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Comprehensive Review

Vitamins - Fat Soluble

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Before understanding the fat-soluble vitamins, you have to understand what are the vitamins? Vitamins (vital=necessary, amines) are those compounds which are necessary to maintain the optimal health and growth, but in small amount, that's why these are known as Micronutrients. These are usually not synthesizing by the body, supplied through the diet. Bacteria and plants both can synthesize the vitamins.

Vitamins do not provide energy but help in releasing energy while the metabolism of macronutrients takes place.

Classification on the basis of solubility:

- **Fat soluble:** These vitamins get absorbed, transported and stored in the body for a longer period. Their availability depends on the fat, so its deficiency directly connected to fat mal-absorption. They poorly excreted and stored in the body in adipose tissues. Toxicity can be possible if used in excess. For example Vitamin A, D, E, K.
- **Water soluble:** They can get easily absorbed and transported throughout the body. These vitamins can't be stayed longer in the body and released through urine from the kidney. All the water-soluble vitamins flush out from the body during hemodialysis and should be replaced by supplements to full fill the requirements. Only vitamin B12, water-soluble vitamin, can get stored for long in the body. For example Vitamin B complex (B1, B2, B3, B5, B6, B7, B9 and B12) and C.

Vitamin A: This is the most abundant vitamin and found in colorful food. It is necessary for the maintenance of good vision, cell growth, immunity, skin health and so on. Vitamin A found in two forms in nature, Perform (retinol, an animal source of food, for example, liver) and provitamin (carotene, in the vegetarian source of food for example; colorful vegetable and fruits). Beta carotene is predominant carotene in the human diet. It breaks in the human intestine and gives t molecules of retinal and retinol.

It performs various roles in the body. It is important for maintaining vision, normal growth, fertility, and fetal development. It also takes part in erythropoiesis (red blood cells formation), enhancing the immunity and it also serves as anti-oxidant in the body. In fact, different functions performed by each specific form of vitamin A.

Figure 1: Structure of vitamin A.

Recommended daily allowance

- Men: 3500IU
- Women: 2800 IU

(IU – international unit)

The requirement may vary in growing children, pregnancy and lactation. Our liver stores vitamin A in large quantity, which can be sufficient for 6 -9 months for a person.

Food sources

- **Animal sources:** Liver, whole milk, eggs, butter, cheese, fish and meat are the rich sources. Cod or shark liver oils are the richest sources of vitamin A (mostly used as a supplement).

- **Plant Sources:** Green leafy vegetables, for example, spinach, amaranth, etc. The darker the green leafy, the higher the amount of carotene in it. Other sources are papaya, pumpkin, and mango. Carrot is a good source of vitamin A.

Deficiency disease

Mostly vitamin A deficiency effects on eyes. There are many diseases related to eyes according to the level of severity for example.

- **Night blindness:** People with having this problem are not able to see anything in dim light.
- **Xeroplthalmia:** When night blindness left untreated, then the cornea and conjunctiva become dry, thick and wrinkled. It leads to keratinization and ultimately a healthy eye losses transparency. All these changes are known as Xeropthalmia.
- **Bitot's spots and Keratomalacia:** If xeropthalmia gets critical, then the formation of the ulcer on the cornea appears. It's end result could be total blindness. The main reason for Keratomalacia is Protein Energy Malnutrition (PEM).

Toxicity

The excess intake of this vitamin for a long duration can be toxic. It usually results in high doses of Vitamin A supplements without any medical advice. Polar bear liver contains a good amount of Vitamin A and arctic explorers who eat that liver to survive, have more chances to get Vitamin A toxicity.

Vitamin D

Sunlight plays a significant role in preventing bone-related disorders.

Vitamin D gets synthesized under the skin in the presence of sunlight. It regulates the metabolism of calcium and phosphorus.

Vitamin D is a group of closely related compounds. Naturally occurring forms of vitamin D in human are Ergocalciferol (D2) and Cholecalciferol (D3). Primarily, Vitamin D is modified steroids.

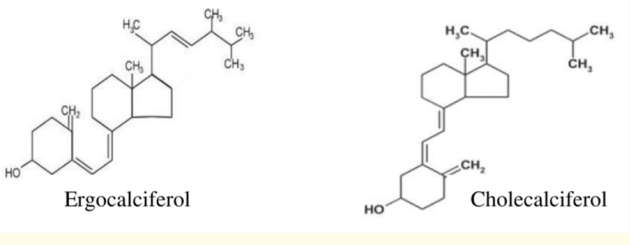

Figure 2: Structure of vitamin A.

