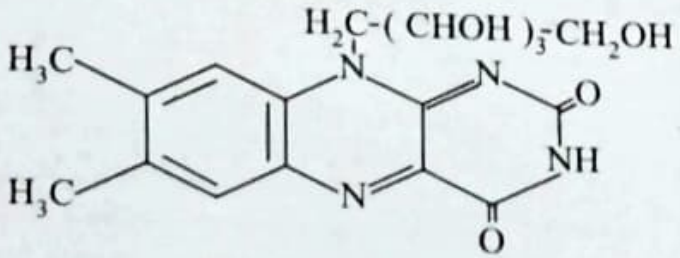
Functions:. The most important function of thiamine is its role as a coenzyme. It combines with
osphoric acid to form thiamine pyrophosphate (TPP) which functions as a coenzyme: TPP is the
enzyme of carboxylase which is required for oxidative decarboxylation of pyruvate during the
ological oxidation of glucose. The oxidation of other α-keto acids and 2-keto acids derived from
mino acid metabolism also requires thiamine. TPP is also the coenzyme of transketolase, another
nzyme involved in carbohydrate metabolism.

Thiamine is necessary throughout life for release of energy from fuel molecules. The amount
quired is related to body weight, calorie intake, and the small amount of vitamin synthesized in the
testinal tract. On the basis of these considerations, a thiamine allowance of 1.2–1.5 mg/day for males
nd 1.0–1.2 mg/day for females is recommended. The requirement of thiamine increases during
regnancy and lactation; an additional allowance of 0.3 mg is recommended in these cases.

2.2 Riboflavin (Vitamin B-2)

his vitamin is widely distributed in plant and animal foods in small amounts. Relatively good dietary
ources of the vitamin are milk, cheese, liver eggs and leafy vegetables. Dried yeast is also a rich
urce of the vitamin. Pulses and lean meats contain appreciable amounts of riboflavin.

Riboflavin belongs to a group of yellow fluorescent pigments called flavins. The flavin ring is
tached to an alcohol related to ribose (ribitol).



Riboflavin

Riboflavin is orange yellow in colour. On reduction, it changes into a colourless form. It is less
luble in water than thiamine but is more stable to heat in acid and neutral media. It is destroyed by
ating in alkaline solution. Owing to heat stability and limited water solubility, very little of the
amin is lost during the cooking and processing of food. Baking soda used for faster cooking
stroys much of the riboflavin content of the food.

On exposure to light, riboflavin readily loses its vitamin activity due to the photochemical
avage of the ribitol moiety of the vitamin, forming lumiflavin. Lumiflavin is a stronger oxidizing

agent than riboflavin and can catalyze the destruction of a number of other vitamins, particularly ascorbic acid. When milk is sold in glass bottles there is 50-70 per cent loss of riboflavin potency in two hours due to the effect of direct sunlight. With the advent of paper or plastic milk containers this problem has disappeared.

Deficiency: Riboflavin is essential for growth and is thought to have multiple functions in production of corticosteroids, formation of red blood cells, synthesis of glucose from non-carbohydrate materials and thyroid enzyme regulating activity. Its deficiency in man results in reddened, denuded areas on the lips, with cracks at the corners of the mouth (cheilosis); swollen and reddened tongue (glostitis), and scaly, greasy dermatitis of the face, ears and other parts of the body. The vitamin deficiency also results in eye disorders such as itching, burning, lacrimation, dimness of vision and cataract. Symptoms of general debility and behavioural changes may also be associated with a deficient intake of riboflavin.

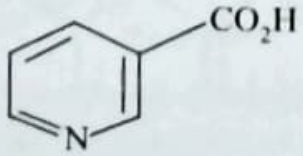
Function: Free riboflavin, such as is found in some foods, must be phosphorylated in the intestinal tract before it can be absorbed. On combining with phosphoric acid, it becomes part of the structure of two flavin coenzymes—flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD). These coenzymes are attached to some enzymes (flavoprotein enzymes). Most of these enzymes catalyze many oxidation and reduction reactions in the cells,

The recommended daily allowance for riboflavin is 1.5–1.8 mg for men and 1.1–1.4 mg for women with an additional 0.3 mg during pregnancy and 0.5 mg during lactation. It is reported that women using oral contraceptives have increased riboflavin requirements.

5.2.3 Niacin

The term "niacin" includes both nicotinic acid and nicotinamide, both natural forms of the vitamin with niacin activity. In foods, both these forms of the vitamin and their coenzyme forms occur. Good sources of the vitamin are lean meat, yeast, fish, poultry, groundnuts, pulses and whole grain cereals. Vegetables and fruits are poor sources. Niacin can be synthesized by the bacteria of the intestinal flora and is formed in the tissues from the amino acid tryptophan, which has niacin sparing activity. This explains why some foods rich in tryptophan, e.g., milk and egg, have a far greater niacin potency than would be expected from their actual content of niacin.

