

VITAMINS

- Vitamins and minerals are minor constituents that need to be present in diet in **minute quantities to promote good health and to maintain life.**
- Vitamins are a group of complex organic compounds that are essential to **normal functioning and essential metabolic reaction in the body.**
- They are required for carrying out vital functions of the body and many of them are involved in the **utilization of major nutrients like proteins, fats and carbohydrates.**
- Although they are needed in small amounts, they are essential for the health and well being of the body.

VITAMINS

- Natural substances found in food
- Vitamins regulate body processes such as energy production, blood clotting and calcium balance.
- Important in controlling critical metabolic process- Most of the B vitamins are essential components of specific coenzymes for enzymes participating in energy metabolism and other specialized activities.
- Fat soluble- Dissolve in fat and stored in body
- Higher concentration in fish than land animals A, D, E, K vitamins
- Vitamins help to maintain organs and tissues healthy.

Fish as a sources of vitamins:

- All the vitamins necessary for good health are present to some extent in fish.
- The vitamin content of fish varies with the same species, their parts and even season.
- Fishes are good sources of fat soluble vitamins A,D and E and of water soluble vitamins of B group.
- Fish liver oils are known as the richest source of vitamin A and D, abundant in the liver of lean fish and shellfish and in the meat of fatty fish.
- Vitamin A content upto 30,000 IU/g and of vitamin D upto 250,000 IU/g of liver has been found in some species.

- Fish liver oils are very often used for medicinal purposes because of these vitamins.
- Fish oils are also rich in vitamin E than any other animal fat.
- Fish and shellfish are good sources of most of the B vitamins that are present in the skin, liver and gut of the fish.
- The flesh usually contains more than half the total amount present in the fish.
- The roe is also a good source of these vitamins.

Vitamin content of edible flesh of fish

Vitamin	Average content ($\mu\text{g } \%$)
Vitamin A	25
Vitamin D	15
Vitamin E	12
Vitamin B	
Thiamin	20
Riboflavin	120
Nicotinic acid	3000
Vitamin B ₁₂	1
Pantothenic acid	500
Pyridoxine	500
Boitin	5
Folic acid	80
Vitamin C	3000

- **Classification;** They are classified into water-soluble and fat-soluble.
- The fat soluble vitamins A, D, E and K have diverse roles.
- The water soluble vitamins comprise vitamin C and eight B vitamins namely thiamin, riboflavin, niacin, pyridoxine, cobalamine, folate, pantothenic acid and biotin.

- Fat-soluble vitamins — *vitamins A, D, E and K* — *dissolve in fat before they are absorbed in the bloodstream to carry out their functions. Excesses of these vitamins are stored in the liver, and are not needed every day in the diet.*
- In contrast, water-soluble vitamins dissolve in water and are not stored by the body. Since they are eliminated in urine, we require a continuous daily supply in our diet.
- Water-soluble vitamins are easily destroyed or washed out during food storage or preparation. Proper storage and preparation of food can minimize vitamin loss. To reduce vitamin loss, always refrigerate fresh produce, keep milk and grains away from strong light, and use cooking water from vegetables to prepare soups.

VITAMIN A

An alcohol mostly occurs in nature in the form of fatty esters.

Forms-

1. **Retinol**- easily absorbed by body, abundant in some animal derived foods

Retinol (A1)- Marine fish, found in liver and viscera of fish and other animals.

3,4 dehydroretinol (A2)- only Freshwater fish

The only diff. is an extra double bond present in the carbon ring structure in VITAMIN A2.

Fish is rich source of this vitamin.

