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Full Length Review Article

Biological importance of vitamins for human health: A review

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Abstract

Vitamins are direly important for human health, growth, development, reproduction and maintenance, and their deficiencies are imposing serious health hazards. Thirteen vitamins are true vitamins which are further classified as water soluble and fat soluble vitamins. Vitamin A, E, K and D are fat soluble vitamins whereas, vitamin B1, B2, B3, B5, B6, B9, B12, biotic and vitamin C are water soluble vitamins. There are many other food components which have vitamin activity but these are not true vitamins. There are wide range of dietary sources including both plant and animal sources for these vitamins. Their regular dietary intake is essential for proper maintenance of health and development. Vitamin deficiencies are causing the serious health problems, impairment of normal growth and development. Basic introduction of vitamins, their biological importance, daily dietary requirement and dietary sources for vitamins are discussed in this review article.

Keywords: Vitamin A, B complex, vitamin C, biotin, vitamin E, vitamin K

Introduction

Vitamins are groups of highly complex compounds, organic in nature, present in foodstuffs in traces, essential for normal metabolism and absence of these nutrients cause disorders whereas, resupply of these nutrients can cure the deficiency symptoms (Marshall, 1986). Vitamins are diverse in nature relative to fats, carbohydrates and proteins. Vitamins are differentiated from other groups by their organic nature and their classification depends on chemical nature and function. Very trace amounts of vitamins are needed for growth, development, health and reproduction. Some vitamins are deviants from usual definition and not always needed to be part of food stuff i.e. ascorbic acid, vitamin D and niacin. Ascorbic acid is synthesized by animals, niacin synthesized from tryptophan amino acid and vitamin D synthesized from UV radiation from sunlight. Therefore, specific species and under certain conditions vitamin D, ascorbic acid and niacin does not fit in the definition of vitamins (McDowell, 2000). So, far as classification of vitamins is concerned, these are divided into two main categories i.e. water soluble and fat soluble vitamins. Vitamins of B complex and C are water soluble whereas, vitamin A, D, E, and K are fat soluble. Fat soluble vitamins have association with fats and absorb with dietary fats. Absorption of fat soluble vitamins follow the same mechanics as for absorption of fats. Water soluble vitamins are not associated with fats and rendered unaffected by alterations in fat absorption (McDowell, 2000; Wardlaw et al., 2004).

In earlier days of vitamin discovery, chemical composition of vitamins was unknown and these factors were designated with alphabet letters. Alphabetizing became complicated due to different forms of vitamins (vitamin B complex), differences in chemical structure within groups and determination of chemical functions. Vitamins were also named based on their function and sources. Vitamin H was named to the factor which protects the *haut*, a German word meaning skin. Vitamin K is derivative from Danish word *koagulation* meaning coagulation. Pantothenic acid derived from Greek word *pantos*, means found everywhere. Rules for nomenclature of vitamins were established by Committee on Nomenclature of the American Institute of Nutrition (Cnain, 1981).

Human body is unable to synthesize the vitamins so, their intake through diet is necessarily vital. Vitamins are chemically complex compounds and have significant role in growth and development of the human body. There are numerous vitamins like; vitamin A, vitamin C (ascorbic acid), vitamin D, vitamin E, vitamin B12 (cobalamin), vitamin B6, vitamin B5 (Pantothenic acid), vitamin B1 (thiamin), vitamin B3 (niacin), vitamin B2 (riboflavin) and vitamin B9 (folate, folic acid, or folacin), flavonoids (vitamin P). Severe or even fatal diseases are caused by deficiency of vitamins. Vitamin deficiencies are associated with specific disease like, vitamin A associated with Blindness, vitamin B1 with beriberi, vitamin B3 with pellagra, vitamin B6 with anemia, vitamin C with scurvy and vitamin D with rickets (Asensi-Fabado and Munne´-Bosch, 2010). Biological importance of fat soluble and water soluble vitamins for human health is exclusively discussed in this review article.

Fat soluble vitamins:

Vitamin A, D, E and K are the fat soluble (Figure 1). Basic introduction of vitamins, biological importance, daily dietary intake and dietary sources are descried for fat soluble vitamins.

