SBT1102 – BIOCHEMISTRY

UNIT 1 CARBOHYDRATES

Introduction. Classification, Properties and Biological importance. Isomers, epimers, enantiomers,mutarotation, open chain and closed chain structures of glucose.

UNIT 2 AMINOACIDS AND PROTEINS

Aminoacids: classification- essential and non-essential amino acids, protein and non-protein amino acids, Zwitter ions. Proteins: Classification- based on i) shape and solubility and ii) increasing complexity of structure. Structure of proteins: primary, secondary, tertiary and quaternary, biological significance. Concept of isoelectric point and its significance.

UNIT 3 LIPIDS

Introduction, Classification, Properties and Biological importance. Fatty acid nomenclature and structure, Lipids in cell membrane Cholesterol and Steroids, Hormones - structure and function

UNIT 4 NUCLEIC ACIDS

Introduction- Nitrogeneous bases - Purines and Pyrimidines - Nucleosides and Nucleotides -- Structure of nucleic acids - DNA, RNA: m-RNA, t-RNA, r-RNA - Biological importance of nucleic acids. 16s rRNA and its significance.

UNIT 5 VITAMINS AND MINERALS

Vitamins: fat soluble and water soluble vitamins. Minerals: Micro and Macro minerals. Biological importance of vitamin and minerals, deficiency symptoms

Vitamins - Introduction

Vitamins are essential nutrients that are required by the body. Since they were discovered and their positive effects became known for us, they became one of the most common products of the pharmaceutical industry. They all have a unique role in maintaining normal cell function, growth and development. Vitamins are classified into two categories:

- Fat soluble vitamins (A, D, E and K),
- Water soluble vitamins (B and C).

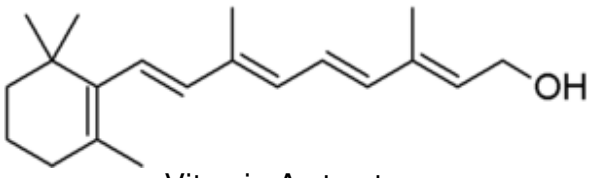
Fat-soluble vitamins, once ingested, the body uses what it needs at the time and stores the rest in fat tissue. The vitamins can be stored and remain here until they are needed for future use. If too much is ingested this can cause hypervitaminosis, a potentially dangerous condition. Deficiencies can also occur when fat intake is low or if fat absorption is compromised in certain conditions (e.g. taking certain drugs, cystic fibrosis).

In contrast water-soluble vitamins are not stored in the body. The body uses the amount needed and any excess is excreted in urine. As they are not stored, the body requires a constant supply in order to stay healthy.

Fat Soluble vitamins

Vitamin A (retinal)

Role



Vitamin A structure

- Good vision: It is a component of retinal pigments, which helps especially in low lighting.
- Reproduction, cell division and gene expression.
- Participates in bone and tooth development.
- Maintains mucous membranes of the mouth , nose, throat and lungs, by keeping them moist.
- Maintains healthy skin.
- Antioxidant, which may protect against cancer. Beta-carotene is an antioxidant.
- Supports immune function.

Source

Vitamin A primarily comes from animal sources: eggs, meat, fortified milk, cheese, cream, liver, kidney, cod, and halibut fish oil. Beta-carotene comes from colourful fruits and vegetables, such as carrots, pumpkin, winter squash, dark green leafy vegetables and apricots. Usually the more intense the colour of the fruit or vegetable, the more beta-carotene it contains.

Excess

This can either be acute or chronic and can present with a number of symptoms. Acute toxicity causes dry, itchy skin, headache, nausea, loss of appetite and blurred vision. Severe toxicity can result in growth retardation, enlargement of the liver and spleen, loss of hair, bone pain, increased pressure in the skull and skin changes. Increased amounts of beta-carotene can turn the skin yellow or orange.

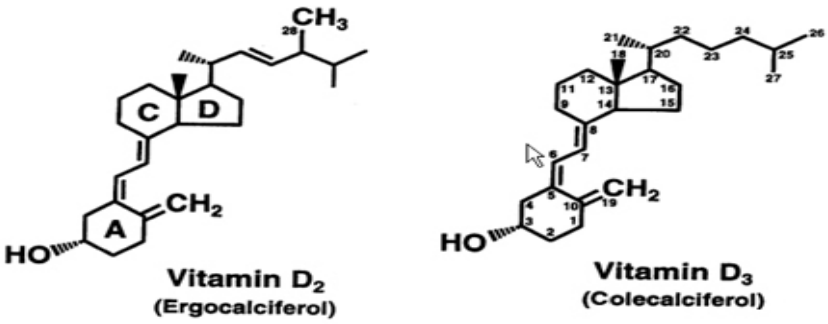
Deficiency

This is usually associated with strict diet restriction or excessive alcohol intake.