- **Carotenoids**- Converted to Vitamin A once absorbed by body, Biologically active forms of Vitamin A and highly concentrated in fish liver oils and in small amounts in fish muscles.
- These vitamins are vulnerable to oxidation and overcooking
- Elasmobranchs- accumulate Vitamin A in liver and less in tissue
- Teleost- accumulate in body tissue and liver



Fish	Vitamin A (IU/100g)
Cod, Haddock, Pollack (lean white fish)	25-50
Herring, Mackerel	100-4500
Shark liver	13300

- Vitamin A- essential for transmission of light stimuli from eyes to brain and for night vision
- Promotes growth and health of all cells
- Important for reproduction and embryo development
- Acts as antioxidant- helps to reduce risks of some cancers and heart disease

Vitamin D

- Two major physiological forms vitamin D: vitamin D₂ (ergocalciferol) and vitamin D₃ (cholecalciferol).
- Vitamin D₃ contain more simplified, unsaturated eight-carbon side chain.
- Vitamin D is found in animal foods as Vitamin D₃ and 25-hydroxy vitamin D.
- Fish liver is an excellent source of vitamin D.
- Finfish and shellfish are also known to be natural vitamin D contributors.
- Food processing, cooking and storage of foods do not generally affect the concentration of vitamin D.
- Promotes absorption of calcium and phosphorus from intestine.

- Without vitamin D , small intestine absorbs not more than 10-15% of dietary calcium
- Controls bone formation and resorption (Rickets-soft and mal-formed because they cannot retain calcium)
- Fatty and semi fatty fishes- Vitamin **D3-Cholecalciferol**- 500-3000 IU/100g
- Liver oil – rich source
- Oysters and mollusc- rich source of provitamin D (7- dehydrocholesterol)
- Vitamin D is also found in oily fish (e.g., herring, salmon and sardines) as well as in cod liver oil.

VITAMIN E

- Vitamin E benefits the body by acting as an antioxidant, and protecting vitamins A and C, red blood cells, and essential fatty acids from destruction. Vitamin E is the most effective fat soluble vitamin.
- Natural vitamin E exists in eight different forms, four tocopherols (α , β , γ and δ tocopherols) and four tocotrienols (α , β , γ and δ tocotrienols).
- Seafood provides small amounts of vitamin E. Fatty fish have greater quantities than lean fish.
- Shellfish have very little vitamin E.
- Tocopherol and/ or antioxidants are usually added to fish oils to protect them from rancidity.

VITAMIN E (tocopherol)

- During processing, losses of vitamin E can occur quite rapidly due to oxygen, light, heat and various metals, (primarily iron and copper) or presence of free radicals, that initiate autoxidation.
- The vitamin E composition is expressed as mg of α tocopherol equivalents.
- Vitamin E – antioxidant- protecting PUFA and low density lipoprotein (LDL) cholesterol from oxidation by free radicals
- Have anti inflammatory effects
- α tocopherol – abundant form of vitamin E in fish oils
- 0.2- 270 mg/100 g (edible parts of fish and invertebrates)

VITAMIN K

- Vitamin K is naturally produced by the bacteria in the intestines, and plays an essential role in normal blood clotting, promoting bone health, and helping to produce proteins for blood, bones, and kidneys.
- There are two major forms of vitamin K that exist in nature: phyloquinone and menaquinone.
- In most fish and shellfish, there are only minute amounts of vitamin K.
- Vitamin K is quite stable to oxidation and most food processing.
- It is unstable to light, alkali, strong acid and reducing agents.
- The vitamin K composition in foods is commonly expressed as microgram of vitamin K.

VITAMIN K (group of compounds called phylloquinone or menaquinone)

- Anti-hemorrhagic factor
- Fish contains variable but relatively low amounts of vitamin K
- Salmon, canned tuna and mackerel containing the highest concentrations.
- Lobster, clams, mussels, oysters and scallops, also contains low levels of vitamin K
- Shrimp is an exception; it contains no measurable vitamin K.

Water soluble vitamins

- Fish good source of B vitamins
- Red meat higher content of vitamin B than white meat
- Fish liver, eggs, milt are good sources of thiamine (B1), riboflavin (B2), niacin (B3)), pantothenic acid, pyridoxine (B6), biotin (B7), folic acid and cobalamine (B12)
- 4 oz/100g fish provide approx. 10% RDA of these vitamins
- B12- 100% RDA in 100g portion
- Fish hold in eye ball a greater amount of thiamine

Vitamin B₁

Function: It is extracted from food in the digestive tract in a form that requires specialized proteins for absorption into the bloodstream. Once in the bloodstream, this form of thiamin requires specialized proteins for distribution to cells throughout the body.

Helps to release energy from foods, promotes normal appetite, and is important in maintaining proper nervous system function.