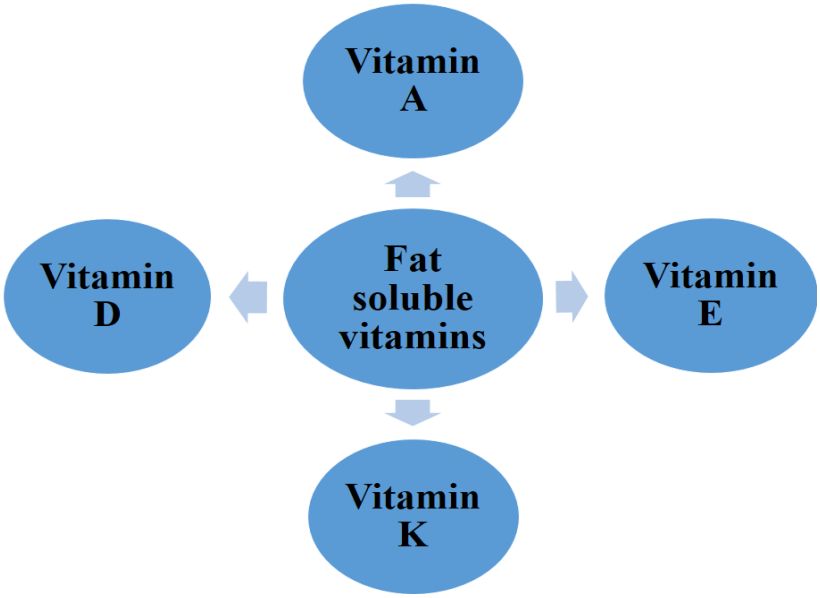

Figure 1: Fat soluble vitamins

Vitamin A:

Introduction:

Vitamin A is most complicated in nature. It can be obtained both from plant and animal sources.Vitamin A from animal sources is known as retinoids whereas, from plant sources these are called provitamin A carotenoids. Retinol, retinal, retinoic acid and retinyl esters are different forms of retinoids. α-carotene, β-carotene and β-cryptoxanthin are the plant originated provitamin A carotenoids which are converted into preformed vitamin A retinoids during digestion in human body (WHFoods, 2017).

Biological importance:

Vision, support, support to immune system and inflammatory systems, cell growth and development, antioxidant activity, promoting proper cell communication (WHFoods, 2017).

Daily requirement:

Daily intake requirement of vitamin A for young males is 900 micrograms, for females 700 microgramsand for children 300-400 micrograms (WHFoods, 2017).

Dietary sources:

Provitamin A carotenoid sources are sweet potato, carrots, spinach, kale, mustard greens, collard greens, turnip greens, Swiss chard, winter squash, Romaine lettuce, Bok Choy, cantaloupe, bell pepper, parsley, broccoli, asparagus, sea vegetables, chili peppers, tomatoes, basil, papaya, shrimp, eggs, Brussels sprouts and grapefruit.

Preformed vitamin A sources are shrimp, eggs, cow's milk, cheese, yogurt, salmon, sardines, chicken, turkey, tuna, cod, scallops, beef and lamb (WHFoods, 2017).

Vitamin D:

Introduction:

Vitamin D is very important for human body but exact intake dose is variable and has inconsistent pattern because exposure of sunlight also produce vitamin D in human skin. Ultraviolet B (UVB) wavelength of sunlight strikes the body and resultantly 7-dehydrocholesterol in human body is converted into cholecalciferol which is preliminary form of vitamin D. However, amount of cholecalciferol produced by UV-B is unpredictable due to type and nature of skin pigments, skin health and nature of sunlight. Cholecalciferol is not fully active form of vitamin D but there is involvement of kidney and livers for conversion of cholecalciferol into active form of vitamin D and these additional steps further make the prediction difficult. Food sources are very limited which provide vitamin D but amount of this vitamin in body can be increased by increasing the exposure to sunlight (WHFoods, 2017).

Biological importance:

Vitamin D is important for normal body functioning as its deficiency cause the malformation and softening of bones. Vitamin D deficiency is associated with many disorders like, osteoporosis, rickets, osteomalacia, loss of balance, diabetes, rheumatoid arthritis, asthma, depression, epilepsy and lowered immune function. Malformation of bones in children is called rickets whereas, in adults it is called osteomalacia (Wagner and Greer, 2008). Vitamin D increases the calcium absorption from food and reduce the losses through urine. It also maintains the blood calcium level by pulling out the calcium from bones but this option prevails only if there is sufficiently enough vitamin D in foods. Vitamin D deficiency also increase the risk of blood sugar level and diabetes (Belenchia et al., 2013). Vitamin D is involved in maturation of white blood cells that is frontline for immunity responses. Consistent association was also identified between increased risk of respiratory infection and vitamin D deficiency (Jolliffe et al., 2013). Vitamin D deficiency is reported to be increasing since 1980s due to increased use of sunscreens and decreased exposure to the sunlight (Faurschou et al., 2012).

Daily requirement:

Dietary intake should be 15 micrograms (600 International Unit) in daily basis for teenager males and females (WHFoods, 2017).

Dietary sources:

Egg yolks,tuna, salmon, sardines, mushrooms, cow's milk, soy milk, orange juice and fortified foods (WHFoods, 2017).

Vitamin E

Introduction:

Vitamin E is a broad term which comprised of four different tocopherols and four different tocotrienols. Collectively these eights compounds are called "tocochromanols" and these are fat soluble antioxidants. Alpha-tocopherol is well known and well-studied component of vitamin E. Being antioxidant, vitamin E protects the membrane fats from oxidative damage and maintain the cellular functioning. This vitamin also protects the food from oxidative damage during storage and processing (WHFoods, 2017).