- **Mild:** night blindness, diarrhea, reduced resistance to infection, impaired vision.
- **Severe:** inflammation of the eyes, keratinisation of the skin and eyes and blindness in children.

Vitamin D

Role



Participates in metabolism of calcium and phosphate and maintains adequate serum concentrations of both. It also promotes calcium absorption in the gut. Vitamin D is especially important in growing children, as it is needed for strong bones and teeth. Research shows that it also provides protection against osteoporosis, hypertension, cancer, and some autoimmune diseases.

Source

Primary source is milk and other dairy products. It is also found in oily fish and cod liver oil. It is not only found in foods, it can be synthesised in the skin and is triggered by the exposure to UV rays from sunlight (it is recommended to get 10 to 15 minutes of sunshine three times weekly is enough to produce the body's requirement of vitamin D)

Excess

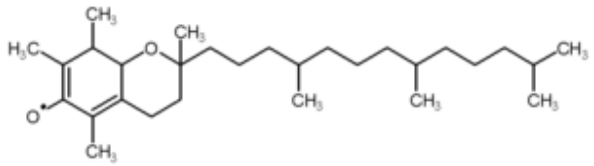
Toxicity causes elevated plasma concentration of calcium which can have some side effects: Blood vessel contract, high blood pressure and Calcium deposits in soft tissues such as the heart and lungs, Kidney stones, Nausea, vomiting, constipation, poor appetite, weakness, and weight loss.

Deficiency

The main diseases associated with vitamin D deficiency are Osteomalacia and rickets (in children). The symptoms that arise are nausea, weight loss and irritability for mild cases, and mental and physical growth retardation, kidney damage and movement of calcium from bones into soft tissues for the severe cases.

Vitamin E

Role



Vitamin E structure

It is an antioxidant that protects Vitamin A and C, red blood cells and essential fatty acids from becoming destroyed. It also prevents cell membranes from being damaged.

Source

It can be found in natural or synthetic forms. It is found in vegetable oils, cereals, meat, poultry, eggs, fruits, vegetables, legumes, wheat germ oil and whole grain and is also available as a supplement.

Excess

There is an increased risk of bleeding especially in patients taking blood-thinning agents such as heparin, warfarin or aspirin, and in patients with vitamin K deficiency. It can also cause nausea and digestive tract disorders.

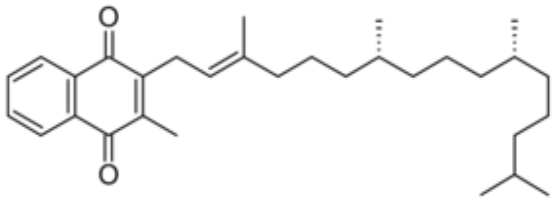
Deficiency

This is very rare and impossible to produce without starvation. It generally occurs in infants and people unable to absorb fats.

Vitamin K

Vitamin K is group of compounds derivated from 2-methyl-1,4-naftochinon (IUPAC: 2-methylnaphthalene-1,4-dione)

Role



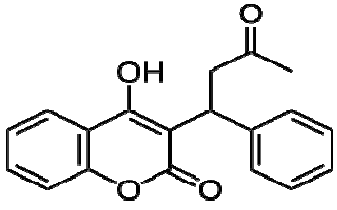
Vitamin K_1 structure

It has an important role in normal blood clotting (**factors II, VII, IX and X** are vitamin K dependent, because it works as cofactor in carboxylation of glutamic acid to γ-carboxyglutamic acid which is essential for calcium binding on these factors), for synthesis of protein C and S and it is also needed to help build strong bones.

Role in coagulation therapy

The role of vitamin K is often exploited in anticoagulation treatments in patients with increased risk of thrombosis. These compounds used are referred to as vitamin K antagonists, many of these are coumarin based, the best know of which is warfarin. Coumarin based compounds function by preventing the conversion of the inactive epoxide form of vitamin K into its activated form by inhibiting the enzyme responsible for its reduction (vitamin K epoxide reductase).

Alternative anticoagulation treatments include heparin (via the inactivation of thrombin) in vivo and EDTA, oxalate and citrate (which remove Ca^{2+}) but can only be used in vitro due to the biological importance of Ca^{2+}.



Warfarin

Source

It is found in green leafy vegetables, such as broccoli and spinach, pulses, vegetable oils, cereals, milk, milk products, meat, eggs and fruit. Bacteria in the intestines can also synthesis Vitamin K and contribute to the available pool.