Ergocalciferol formed from ergosterol by sunlight in the plants, where cholecalciferol found in animal tissues. Both of the forms are inactive and get activated in the sunlight, and provide the activated form of vitamin D. Vitamin D production under the skin is directly proportional to sunlight exposure.

Figure 3: Activation of vitamin D in the body.

Today, people cover the whole body, decreased the outdoor living and apply the sunscreen, because of that the sun exposure become minimal. In that case, vitamin D doesn't get activated, and we are totally dependent on the diet for it.

Vitamin D gets absorbed by the intestine from the digested food and then it enters the circulation and ultimately distributed to the entire body.

Ergocalciferol and cholecalciferol, both are inactive forms. These forms further get metabolize in the liver and kidney, after that it gets finally converted into the active form of vitamin D.

Functions

Vitamin D plays a important role in balancing the optimum levels of calcium and phosphorus in the body. It's active form, Calcitriol, helps to that by acting on targeted organs – intestine, bones, and kidney. Because of the vitamin D deficiency, some of the diseases may occur, for example, breast cancer, colon cancer, prostate cancer, heart disease, weight gain and so on. Few of the studies shows that vitamin D treatment may help to prevent autism, autoimmune disease, cancer, chronic pain, depression, diabetes, heart problem, high blood pressure, etc. Along with strengthening the bones, vi-

tamin D also helps to regulate the immune system and the neuromuscular system. Dark skinned people absorb less sunlight as compared to light-skinned people, because of the presence of melanin in the skin.

Recommended dietary allowance

- For all without sunlight – 400 IU (growing children, pregnant and lactating mother)
- With sunlight – 200 IU

Food sources

Beside of sunlight vitamin D is found in few of the food items, for example, Cod liver oil, oily fish, egg yolk, liver, mushroom, butter, and cheese. You can also get vitamin D fortified food in the market now these days, for example, milk, margarine, and baby food.

Deficiencies

The deficiencies may appear in prolonged bedridden people, strict vegetarians, fat mal-absorption, chronic alcoholism, and severe liver and kidney disease. In pregnancy and lactation, the demand for vitamin D enhanced, if not supplied in the right amount then deficiencies may occur. Its deficiencies may cause Rickets in children and osteomalacia in adults.

Rickets

Rickets may appear in the children with age of 6 months to 2 years. Improper mineralization during the formation of bones may result in soft and deformed bones. For example, bowlegs, knock – knees, pigeon chest and kyphoscoliosis. The severe conditions delayed walking and formation of teeth.

Osteomalacia

In this condition the bone matrix is normal, but the mineralization deficit. These types of bones are more prone to fracture. Because of the weakness of proximal muscles, the patient may walk with knock-knees and waddling gait.

Osteoporosis is the early stage of osteomalacia. In chronic renal failure, vitamin D cannot convert into its active form, calcitriol and this condition is known as renal rickets.

Toxicity

This is most common in the case of vitamin overdose as supplement. 2000 IU per day for a prolonged period may lead to toxicity. Increased vitamin D consumption can cause more absorption of calcium which result hypercalcimia. This high amount of calcium may deposit in soft tissues for example- in kidney, arteries and can damage that particular organ. Increased serum calcium levels can cause kidney stones.

Vitamin E

It's an essential vitamin, and also works as an antioxidant. It mostly found in vegetable oil. It is usually known as Tocopherol. The tocopherol generally of 8 types, in which alpha-tocopherol is most important and abundant. The phenolic group in the compound is responsible for its antioxidant property.

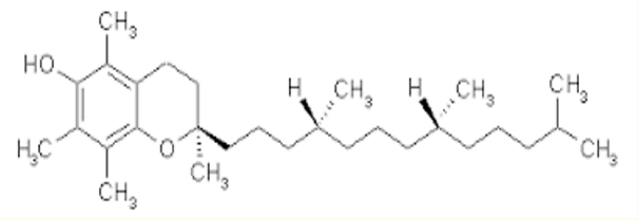

Figure 4: Vitamin E chemical formula.

Vitamin E attached to the fat in the diet. During digestion, vitamin E get separated from the digested food and mixed with the bile salts. After that, the intestinal wall absorbs it and releases it into the blood flow. Vitamin E deficiency can be occurring in the condition of fat malabsorption. The distribution of Vitamin E to the liver and other tissues occur through the bloodstream. From the liver, it exported to the peripheral tissues in the form of VLDL and LDL. Mainly it gets stored in the adipose tissues.