Niacin is one of the stablest vitamins, being relatively resistant to heat, light, acids and alkalis. Its loss from foods occurs via trimming, leaching, etc., with parallel loss of other water-soluble vitamins.



Nicotinic acid

In man, deficiency of niacin results in weakness and indigestion followed by ulcerated mouth and tongue. Prolonged deficiency leads to pellagra, and this results in dermatitis, diarrhoea and depression or dementia. Skin lesions are aggravated by exposure to sunlight; neurological symptoms and mental changes occur in more advanced cases.

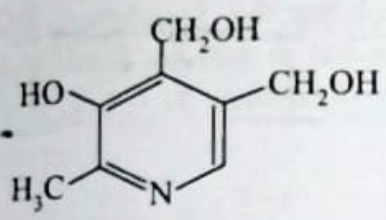
The chief function of niacin in the body is to form the active part of the coenzymes that play an important part in biological oxidations. Nicotinamide is the component of two coenzymes nicotinamide adenine dinucleotide (NAD), and its phosphate; nicotinamide adenine dinucleotide

synthesis. Also ... in the electron transport reactions involved in the release of biological energy.

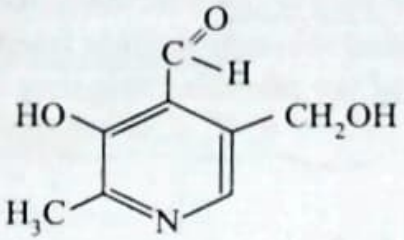
As tryptophan has niacin sparing action, the niacin requirement of the body is expressed as niacin equivalent. It is assumed that 60 mg of tryptophan in the diet is equivalent to 1 mg of niacin. The recommended daily allowance of niacin is 16–20 mg for men and 13–16 mg for women. During pregnancy an increase of 2 mg and during lactation 4 mg of niacin is recommended.

5.2.4 Pyridoxine (Vitamin B–6)

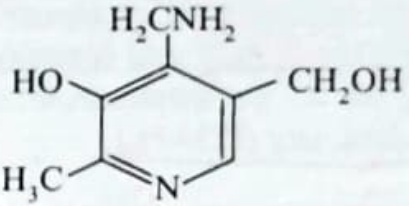
There are 3 chemical compounds found in foods which have vitamin B–6 activity. They are pyridoxine, pyridoxal and pyridoxamine.



Pyridoxine



Pyridoxal



Pyridoxamine

The term B–6 or pyridoxine is used to designate this group of substances. This vitamin is widely distributed throughout the plant and animal kingdoms. The best sources are meat, especially liver, some vegetables and grain cereals with bran.

Pyridoxine (pyridoxol) is the most stable form of this vitamin and is the form used for the fortification of foods. The vitamin is stable in an acid medium and relatively stable in alkaline solution. It is very unstable to light. The product formed by photoconversion is biologically inactive.

Deficiency: Deficiency of vitamin B–6 in infants may result in epileptic form of convulsions, loss of weight and abdominal distress, vomiting and hyper irritability. In adults, deprivation of vitamin B-6 may cause depression, confusion and convulsions. Administration of vitamin B–6 antagonist (deoxypyridoxine) to subjects receiving a diet low in vitamin B–6 results in greasy (seborrheic) dermatitis around the eyes, in the eyebrows have and at the angles of the mouth, along with soreness of the mouth and a smooth red tongue, that, responded to pyridoxine but did not respond to thiamine, riboflavin and niacin. Vitamin B–6 deficiency has been shown to increase urinary oxalate formation and has been indicated in renal calculi formation.

Pregnant women on a normal diet have shown B–6 deficiency. It is also reported that women taking oral contraceptive agents have increased urinary excretion of tryptophan and impaired glucose tolerance, and these are rectified by vitamin B–6 supplementation.

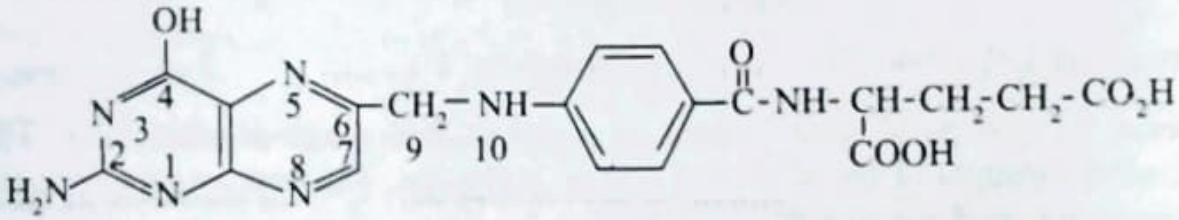
Function: Pyridoxine is found in cells in the active form, pyridoxal phosphate (PLP). This is the coenzyme of many enzymes involved in carbohydrate, fat and protein metabolism, being required in transamination, deamination, desulphuration and decarboxylation reactions. The vitamin is the cofactor of enzymes involved in the conversion of tryptophan to niacin, the essential fatty ...