- requirement: 1 µ/kg/day (except newborns)

Excess

This can cause the breakdown of red blood cells and also liver damage. Therefore if a person is taking blood-thinning agents, they may need to limit the amount of Vitamin K intake.

Note: Vitamin K is an antidote for warfarin.

Deficiency

It is very rare in adults, but can occur in individuals that cannot absorb it properly, due to lack of intestinal bacteria, as well as those being treated long term with antibiotics. It can cause excessive bleeding and increased tendency to bruise. It may also be the cause of haemorrhagic disease of newborn, because placental transfer of vitamin K is very low, its level in breast milk is low as well. (prevention: 1 mg of vit. K intramuscularly 2–6 hours after birth and then 1 mg of vit. K per os every week till age one month, and for exclusively breast feeded children till age 6 months).

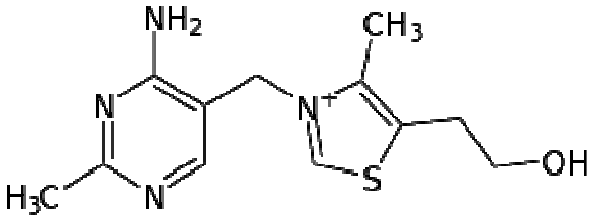
Water Soluble vitamins

Water-soluble vitamins consist of the B-group vitamins and vitamin C. Their deficiency is treated by administration of the deficient vitamin.

B Group Vitamins Features

- A common feature of group B vitamins is their occurrence in yeast (except vitamin B_{12}). However, if the yeast is included in the diet only as a means of rising bread, then yeast is not considered the major source of group B vitamins in humans; a small quantity of yeast does not contain nutritionally significant amount of B vitamins.
- Their metabolic effects are inter-linked.
- Deficiency of only a single vitamin occurs rarely.
- They are produced by the intestinal micro flora but the amount produced is generally only a fraction of the daily recommended intake.
- Some are more frequently called by their name, others by number. Some vitamins may not have a number because it has been found that some substances, originally considered as vitamins, are NOT essential for humans, therefore they are not vitamins or are a mixture of substances.

Vitamin B_1 (thiamine)



Vitamin B1 - structure

Thiamine (vitamin B_1) is a coenzyme decarboxylase important for the metabolism of glucose and energy supply to nerve and muscle cells.

Source

Meat, fish, cereals, yeast, legumes.

Daily recommended intake for adults: 1-1.4 mg

Deficiency

The disease beri-beri from a lack of dietary vitamin B_1 is found today in very poor population groups (e.g. refugees) in countries where people live mostly on polished/white rice. It may also develop in people who live mostly on refined wheat flour products and among alcoholics and food faddists.

A typical image consists of nervous disorders, especially peripheral nerves (dry beri beri), edema and heart disease (beri beri wet). Impaired absorption of vitamin B_1 occurs in alcoholics and is manifested by Wernicke encephalopathy.

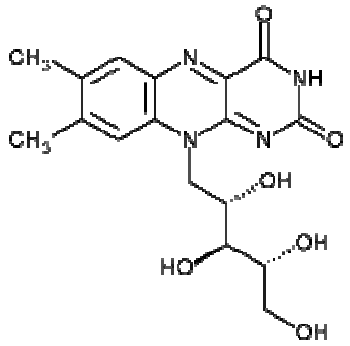
Suboptimal thiamine status based on biochemical criteria in Europe was detected only in 4-6% of the population. Risk group are alcoholics.

Laboratory evaluation: thiamine excretion in the urine. In the absence of erythrocytes is reduced transketolase concentration in the blood and the sea is high concentrations of glycoxalate.

Excess

Signs of excess are not encountered.

Vitamin B_2 (riboflavin)



Vitamin B2 structure

Riboflavin or vitamin B_2 is part of coenzymes flavinadenine mononucleotide (FAD) and flavin mononucleotide (FMN), plays a key role in oxidative metabolism.

Source

A small amount is found in many foods. Main sources are meat, milk and milk products; good sources are also fish, offal (inner organs), eggs, and whole grain cereals. Milling of cereals removes most of vitamin B_2 - some countries (e.g. USA) fortify cereal products with riboflavin.

