FAT SOLUBLE VITAMINS

INTRODUCTION

Dear students you are aware of the fact that our body needs various kinds of macro as well as micro nutrients for sustaining the life. Vitamins are complex organic compounds, and are present in minute amounts in natural food stuffs. Fat soluble vitamins occur in nature in association with lipids and their absorption in known to take place in the presence of dietary fats. conditions that are favorable to fat absorption are said to be favorable for the absorption of fat soluble vitamins. Fat-soluble vitamins can be stored in appreciable amounts in the body due to their lipid nature and are excreted in the feces via the bile.

2. VITAMIN A

Vitamin A is a generic term used for a large number of related compounds such as retinol and retinal which are often referred to as preformed vitamin A. It was discovered in 1909 by Mccullum and Davis. Vitamin A is required for the maintenance of normal vision. Retinol as well as retinal can be inter converted. Other most important compounds of vitamin A family are retinyl esters and β- carotene. Carotenoids are the major precursors of vitamin A and are structurally associated with β-carotene.

FUNCTIONS

1. Vision – it facilitates vision in dim light. Adequate amount of retinol is essential otherwise it results in impaired dark adaptation, normally known as night blindness.

2. Immunity- it is also known as anti infective vitamin. The skin and mucosal cells which line the digestive and urinary tract functions as a barrier to form body's first line of defense against infection. Retinol and its metabolites are much needed for maintaining the integrity and function of those cell lines.

3. Growth and development- both retinol and retinoic acid are very essential for embryonic development.

4. Cell differentiation and gene expression – the differentiation of immature bone cells into different types of mature cells is a very important process which is highly dependent on vitamin A.

5. Reproduction – vitamin A is considered to be very essential during pregnancy as evidenced in recent years. Serum retinol concentration <20µg/dl was found to be associated with preterm delivery.

Sources Vitamin A

Vitamin A has been estimated to possess different potencies which vary with dietary sources. For instance-carotene is less easily absorbed than retinol and needs to be converted to retinal. Free retinol is not generally found in food. Retinyl palmitate is a precursor and is the major storage form of retinol which is exclusively find in foods of animal origin. Yellow orange and green coloured vegetables and fruits contains significant quantities of Vitamin A. Cod liver oil, eggs, butter, milk, sweet potato, carrot, papaya, mango, spinach and broccoli are considered as the good sources.

Deficiency Vitamin A

Maintenance of normal vision is the unique function of vitamin A. Night blindness is one of the specific manifestations of this deficiency. Untreated cases would progress towards the development of bitot's spots, corneal ulceration, keratomalacia and development of corneal scar and it is non-reversible. Deficiency of vitamin A affects growth and development as it impairs skeletal growth. Severe deficiency could have adverse effect on fetal growth and development. Sterility in males is a common problem seen as a consequence of degeneration of germinal epithelium. Both specific and non specific protective mechanisms are known to be adversely affected which tends to increase the individuals susceptibility to develop infections.

TOXICITY

The major symptoms include head ache, drowsiness, nausea, loss of hair, dry skin, reasorption of bone are the major problems encountered among adults. Among infants it results in scaly dermatitis, loss of weight, anorexia, hyper irritability and skeletal pain. These symptoms

are observed when the dose exceeds more than 8000 RE/day which when taken for more than 30 days.

RDA

ICMR has recommended an intake of 4800 µg β-carotene for both adult man and woman. During pregnancy extra allowances are needed to support fetal growth and is estimated to be about 6400µg. During lactation it is 7600µg. For children between the age group of 1-6 years and 7-9 years it is suggested to consume about 3200µg and 4800µg/day of β-carotene.

3. VITAMIN D

Vitamin D is commonally known as a sunshine vitamin since it is synthesized in the skin when exposed to sun light. It was discovered by Sir Edward mellanby in 1918 who identified the antirachitic properties of vitamin D. this vitamin exists in two forms; vitamin D3 also known as cholecalciferol which is found in foods of animal origin. The other form is vitamin D2 referred to as ergocalciferol and is widely distributed among plant substances. Available scientific evidences have suggested that exposing hand and face for about 15 minutes a day for at least three times a week is considered to be sufficient to synthesize vitamin D in the body.

Functions

The most important metabolite of vitamin D which has physiological significance is 1, 25-dihydroxy vitamin D. It has the ability to enhance the level of calcium binding protein in the small intestine thus helps in the absorption of dietary calcium and phosphorus. Mobilization of calcium and phosphorus in association with parathyroid hormone occurs in the bone due to vitamin D. In the kidney vitamin D promotes reabsorption of calcium. 1, 25-dihydroxy is not directly involved in bone mineralization process, but it exerts significant amount on osteoblasts and these in turn would help for proper mineralization. Vitamin D is also involved in the regulation of specific gene activity. This mainly occurs through the binding at specific regions in the DNA.

Sources

Vitamin D is naturally synthesized by exposing the skin to sun light. Most foods have negligible amounts of vitamin D. marine fishes are the good source. Egg yolk and butter milk are

the poor sources. Cod liver oil is one of the richest sources having the highest concentration of 100000 IU/100g.