Function

- It safeguards the cell membrane by the antioxidant property. It also protects the RBC from hemolysis.
- It is commonly known as 'anti-sterility vitamin' as it has observed through some studies, that it is necessary for the normal reproduction and fertilization. Its deficiency may affect the spermatogenesis and motility of sperms.
- Vitamin E reduces the oxidation of LDL, which can cause damage to the heart. So indirectly it reduces the risk of heart disease.
- It increases the activity of 8- aminolevulinic acid synthase and ALA dehydratase which increases the heme synthesis.
- It acts as an anti-inflammatory agent by prostaglandin production.

- Vitamin E plays an important role in respiration by producing co-enzyme Q which is the major component of ETC (Electron Transport Chain).
- Vitamin E spares Vitamin A and carotene by preventing them from oxidation.

Recommended dietary allowance

Man 10mg
Woman 8mg

Deep freezing and food processing degrade the quality of vitamin E in food. During pregnancy and lactation, the requirement becomes high (2-4 mg extra).

Dietary sources

Vegetable and wheat germ oil, sunflower, safflower, cotton seed oil, corn and soya oil, meat, milk and eggs.

Deficiencies

Deficiency is very rare in adults. It usually occurs in premature infants and mal-absorption syndrome. Hemolytic anemia in premature newborn happens due to the less production of hemoglobin and shortens the lifespan of erythrocytes. The reason behind this is the poor placental transfer and presence of less adipose tissue (the usual place to store vitamin E). In the adult, its deficiency causes denature muscles, and in animals it causes sterility.

Toxicity

It used to believe earlier that it's high dosage benefits in cancer and cardiovascular disease, but the studies denied it. Although the excessive quantity can be toxic but slightly high dosage doesn't give any adverse effect.

Vitamin K

It helps in the process of blood clotting. Here K stands for Koagulation (greek).

Its main resources are green leafy vegetables, and it gets synthesize by the bacteria in our intestine. This vitamin usually acts as a coenzyme.

It occurs in nature in 2 forms

1. Vitamin K1 (phylloquinone)- this form of vitamin K mostly found in green leafy vegetable.
2. Vitamin K2 (menaquinone)- this form of Vitamin K produced by bacterial flora found in the colon.

The third form Vitamin K3 menadione is a synthetic form.

Figure 5: Vitamin K structural formula.

Vitamin K absorbed in the small intestine, while other fat-soluble vitamins require bile to get absorbed. Bile obstruction can cause depleted levels of fat-soluble vitamins. In obstructive jaundice, bile cannot pass from the liver to the intestine which stops the absorption of vitamin K. So, in those cases, Vitamin K injected before the surgery.

Functions

It is mainly required for blood coagulation. Clotting factors need vitamin K to get activated, for example, factor 2 (prothrombin), 7, 9 and 10. Thrombin (the active form of prothrombin) converts the fibrinogen to a fibrin clot. This is the reason vitamin K3 used as an antihemorrhagic agent.

Figure 6: Blood clot formation.

Daily recommended allowance

It synthesizes by intestinal bacteria in our body. The requirement from the diet become reduces due to its availability in the body.

The requirement for an adult is 70- 140µg/daily.

Dietary sources

Green leafy vegetables are a great source of it. Other sources are egg and dairy products.

Deficiency

Its deficiency may lead to prolong coagulation and bleeding. Newborns especially preterm infants are more prone to this deficiency because of the following reasons, the infantile colon is sterile, poor placental transfer, low tissue storage of vitamin K.

In adults, vitamin K deficiency has seen in obstructive jaundice and other disease connected to fat malabsorption. People who suffer from Chron's disease and celiac disease also suffer from vitamin K deficiency. Prolong treatment may kill vitamin K synthesis-bacteria and also can cause its deficiency.

Toxicity

Administration of the larger doses of vitaminK3 can cause hemolytic anemia and jaundice. But naturally occurring vitamin K (K1 and K3) does not cause any toxicity.

Fat-soluble vitamins are necessary for our diet. Now these days, fat-free diets are more in trend because of weight loss. By having a fat-free diet, people are unknowingly eliminating these vitamins from their diet. So many adverse effects can cause due to vitamin deficiency. They required in less amount, but they are very necessary to sustain a healthy and disease-free life.

Volume 3 Issue 6 June 2019