Recommended daily intake for adults: 1.2 to 1.5 mg

Deficiency

According to several population studies, the deficiency is widespread in developing countries, where diet is poor in animal foods, vegetables and fruits, and where cereals are milled (white flour). Frequently the deficiency is secondary due to malabsorption, enterocolitis, coeliac disease , chronic hepatitis; in children often after the use of broad-spectrum antibiotics. It may develop in cancer, cardiac disease, diabetes

Clinical picture: The description of the signs of riboflavin deficiency is somewhat inconsistent in various scientific publications. Riboflavin deficiency occurs almost always together with deficiencies of other group B vitamins, which may cause some of the signs. The signs most frequently described are: angular stomatitis, peeling lips (cheilosis), glossitis, and normocytic normochromic anemia.

Laboratory evaluation: decreases secretion of vitamin B_2 in urine (normal values are 106–638 nmol/l) , decreased concentrations of glutathione and glutathione reductase in erythrocytes.

Excess

Signs of excess are not known.

Vitamin B_3 (niacin)

Niacin (vitamin B_3) is the name for nicotinamide and nicotinic acid. It is part of enzymes, oxido-reduction systems (nicotinamide adenine dinucleotide -NAD, nicotinamide adenine diphosphate -NADP). May form in the liver from tryptophan and its biosynthesis is very slow and it is needed vitamin B_6.

Source

The source of most foods - meat, fish, cereals. The recommended daily dose for adults is by age and sex of 13-17 mg

Deficit

Disease pellagra is caused by the current lack of niacin and its precursor tryptophan. Today it has rarely occurs in a very poor population groups or for refugees in developing countries. Occurs in people who eat mostly corn/maize. The symptoms are as a mnemonic device used sometimes called "disease of three D" - dermatitis, diarrhea, dementia.

Surplus

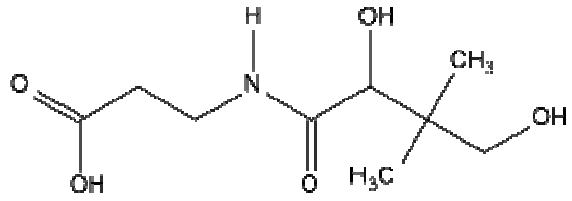
Signs of excess food are not known. High doses of dietary supplements induce vasodilatation, warmth, gastritis, damage to liver cells.Income should not exceed 35 mg / kg / day.

Pharmacological use

Nicotinic acid (niacin) and its derivatives are used to treat hyperlipidemia by inhibiting the secretion of VLDL from the liver and increasing the activity of peripheral lipoprotein lipase. This leads to a reduction in circulating VLDL (ie, TAG) and, consequently, LDL(cholesterol).In contrast adipose tissue blocking the intracellular lipase , thus releasing the MK inventory, further reducing supply to the liver TAG and reduces VLDL synthesis.

- Adverse effects:harmless vasodilation (mediated release of prostaglandins) in the skin associated with subjective stream feeling hot - it can handle submitting aspirin; at 1 / 5 of patients treated with hyperuricemia; skin rash.

Vitamin B_5 (panthothenic acid)



Vitamin B5 structure

Pantothenic acid (vitamin B_5) is part of coenzyme A .

Source

Small amounts are in almost all foods contain a large amount of yeast, liver, meat, milk, whole grains and legumes. The daily recommended dose for adults: 6 mg

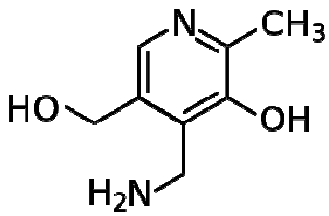
Deficit

Lack is not present - described only when administered pantothenic acid antagonists and extremely malnourished people with symptoms of deficiency of other nutrients, is manifested hair follicle atrophy, loss of pigmentation, dermatitis .

Surplus

Signs of excess are not known.

Vitamin B_6 (Pyridoxine)



Vitamin B6 structure

Pyridoxine the name vitamin B_6 comprises a group of compounds (pyridoxine, pyridoxamine, pyridoxal and phosphate). Itcoenzyme for more than 50 enzymatic reactions - decarboxylase and transaminases, synthesis of acid nicotine and arachidonic acid , affects the function of the nervous system, immune reactions and synthesis of haemoglobin.

Source

It is abundant in food. The daily recommended dose for adults: 13-17 mg

Deficit

Deficiency with normal eating habits does not occur; manifested skin and mucosal changes that occur rhagades corners, peripheral neuropathy .

Surplus

Excess of food does not occur. After a prolonged intake of 50-500 mg have been reported sensory neuropathy.

Vitamin B_7 (Biotin)

Biotin Vitamin B_7 , vitamin H, factor R - Several scholars have described it, only later discovered that it is the same substance) is important for the metabolism of amino acids and fatty acids, is a cofactor for carboxylases.