DEFICIENCY

The common manifestations include rickets and osteomalacia. Rickets is usually seen among children between the ages of 1 and 3 years. The pronounced effect is seen during pubertal stage. Occurrence of osteomalacia is associated with multiple parity. Osteoporosis is an age related problem and is often accompanied by osteomalacia. Deficiency is very common in Indian subcontinent. Practice of purdah, living in improperly ventilated crowded houses.

TOXICITY

An intake of 100µg of vitamin D causes hypercalcemia in children. Among adults, consistently higher amounts of intake in the range of 25,000 – 60000 IU/day for 1-4 months would cause hypercalcemia. Common symptoms observed are loss of appetite, nausea, weight loss and failure to thrive. Hyper vitaminosis occurs when the serum concentration of 25 (OH) D (25, hydroxyl vitamin D) exceeds 700-1600nmol/l. Over exposure to sunlight does not cause toxicity.

4. VITAMIN E

Vitamin E was basically discovered and characterized as a fat-soluble nutritional factor essential for normal reproductive processes. This specific role of vitamin E was found out in the course of carrying out reproductive studies with rats. In the year 1922 it was demonstrated that to prevent fetal death and sterility in rats an important fat soluble dietary constituent was identified to play a vital role in this regard. Initially this was termed as “factor X’ and was also been referred to as “antisterility factor”. Later the name vitamin E was assigned. During the year 1936 it was isolated from wheat germ oil which was termed as tocopherol which is derived from the Greek word tokos and pherein. The term vitamin E is often used to denote a mixture of biologically active tocopherols. There are totally 4 tocopherol compounds namely α, β, γ and δ tocopherol. About 4 types of tocotrienols have also been discovered. ά- tocopherol is most abundantly available in nature and has been shown to possess highest biological activity and also has a vital role in reversing vitamin E deficiency symptoms among humans. In the year 1950s it was rediscovered that, vitamin E has specific role in cellular antioxidant system along with

sulphur amino acid and selenium. Subsequently it was also proven that it is very effective in preventing lipid peroxidation and various other events associated with radical driven oxidative stress.

FOOD SOURCES

Vitamin E is synthesized only by plants and hence is primarily found only in plant based foods. Thus fats and oils of vegetable origin are known to be the richest sources of vitamin E. vegetable oils and oils derived from food grains have been estimated to contain about 50-100mg per 100g of the product. Only 8mg is present in coconut oil. Wheat germ oil is exclusively the rich source of vitamin e containing about 260mg/100g. The chief sources in Indian diets are the vegetable oils, nuts, oil seeds and whole grains. Significant amount of tocotrienols are found in palm oil, rice bran oil and the bran and germ portions of certain cereals like oats, barley and rice.

On an average, consuming 20g oil would contribute 10mg of vitamin E. hence; consuming 400g of food grains would have been found to contain 6-8g of fat, out of which 3-4g of vitamin E might be obtained.

Total tocopherol content of various vegetable oils

Type of vegetable oil	Total tocopherol (mg/100g)
Olive	20.44
Grape seed	15.3
Corn	48.54
Walnut	23.83
Sesame	29.84
Peanut	29.45
Rice	7.49
sunflower	75.82

Functions

1. Antioxidant activity

Due to its antioxidant property vitamin E protects key cell components by neutralizing free radicals before they can cause lipid oxidation or DNA damage. By reducing free radical attack, antioxidants help to break the chain reaction of lipid peroxidation (chain-breaking antioxidant) and they protect the cell membranes by facilitating the processes of lipid repair and lipid replacement. Through this mechanism they may prevent cancer or heart disease or any other form of degenerative disorders. A high plasma concentration of vitamin E is associated with lower risk of cardiovascular disease.

2. Role in cardiovascular disease

Supplementary vitamin E was reported to be effective in reducing atherosclerosis progression in subjects with previous coronary artery bypass graft surgery who have not been treated with lipid-lowering drugs

3. Role in cancer

Vitamin E is known to induce apoptotic phase mainly via a process mediated through mitochondrial pathway and cell cycle arrest which happens due to the suppression of cyclin D by tocotrienols.

Other functions

Apart from its antioxidative role, vitamin E takes part in other biological processes also which are as follows;

- Facilitates the maintenance of cell membrane integrity.
- Exerts anti-inflammatory effect mainly by direct and regulatory interaction with the prostaglandin synthetase and complex of enzymes which are mainly involved in the metabolism of arachidonic acid.
- Plays a major role in DNA synthesis.
- Stimulates immune response.
- Regulates intercellular signaling and cell proliferation mainly by modulating protein kinase C activity.

Deficiency

Vitamin E deficiency is rarely encountered in humans. Overt deficiency symptoms in normal healthy individuals consuming diets low in vitamin E have never been described. Vitamin E deficiency may occur only as a result of certain genetic conditions such as abnormalities occurring in α- tocopherol transfer protein, fat malabsorption syndromes or in severe protein energy malnutrition.