5.2.5 Folic Acid (B_9)

The name folic acid comes from the Latin word for foliage or leaf (folium) because the vitamin wa first isolated from spinach leaves and was known to be widely distributed in green leafy plant Nutritionists use the term "folacin" for folic acid. There is no single compound with the name folacin The word represents a number of related compounds exhibiting the biological properties of folic acid

Yeast, kidney, liver and green leafy vegetables, especially spinach, asparagus and broccoli, ar rich sources of folic acid. Dried beans and whole wheat bread are good sources of the vitamin. Th folic acid content of processed milk, highly milled cereals, eggs, root vegetables and most fruits low.

Folic acid belongs to a group of compounds known as pterins. It consists of three component a pteridine ring attached to p-aminobenzoic acid, which, in turn, is coupled to glutamic acid. It chemical structure is pteroyl-glutamic acid (PGA). In many foods, folic acid contains more than on glutamic moiety with glutamates linked through peptide bonds involving the Υ-carboxyl group. I addition, the 5, 6, 7 and 8 positions of the pteridine ring may be reduced in various forms to yield variety of di- or tetrahydrofolates, i.e., 5, 6, 7, 8 tetrahydrofolate ($PGAH_4$), 5, 6–, 5, 8–, or 7 8-dihydrofolate ($PGAH_2$).



Folic acid (Pteroylmonoglutamic acid,PGA)

A variety of chemical forms of PGA have vitamin activity. The essential subunit structure shoul remain intact for activity. If the parent molecule is broken into its constituents, the nutritional activit is lost. Different members of the folic acid group vary in nutritional effectiveness, stability an availability. For example, N^5-methyl $PGAH_4$, N^5-formyl $PGAH_4$ and N^{10}-formyl PGA are heat stabl whereas others like unsubstituted $PGAH_4$ are rapidly destroyed by heat. PGA itself is unstable to he in acid medium and stable to sunlight when in solution.

Loss of folic acid occurs when foods are processed and stored; vitamin activity is lost processed and stored milks. Primarily, the inactivation is due to oxidation. The destruction of fola runs parallel to that of ascorbate and added ascorbate can stabilize folate.

Folacin deficiency in man results in poor growth, megaloblastic anaemia and other blo disorders, gastrointestinal tract disturbances arising from impaired absorption, and metabol derangement. The vitamin controls macrocytic anaemias of pregnancy. In pernicious anaemia, fol acid gives some initial response but the disease is cured only after administration of vitamin B–12.

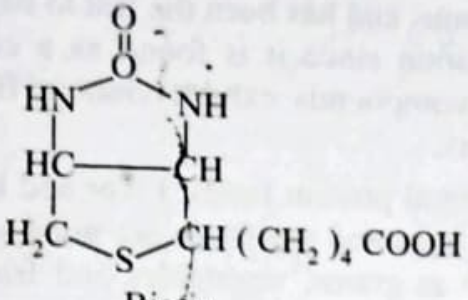
After absorption, folic acid is converted into many active coenzyme forms, the parent bei tetrahydrofolic acid. The principal function of, PGA-containing coenzymes is the transport of on carbon groups (specially, the formyl and hydroxymethyl groups) from one compound to anoth Many of the steps catalyzed by folate-containing enzymes are essential for the synthesis of nucle acids and for normal metabolism of certain amino acids. This explains the important role of folate

The recommended daily allowance of folacin is 400 µg of total PGA activity for nonpregnant, nonlactating adults and adolescents. The requirement during pregnancy is 800 µg/day and during lactation 500 µg day.

5.2.6 Biotin

Biotin is widely distributed in nature and is essential for the health of many animal species including man. Good sources include liver, kidney, egg yolk, groundnuts and some vegetables. Cereal grains, fruits and meat are regarded as poor sources. Wide differences exist in the bioavailability of biotin-bound vitamin is unavailable for nutritional purposes. Biotin of maize and soyabean meal is completely available to test animals, whereas the biotin of wheat is almost unavailable.

Biotin is a water-soluble, sulphur-containing vitamin. It is stable to heat and light but unstable in strong acid or alkali. Its optimum stability is in the pH range 5–8. As it contains a sulphur atom, it is susceptible to oxidation.



Biotin

Deficiencies of biotin are unlikely in man due to its extensive synthesis in the intestinal tract. Deficiency manifestations can be induced by feeding large amounts of the biotin binding protein, avidin, present in raw egg-white. Symptoms of biotin deficiency in man include anorexia, nausea, vomiting, mental depression, and a dry scaly dermatitis.

Biotin is the coenzyme required by several carboxylating enzymes (carboxylases) which have the capacity to add or remove carbon dioxide. The vitamin plays an extremely important role in the metabolism of both carbohydrates and fats.

The dietary allowance for biotin cannot be established easily. The daily recommended quantities are: 0.4 mg for adults, 0.8 mg in pregnancy and 0.6 mg in lactation.

5.2.7 Pantothenic Acid