Source

At low concentrations in many foods. Rich sources are yeast, liver, egg yolk, nuts, lentils. The daily requirement (RDA can not be estimated): 30-60 mg

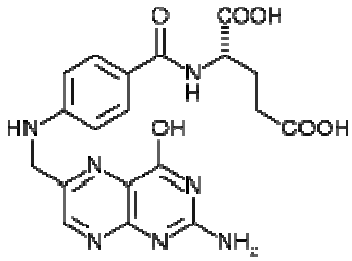
Deficit

Deficiency of food does not occur. Scientists described the people who long consumed a large amount of raw eggs (irreversibly binds to biotin with avidin contained in raw egg white) and improper parenteral nutrition. Symptoms : seborrheic dermatitis , fatigue, anorexia , nausea ,hypercholesterolemia , vascular disorders.

Surplus

Signs of excess are not known.

Vitamin B_9 (Folic acid)



Vitamin B9 structure

Folic acid also is known as vitamin B_9, folate or folacin . Includes a group of compounds: Folic Acid (contains pterin, p-aminobenzoic acid and glutamic) and folic

acid. Along with vitamin B_{12} is essential for the formation of nucleic acids and thus for synthesis of DNA , participate in the transfer radicals and in all processes of cell division , it is important for cell division and tissue with high mitotic activity.Absorbed in the proximal parts of the small intestine and when excess it is excreted in the urine.

Source

Liver, yeast, green leafy vegetables, as well as whole grain cereals, meat, milk, eggs and legumes. The recommended daily adult dose: 400mg. In pregnancy, 600mg for prevention of congenital malformations (mainly cleft neural tube).

Deficit

Deficiency of vitamin B_9 occurs in low supply, absorption or increased need during pregnancy. There is a megaloblastic anaemia , which is characterized by the presence of abnormal precursors of red blood cells in the bone marrow. Compared with normal cells are cells arising from these abnormal precursors of different shape, larger size, reduced viability and reduced ability to transport oxygen . Along with the lack of iron is its lack of a significant cause of anaemia in developing countries. Deficiency during pregnancy causes spina neural tube in the fetus.

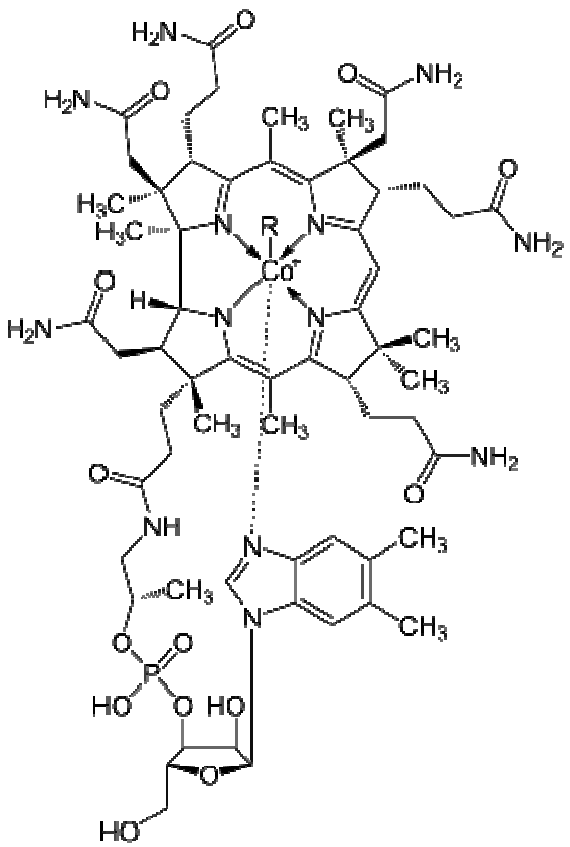
- Laboratory evaluation: serum levels of folate, total homocysteine (increases in the absence, also in the absence of vitamin B_{12})

Surplus

High intake of folic acid can mask vitamin B_{12} , so the upper limit of the daily recommended intake of up to 1000 mg / day.

Vitamin B_{12} (cobalamin)

Vitamin B_{12}(cobalamin) is the collective name for several compounds that are in the center of porphyrin skeletal cobalt . Vitamin B_{12} has a number of biological functions - plays an important role in hematopoiesis, is essential for the development of the central nervous system in children, contributes to the formation of nucleic acids , transmethylation and has anabolic effect. Deficiency of vitamin B_{12} in adults causes macrocytic anemia , impaired rear and lateral spinal cords, peripheral nerves and dementia or depression . Lack of vitamin B_{12} also affects secondary folate cycle resulting in impaired synthesis of purines and pyrimidines necessary for the formation of DNA and RNA.