Deficiency: Beriberi is a nervous system ailment caused by a deficiency of Vitamin B1 (thiamine), the symptoms of which may include weight loss, emotional disturbances, impaired sensory perception, weakness and pain in the limbs, and periods of irregular heartbeat. Swelling of bodily tissues (edema) is common. In advanced cases, the disease may cause heart failure and death.

Sources: Thiamine occurs naturally in fresh foods and cereals, particularly fresh meat, legumes, green vegetables, fruit, and milk

Thiamin (Vitamin B₁)

- Exists in interconvertible phosphorylated forms in nature, as thiamin monophosphate, thiamin pyrophosphate and thiamin triphosphate.
- Most fish and seafood have small amounts of thiamin.
- Thiamin is most stable between pH 2-4 and unstable at alkaline pH as it gets oxidized.
- Thiamin is the most heat labile vitamin.
- Raw fish and shell fish contain thiaminase, an enzyme that destroys thiamin.
- Sulfhydryl groups and other reducing agents protect thiamin from thiaminase reaction.
- Thiaminase is inactivated during cooking process. Thiamin is expressed as mg of thiamin in foods.

- Symptoms of thiamin deficiency include: mental confusion, muscle weakness, wasting, water retention (edema), impaired growth, and the disease known as beriberi.

Vitamin B₂ (Riboflavin)

Riboflavin , also known as vitamin B2, is an easily absorbed micronutrient with a key role in maintaining health in humans and animals

Function: It is the central component of the cofactors FAD and FMN, and is therefore required by all flavoproteins

As such, vitamin B2 is required for a wide variety of cellular processes

Like the other B vitamins, it plays a key role in energy metabolism, and is required for the metabolism of fats, ketone bodies, carbohydrates, and proteins

Deficiency: In humans, signs and symptoms of riboflavin deficiency (ariboflavinosis) include cracked and red lips, inflammation of the lining of mouth and tongue, mouth ulcers, cracks at the corners of the mouth (angular cheilitis), and a sore throat.

A deficiency may also cause dry and scaling skin, fluid in the mucous membranes, and iron-deficiency anemia. The eyes may also become bloodshot, itchy, watery and sensitive to bright light

Sources:

Riboflavin is found naturally in asparagus, bananas, okra, chard, cottage cheese, milk, yogurt, meat, eggs and fish, each of which contain at least 0.1 mg of the vitamin per 3-10.5 oz (85-300 g) serving.

- **Riboflavin (Vitamin B₂)**
- Riboflavin acts as an integral component of two coenzymes, flavin adenine dinucleotide (FAD) and flavin mono nucleotide (FMN).
- Riboflavin occurs naturally in foods as free riboflavin and as the protein bound coenzymes, FAD and FMN.
- Seafood is generally a modest source of riboflavin.
- Some species like mackerel and squid are good to excellent sources.
- Fish consumed whole (e.g smelt and sardines) are also good sources of riboflavin.
- Riboflavin is stable to heat, acidic conditions, and oxidation, if light is excluded.
- Riboflavin is destroyed by exposure to UV and visible light within the range of 420-560 nm.
- The rate of destruction is accelerated by increasing temperature and pH. Thus, riboflavin is generally stable during heat processing and normal cooking of foods, if protected from light. Riboflavin content in foods is expressed as mg of riboflavin.

- **Riboflavin (Vitamin B2)** is the precursor of two coenzymes known as **flavin mononucleotide (FMN)** and **flavin adenine dinucleotide (FAD)**. Both are essential for tissue respiration and the generation of energy from the metabolism of carbohydrates, amino acids and fats.
- Riboflavin is vital for normal reproduction, growth, repair and development of body tissues including the skin, hair, nails, connective tissue and immune system. Riboflavin is mainly converted into FMN and FAD in the small intestine, liver, heart and kidney.