Toxicity

At present there are no reports regarding the adverse effects resulting due to the consumption of vitamin E from natural foods. It is one of the least toxic vitamin. Both humans as well as animals are capable of tolerating relatively high intake levels of more than 100 times the estimated requirement. At very higher doses, vitamin E is thought to impair the utilization of the fat soluble vitamins in the body. For instance, animals that were supplemented high doses of vitamin E were shown to have developed impaired bone mineralization, impaired storage of hepatic vitamin A and prolonged blood coagulation.

Requirment

There are very limited data on vitamin E (alpha tocopherol) requirements. Alpha tocopherol content of vegetable oils and invisible fat in cereals and other foods is generally adequate to meet the daily requirement. Requirement is limited to essential fatty acids. Alpha tocopherol requirement is related to its major role in protecting antioxidant property of essential fatty acid content in the diet and the suggested intake is 0.8 mg per g of EFA. This roughly contributes about 8-10 mg tocopherol /d, depending on the type of edible oil used. Vegetable oils and invisible fat from cereals and other foods like nuts and vegetables contributes adequate tocopherol in Indian diets.

5. VITAMIN K

Vitamin K was the last fat soluble vitamin to be discovered. Vitamin K was appeared to have very limited functional role in humans i.e. its major role in initiating blood clotting mechanism. This vitamin was discovered in 1934 by a Danish scientist Dam. He explored the fact that bleeding in chickens could be prevented by feeding decayed fish meal. Vitamin K is also referred to as coagulation vitamin, antihemorrhagic vitamin and prothrombin factor. Vitamin K is highly indispensable for maintaining normal blood coagulation system in both humans as well as other experimental animals. In general it exists in two forms in nature. Vitamin K1 is widely distributed among plant kingdom and is termed as phylloquinone. The other form is K2 which was isolated from putrid fish and is called as menaquinone. The last form is K_3 known as menadione and it is of purely synthetic form. This vitamin can be synthesized by intestinal flora. It is considered as one of the most important nutrient during infancy because intestinal synthesis is insufficient and it needs to be provided externally.

FUNCTIONS

The well known function of vitamin K is its role in the synthesis of blood clotting factors. Vitamin K is considered as one of the most essential nutrients required for catalyzing the conversion of the precursor of prothrombin to thrombin. Inturn prothrombin in the blood catalyzes the conversion of fibrinogen to fibrin, a factor involved in blood coagulation. The level of prothrombin in the blood is a major determinant of the rate at which the blood will clot.

There are mainly two pathways- extrinsic and intrinsic and are thought to have involved in the process of generating prothrombin and thrombin. The clotting process is proposed to be initiated by the absorption of factor XII into collagen which further leads to into activation into XIIa. This in turn cleaves IX and is known to be vitamin K dependent. Once it is carboxylated it binds with calcium and phospholipids and converts X to Xa which is also a vitamin K dependent factor. Further Xa hydrolyzes prothrombin to thrombin. This is the final step which results in the conversion of fibrinogen to fibrin and initiates the clot formation.

SOURCES

Vitamin K is widely distributed in plant foods. Green vegetables are known to contain highest concentration. Dark green leafy vegetables such as kale, parsley and spinach would have

been estimated to contain about 300-600µg/100g. Broccoli, Brussels sprouts and lettuce are the intermediary sources having about 100-200µg/100g. non leafy vegetables such as green beans, cauliflower and cucumber are also considered as significant sources which contains on an average 20-50µg/100g. certain vegetables oils such as soy bean, rapeseed and olive oils are known to contain relatively higher amount which ranges from 50-200µg/100g. Fermented foods such as cheese are also known to contain considerable amounts. Apart from these intestinal bacterial synthesis is also known to provide significant amount.

DEFICIENCY

Deficiency is rare among adults. Primary deficiency normally referred to as neonatal haemorrhage is occasionally seen among infants. This could be mainly due to the fact that infants when they are born their stomach is completely sterile and is free from bacterial contamination. This could become a causative factor for the infants to develop deficiency particularly when they are fed for long periods on cow's and human milk as they are known to contain relatively smaller amounts of vitamin K. Antibiotics, and salicylic acid based medications are known to intestinal bacterial flora. Symptoms of deficiency is mainly manifested as prolonged blood coagulation time and increased susceptibility to haemorrhage.

RDA

The incidence of deficiency is very rare among Indians and ICMR considered that no such recommendation is needed. A dose of 0.5-1.0mg of vitamin K can be administered intramuscularly to infants suffering from deficiency. The committee on medical aspects of food policy of the United Kingdom declared that an intake of 1µg/kg/day is thought to be safe and adequate for adult age group.

CONCLUSION

Adequate intake of fat soluble vitamins is very essential for maintaining normal physiological functions. They could also be consumed as a means of correcting and preventing the disorders resulting due to the deficiency of these vitamins. Foods composed of fat soluble vitamins are widely distributed in nature and a regular intake of such food would help to meet the daily requirement. Since fat soluble vitamins can be stored in appreciable amounts in the

body it is safer to consume them at a level designated by the nutrition expert committees in order to prevent the adverse effects.