Vitamin B12 structure

Source

In nutritionally significant quantities occurs only in animal foods. Rich sources are liver, kidney, meat warm-blooded animals (1-2 ìg/100 g), fish, egg yolk and dairy products (milk ìg/100, 0.3 ml cheese ìg/100 0.2 to 0.6g). Plant foods contain trace amounts of vitamin B_{12} only if it has been processed by bacterial fermentation (e.g beer). Absorbed in the small intestine only if the stomach creates a complex with an internal factor .Therefore it is necessary to properly functioning stomach and large amounts of vitamin B_{12} are formed by the intestinal flora in humans unusable. Cobalamine with an internal factor in the distal ileum bind to specific receptor cubilin and this complex then enters by endocytosis into enterocytes. Inside the enterocyte cobalamin binds to other carriers and excreted into the plasma. 75-80% is bound to haptocorrin and goes to hepatocytes. The cells of other organs enter only vitamin B_{12} bound to transcobalamin II (the holotranscobalamin) after binding to specific receptors through endocytosis. The cell cobalamin is converted to active metabolites and adenosylcobalamine methylcobalamin, which serve as cofactors of enzymes. The daily recommended dose for adults : 3 mg. Minimal in infants: approximately 0.1 to 0.3 mg.

Function

Haemopoiesis; development of the central nervous system in childhood; cofactor of two metabolic reactions: conversion of homocysteine to methionine by methionine synthase (failure of this reaction leads to the accumulation of homocysteine); conversion metylmalonyl-CoA to succinyl-CoA action metylmalonyl-CoA mutase (failure of this reaction leads to an accumulation of methylmalonic acid and its increased urinary excretion).

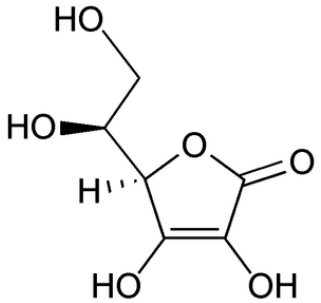
Deficit

Its deficiency is clinically manifested failure to thrive, macrocytic anemia and neurological symptoms. An adult is a stock (2-5 mg) of vitamin B_{12} in the liver, which cover the need for a period of 5-10 years. Stocks, which creates the infant in utero (approximately 25 micrograms), will be exhausted as early as 3-5 months. Among laboratory manifestations include mostly macrocytic anemia, elevated aminotransferases, hyperhomocysteinemia and increased acid secretion metylmalonic acid plasma concentrations of homocysteine and methylmalonic acid excretion increased in the urine. Metabolic changes precede clinical manifestations. Pernicious anemia is an autoimmune disease that leads to atrophy of the gastric mucosa and by the lack of intrinsic factor.

Surplus

Signs of excess were reported even after a high intake (5 mg) of the supplement.

Vitamin C



Vitamin C structure

L-ascorbic acid , also known as vitamin C is water soluble strongly reducing effects. Man (as well as other primates and guinea pigs) cannot synthesize it, since it lacks L-gulonolactonexidase activity, therefore it must receive in food. L-ascorbate is involved in the hydroxylation of collagen , the synthesis of carnitine , the metabolism of tyrosine , acts as an antioxidant, supports immune system, iron absorption, has an effect on beta-oxidation of fatty acids , increases the activity of microsomal enzymes, accelerates the detoxification of xenobiotics. Reducing the effects of ascorbic acid are due to its easy oxidation to dehydroascorbate:

Source

Fruits, vegetables (including potatoes), liver. Average losses in cook foods are 30%. The daily recommended dose for adults : 100 mg . When the determination is considered, in addition to prevention of deficiency symptoms, as well as strengthening the immune system and prevention of degenerative diseases. Increased need for considerable physical exertion, psychological stress, alcohol abuse and drugs, some diseases (eg diabetes, renal insufficiency, infection). Intake of 150 mg / day is recommended for smokers.

Deficit

Ascorbic acid deficiency - scurvy (scurvy) - now appears only in extreme conditions. With a slight lack of preclinical manifestations we see in our country (fatigue, prolonged convalescence, impaired wound healing and decreased resistance to infection).

- Laboratory evaluation of the situation: the level of vitamin C in plasma. Clinical symptoms appear with values ≤ 10 µmol/L, an indicator of low intake of vitamin C are considered to values below 37 µmol/L. In terms of prevention of atherosclerosis and the tumors are regarded as desirable values ≥ 50 µmol / L.