Niacin (Vitamin B3)

- The term 'niacin' is the generic descriptor for nicotinic acid and nicotinamide.
- These compounds are essential for formation of the coenzymes, nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) in the body.
- involved in energy production, normal enzyme function, digestion, promoting normal appetite, healthy skin, and nerves.
- Niacin can be biosynthesized from the amino acid tryptophan.
- Niacin contents in fish and seafood considerably vary depending on the variety of fish or seafood.
- **Lean white fish and shellfish tend to contain smaller amounts of niacin, whereas some varieties such as mackerel, salmon and tuna are rich in the vitamin.**
- Nicotinic acid is found mainly in plant foods; but animal foods contain nicotinamide, which is bioavailable.

- In uncooked foods, niacin is present as NAD and NADP, but these nucleotides may be hydrolyzed to nicotinamide by cooking.
- Niacin is not affected by thermal processing, light, oxygen and pH. It is stable during processing, storage and cooking of foods.
- Niacin content in foods is commonly expressed as mg of niacin equivalents (NE).
- Sixty mg of dietary tryptophan is considered equivalent to 1 mg of niacin. Thus, 1 mg NE is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

- **Vitamin B6- Pyridoxine**
- aids in protein metabolism and red blood cell formation. It is also involved in the body's production of chemicals such as insulin and hemoglobin.
- Vitamin B6 in free and bound forms is found in a wide variety of foods including seafood.
- Fish are good to rich sources of vitamin B6.
- Vitamin B6 is unstable to light, both visible and UV.
- The vitamin is stable in acidic conditions, if protected from light.
- The stability of vitamin B6 towards heat treatment, processing, and storage depends on the pH of the media. Losses of the vitamin increase as pH increases.
- The vitamin B6 contents in food are expressed as mg of vitamin B6.
- anemia, kidney stones, and nausea.
- A vitamin B6 deficiency in infants can cause mental confusion.

Folate/Folic acid

- Folic acid found in dietary supplements and used in food fortification.
- role in controlling homocysteine levels, thus reducing the risk for coronary heart disease.
- Needed for growth and blood formation
- Antianemic substances
- Seafood provides small amounts of folate.
- Folate is sensitive to heat, acids, oxidation and light. Folate losses by food processing and storage are variable by food matrices, oxygen availability, heating times and forms of folate in foods.
- Folate is quite stable in dry products if protected from light and oxygen but folate losses are large in water.
- Reducing agents such as ascorbic acid increase folate retention, whereas metals like Fe^{2+} increase folate losses. Folic acid is generally more stable than naturally occurring folates.

- **Vitamin B12**

- Aids in the building of genetic material, production of normal red blood cells, and maintenance of the nervous system.
- Cyanocobalamin and hydroxocobalamin are the forms of vitamin B12 used in most dietary supplements and are converted to adenosylcobalamin and methylcobalamin in the body.
- Vitamin B12 found in nature appears to be from synthesis by bacteria and other microorganisms growing in soil and water.
- Fish and shellfish are rich sources of vitamin B12, with salmon, herrings, sardines, mackerels, oysters and clams at the top of the list.
- The most prevalent forms of vitamin B12 in fish and seafood are adenosylcobalamin, hydroxocobalamin and methylcobalamin.

- Sulfitocobalamin is found in canned fish. Vitamin B12 is generally stable if protected from light.
- Cobalamins are considered to be stable to thermal processing, but large losses of the vitamin occur by leaching into the cooking water.
- Cyanocobalamin is the most stable form of vitamin B12. Strong alkaline and acid conditions, intense visible light and oxidising agents inactivate the vitamin.
- The vitamin B12 concentrations in foods are expressed in mg or μg of vitamin B12.

Panthenic acid vitamin B5

- Involved in energy production, and aids in the formation of hormones and the metabolism of fats, proteins, and carbohydrates from food.
- Panthotenic acid, also known as, occurs primarily bound as part of coenzyme A and acyl-carrier proteins.
- Panthothenic acid is found in plant and animal derived foods because of its diverse metabolic functions as a structural component of coenzyme A.
- Fish and seafood contain a moderate amount of pantothenic acid.
- Pantothenic acid is stable to atmospheric oxygen and light, whereas large losses of the vitamin can occur in the blanching and boiling of foods.
- The stability of pantothenic acid is highly pH dependent.
- The vitamin is stable in slightly acidic solutions at pH 5-7s. The panthothenic acid content in foods is commonly expressed as mg of pantothenic acid.

Biotin

- Biotin helps release energy from carbohydrates and aids in the metabolism of fats, proteins and carbohydrates from food. Contains sulphur.
- Biotin is widely distributed in many foods, but its concentrations are relatively low compared with that of other water soluble vitamins.
- Liver contains considerable amounts of biotin.
- Most of biotin in animal products is in a protein bound form.
- Biotin is generally stable to heat, but it is gradually destroyed by UV light.
- In strong acidic and alkaline solutions, biotin is unstable to heating.
- The sulphur atom in biotin is susceptible to oxidation with formation of biotin sulfoxide and biotin sulfone during food processing, which leads to loss of biotin activity. Biotin in foods is expressed in μg of biotin.
- fatigue, loss of appetite, nausea, vomiting, depression, muscle pains, heart abnormalities and anemia.

Vitamin C

Ascorbic acid is a sugar acid with antioxidant properties

The L-enantiomer of ascorbic acid is commonly known as vitamin C.

The formula of which is $C_6H_8O_6$

Function: Ascorbate acts as an antioxidant by being available for energetically favourable oxidation

Many oxidants (typically, reactive oxygen species) such as the hydroxyl radical (formed from hydrogen peroxide), contain an unpaired electron, and, thus, are highly reactive and damaging to humans and plants at the molecular level.

This is due to their interaction with nucleic acid, proteins, and lipids. Reactive oxygen species oxidize (take electrons from) ascorbate first to monodehydroascorbate and then dehydroascorbate.

The reactive oxygen species are reduced to water, while the oxidized forms of ascorbate are relatively stable and unreactive, and do not cause cellular damage.

Ascorbic acid and its sodium, potassium, and calcium salts are commonly used as antioxidant food additives.

These compounds are water-soluble and thus cannot protect fats from oxidation
vitamin C, is required for correct collagen synthesis in humans.

Normal collagen synthesis depends upon the hydroxylation of proline and lysine residues in the endoplasmic reticulum, to form hydroxyproline and hydroxylysine, respectively.

Prolyl and lysyl hydroxylase, the enzymes that catalyze the hydroxylation reactions, require vitamin C as a cofactor.

In cases of chronic deficiency, hydroxyproline and hydroxylysine are not formed in appreciable amounts and the resulting collagen fibrils are considerably weaker.

Deficiency: Scurvy (N.Lat. scorbutus) is a disease that results from lack of vitamin C

The scientific name of vitamin C, ascorbic acid, is derived from the latin name of scurvy, scorbutus. Scurvy leads to the formation of liver spots on the skin, spongy gums, and bleeding from all mucous membrane

The spots are most abundant on the thighs and legs, and a person with the ailment looks pale, feels depressed, and is partially immobilized.

Sources: Citrous fruits, amla

- **Vitamin C**

- Occurs in two forms, the reduced ascorbic and the oxidized dehydroascorbic acid.
- Ascorbic is reversibly oxidized to dehydroascorbic acid. Further oxidations convert dehydroascorbic acid to the inactive and irreversible compound diketoglutaric acid. There are two enantiomeric pairs, L- and D-ascorbic acid and L- and D-isoascorbic acid.
- L-ascorbic acid and D-isoascorbic acid have the biological activity of vitamin C.
- L-ascorbic acid and dehydroascorbic acid are naturally occurring forms of vitamin C, but D-isoascorbic acid is not found in foods.
- D-isoascorbic acid is synthesised commercially and used as an antioxidant in foods, usually processed and canned fish.

- Fish and seafood are not considered good sources of vitamin C.
- Vitamin C is very susceptible to oxidation during the processing, storage and cooking of foods, especially under alkaline conditions.
- Maximal stability occurs between pH 4 and 6, however, degradation rates are influenced by oxygen availability, the presence of antioxidants, thermal processing conditions, transition metal catalysts, oxidizing lipid effects and the presence of ascorbic acid oxidase.
- Vitamin C contents in foods are commonly expressed in mg of vitamin C.

- Needed for biosynthesis of thyroid hormones
- 0.3-3mg/kg in fish

FLOURINE

- Fish highest flourine among all foodstuff of animal origin
- Antarctic krill- 1000 mg/kg