Surplus

Signs of excess food are not. Approximately 1% of the unused vitamin C is converted to oxalate, the risk of urinary calculi, but low in healthy subjects. The care

the daily intake should not exceed 1000 mg. Very high doses (5 g) can cause diarrhea . At high ascorbate intake (about grams per day), most of the substance excreted in the urine. It can then interfere with many clinical biochemistry determination by routine chemical urinalysis.

Minerals - Introduction

Dietary minerals and trace elements are chemical substances required by living organisms in addition to carbon, hydrogen, nitrogen, and oxygen that are present in nearly all organic molecules.

Minerals are present in up to tens of thousands of grams in the human body whilst only a few grams of trace elements are required by the body. The recommended dietary allowance of minerals (RDA) is usually greater than 200 mg/day whilst that for trace elements is less than 200 mg/day and this can be used to classify the difference between minerals and trace elements.

Minerals and trace elements are usually provided by dietary intake however they can be ingested in various forms including:

- these be supplied from foods in which they occur naturally,
- as complex compounds,
- in the from natural inorganic sources (such as calcium carbonate from ground oyster shells).

Macro and micro minerals:

Macro minerals are present at larger levels in the animal body or required in larger amounts in the diet. Macro minerals include calcium, chlorine, magnesium, phosphorus, potassium, sodium, and sulfur.

Micro minerals are often referred to as trace minerals, meaning they are present at low levels in the body or required in smaller amounts in the animals diet. Micro minerals include chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, and zinc.

Macrominerals

Calcium

Function

- Calcium is the most abundant mineral in the human body, containing approximately 1200g. 99% of the calcium is present in bones and teeth present mainly as hydroxyapatite, with a calcium to phosphate ratio of 2:1. The calcium makes up the inorganic component of the bone and provides cross linkage between the collagen fibrils of bone and forming a more rigid structure.

Remodeling or bone turnover is the process of resorption followed by replacement of bone with little change in shape and occurs throughout a person's life. Osteoblasts and osteoclasts, coupled together via paracrine cell signalling, are referred to as bone remodeling units. The process of bone resorption by the osteoclasts releases stored calcium into the systemic circulation and is an important process in regulating calcium balance. As bone formation actively fixes circulating calcium in its mineral form, removing it from the bloodstream, resorption actively unfixes it thereby increasing circulating calcium levels.

In children and adolescents, the rate of bone formation predominates over the rate of resorption whilst in adult life the rate of resorption is greater which leads to the loss of bone strength and causes osteoporosis.

- Calcium also plays a role in several process such exocytosis, neurotransmitter release, and muscle contraction in smooth muscle.

- In the electrical conduction system of the heart, calcium works together with sodium as the minerals that depolarize the cell, proliferating the action potential and causing the plateau phase of the action potential.

- Calcium also reduces the neuromuscular excitation of neurons.

- Calcium plays a very important role in hemocoagulation in both the intrinsic and extrinsic pathways.

- Calcium is also thought to have a role in the prevention of colorectal cancer.

Sources of calcium

- Calcium is mainly found in milk and it is excellently absorbed.

- Soymilk and other vegetable milks are usually sold with calcium added so that their calcium concentration is as high as in milk.

- Leafy green vegetables are a very good source of calcium.

Deficiency of calcium

A deficiency of calcium can lead to disorders such as osteomalcia, osteoporosis, rickets, increased neuromuscular irritability, tachycardia, impaired blood clotting and increased carcinoma of the colon.

Greater amounts of calcium are required daily during:

- rapid growth in adolescence
- during pregnancy and lactation
- In elderly adult life

Potassium

Function

- Potassium is the primary intracellular ion with a concentration of 140mEq/l. It is the main ion involved in nerve and muscle repolarisation.

- Potassium also maintains homeostasis with intracellular osmotic pressure and fluid balance.

- Potassium ions also control the heart conduction system.

Sources of Potassium

- Potassium is present in all plant foods. Important sources include vegetables, fruits, pulses and nuts.

Deficiency of Potassium

Potassium deficiency can be caused by:

- gastrointestinal loses (vomitting, diarrhoea)
- the urinary system (Cushing's syndrome, osmotic diuresis, diuretics)
- Skin losses (excessive sweating, burns).

Clinical features of reduced levels of potassium include spasms, headache, and dehydration.

Magnesium

Functions

- Magnesium is essential for all biosynthetic processes including glycolysis, formation of cyclic AMP, energy dependent membrane transport and transmission of the genetic code.

- Greater than 300 enzymes are known to be activated by magnesium ion.

- Magnesium is also required for maintenance of electrical potentials of nerve and muscle and for the transmission of signals across neuromuscular junctions.

Source of Magnesium

Magnesium is found in green leaves, potato, nuts, legumes and whole grains.

Deficiency of Magnesium

Purely dietary magnesium deficiency has not been reported in people consuming natural diets.

Sodium

Function

Sodium is an cation which is found in higher quantities extracellulary compared to intracellulary. Sodium is used in:

- depolarisation of nerve and muscle tissues
- maintenance of osmotic pressure and acid base balance in the body.
- Sodium also maintains the water balance in the body.
- It also prevents muscle and nerve irritability.

Sources of Sodium

Sodium is mostly found in table salt, salty foods, meat, eggs and milk.

Deficiency of Sodium

Sodium deficiency can be caused by:

- gastrointestinal loses (vomiting, diarrhoea)
- the urinary system (Cushing's syndrome, osmotic diuresis, diuretics)

Clinical features of reduced levels of sodium include irritability, muscle weakness, paralysis and impaired heart function.

Sulfur

Function

Sulfur is a component of amino acids methionine and cysteine and has a role in detoxication processes as a component of glutathione.

Source of Sulfur

Sulfur is found in foods which are rich in protein.

Micro-minerals:

Iron

Function

Iron has several functions in the human body which include:

- being a constituent of the haemoglobin molecule - 70%
- myoglobin stored in muscles
- an activating molecule of several enzymes
- found in storage molecules such as ferritin and hemosiderin.

Sources of Iron

Meat, eggs, vegetables and cereals are all sources of iron. Haem and non-haem forms of iron are absorbed by different mechanisms. Haem iron is highly absorbed and averages 40% of the total iron in all animal tissues.

Deficiency of Iron

Three stages of impaired iron status have been defined:

- ferritin levels falling below 12 micrograms per litre but no functional impairment can be seen.
- Iron deficient erythropoiesis where the red cell protoporphyrine levels are elevated, transferrin saturation is reduced to less than 16% and work capacity performance may be impaired.
- Iron deficiency anemia - characterized by small red cells (microcytosis) with low haemoglobin (hypochromia).

Iron deficiency is observed mainly during the following conditions:

- 6 months - 4 years of age because the iron content of milk is low
- During the rapid growth of adolescence, because of needs of an expanding red cell mass and the need to deposit iron in myoglobin
- During the female reproductive phase, because of menstrual loses of iron
- During pregnancy because of the expanding blood volume of the mother, the demands of the fetus and placenta and blood loss during childbirth.

Excess quantities of Iron

Excess quantities of iron cause iron overload and hemochromatosis. Iron overload can also be caused my genetic mutations (HfE mutation on chromosome 6).

Copper

Function

Copper is a constituent of many enzymes. It is also a constituent of many pigments and is important for immune functions.

Sources of Iron

Copper is found in organ meats, especially liver. It is also found in seafood, nuts and seeds.

Deficiency of Iron

In exceptional circumstances, copper deficiency is seen in malnourished children and causes anaemia, bone demineralisation, impaired immunity, and lack of hair and nail growth.

Fluoride

Function

Fluoride is required for bone and teeth formation

Sources of Fluoride

Fluoride is found in foods such as water tea, and fish.

Deficiency of Fluoride

A lack of fluoride in the diet will cause increased caries formation and poor bone mineralization.

Iodine

Function

Iodine is a major component of thyroid hormones.

Sources of Iodine

Iodine is mainly found in seafood and sea fish, eggs, milk and iodised salt.

Deficiency of Iodine

A lack of Iodine will cause a variety of conditions including cretinism, goitre, miscarriages, still births of children and mental retardation

Selenium

Function

Selenium is present at the active site of glutathione peroxidase that catalyses the breakdown of hydroperoxidases and prevents the damage caused by free radicals.

Sources of Selenium

Selenium is found in seafood, kidneys and liver. It is found in grains and other seeds.

Deficiency of selenium

A lack of Selenium will cause decreased lymphocyte numbers and natural killer activity and decreased interferon formation. It also causes Keshan's disease and Kashin Beck disease.

Zinc

Function

Zinc is involved in 200 enzymatic reactions. It is a component of superoxide dismutase and prevents oxidative stress. It positively influences tissue growth and healing and participates in insulin formation and spermatogenesis.

Sources of Zinc

foods containing zinc include meat, liver, eggs and seafood. Wholegrain products contain zinc in a less available manner.

Deficiency of Zinc

Zinc deficiency causes growth retardation, impaired immune functions, loss of appetite and skin, nail and hair change(white spots on nails),acrodermatites enteropathica(hair loss,diarrhoea,anorexia).