Biological importance:

LDL (low-density lipoprotein) cholesterol is protected by vitamin E from oxidative damage caused by free radicals. Deficiency of vitamin E make the LDL cholesterols prone to oxidative damage and convert them into oxidized LDL. Oxidized LDL accumulates in the blood vessels and cause hardening of arteries known as atherosclerosis. Deficiency of vitamin E is also associated with heart attack, cancer, stroke, fibrocystic breast disease, epilepsy, PMS, diabetes, parkinson's disease, cataract, alzheimer's disease, intermittent claudication, cold sores, immune health and macular degeneration (WHFoods, 2017).

Daily requirement:

Daily recommended intake of vitamin E is 15 milligrams for males and females of adult age while 5 milligrams for children (WHFoods, 2017).

Dietary sources:

Vitamin E dietary sources are sunflower seeds, spinach, swiss chard, turnip greens, asparagus, beet greens, mustard greens, chili peppers, almonds, broccoli, bell peppers, kale, tomatoes, avocado, peanut, shrimp, olives, olive oil, collard greens, cranberries, raspberries, kiwifruit, carrots, green beans and leeks (WHFoods, 2017).

Vitamin K

Introduction:

Blood clotting factors are named as vitamin K because it is derived from German word "*koagulation"* which means blood clotting (Shearer et al., 2012; Shearer, and Newman, 2014). K1, K2 and K3 are three basic types of vitamin K. K1 form is most prevalent and needed for photosynthesis of plants. K2 form is synthesized from K1 and K3 form by bacteria and other microorganisms. In human body, K2 is also synthesized by biological conversion of K1 and K3. K2 is not present in preformed form is plants but it is produced by fermenting bacteria through transformation of K1 into K2 (Hirota et al., 2013). Key functions of vitamin K are photosynthesis, antioxidants and energy generation by electron movement (Kurosu and Begari, 2010). Scientific names for K1, K2 and K3 are phylloquinones, menaquinones and menadiones respectively.

Biological importance:

Blood clotting is beneficial or harmful depending upon the conditions of occurrence. Blood clotting is very complex process because there is involvement of twenty different proteins for completion of clotting process and four proteins among them requires vitamin K for their activity (Shearer et al., 2012; Shearer, and Newman, 2014).

In young person's there is rare incidence of vitamin K deficiency but frequent in newborns because placenta prevent the extensive movement of vitamin K to fetus. Severe gastrointestinal and liver diseases provoke the incidence of vitamin K deficiency (Shearer et al., 2012; Shearer, and Newman, 2014).

Vitamin K is important for bone health and its deficiency increases the risk of bone fracture. Experimentally it is proved that uptake of vitamin K by bone cells is in the form of K1 and K2. Vitamin K is composed of prenyl repeating units. K2 further consists of numerous subtypes called MK-4, MK-5, MK-7, MK-8, and MK-9 having 4,5,7,8, and 9 prenyl units. "M" in "MK" stands for "menaquinone" that is scientific name of K2 form whereas, "K" indicates the common name of vitamin K (Shearer et al., 2012; Shearer, and Newman, 2014).

Osteoclasts are special type of the cells involved in demineralization of bones and make the minerals available for other body functions but too much demineralization can harm the bones. Vitamin K keeps the osteoclasts cells under controls and induce the programmed cell death to avoid the extensive production of osteoclast cells and to keep the demineralization under control (Atkins et al., 2009; Shearer, and Newman, 2014).

Under-carboxylatedosteocalcin is a disorder in which risk of bone fracture is increased especially hip fracture. This disorder is caused by lower carboxylation of osteocalcin protein. Vitamin K especially K1 and K2, regulate the carboxylation of osteocalcin proteins and strengthen the bones.Vitamin K is associated with blood clotting disorders, coronary artery disease, osteoporosis, liver disease, cancer, crohn's disease, celiac disease, cystic fibrosis and ulcerative colitis (Shearer et al., 2012; Shearer and Newman, 2014).

Daily requirement:

Daily value for vitamin K intake is 80 micrograms. WHFoods recommended the 90 micrograms daily required intake for females and 120 micrograms for males while 55 micrograms for children (WHFoods, 2017).

Dietary sources:

Specifically, food sources for K1 are dark green leafy vegetables, for K2 are eggs, meat, fish, dairy, fermented animal foods and fermented plant foods whereas, K3 is not naturally present in the dietary foods (Shearer et al., 2012; Shearer, and Newman, 2014).

Generally dietary sources for vitamin K are kale, spinach, mustard greens, collard greens, beet greens, swiss chard, turnip greens, parsley, broccoli, brussels sprouts, romaine lettuce, asparagus, basil, cabbage, bokchoy, celery, kiwifruit, leeks, sage, green beans, cauliflower, cucumber, tomatoes, oregano, black pepper, green peas, blueberries, grapes, carrots, summer squash, cloves, chili peppers, soybeans, avocado, raspberries, winter squash, pear, cranberries, bell peppers, plum, cantaloupe and eggplant (WHFoods, 2017).

Water soluble vitamins

Water soluble vitamins are vitamin B1, B2, B3, B5, B6, B9, B12, Biotin and Vitamin C (Figure 2). basic information, biological importance, daily required amount and dietary sources for these vitamins are discussed subsequently.

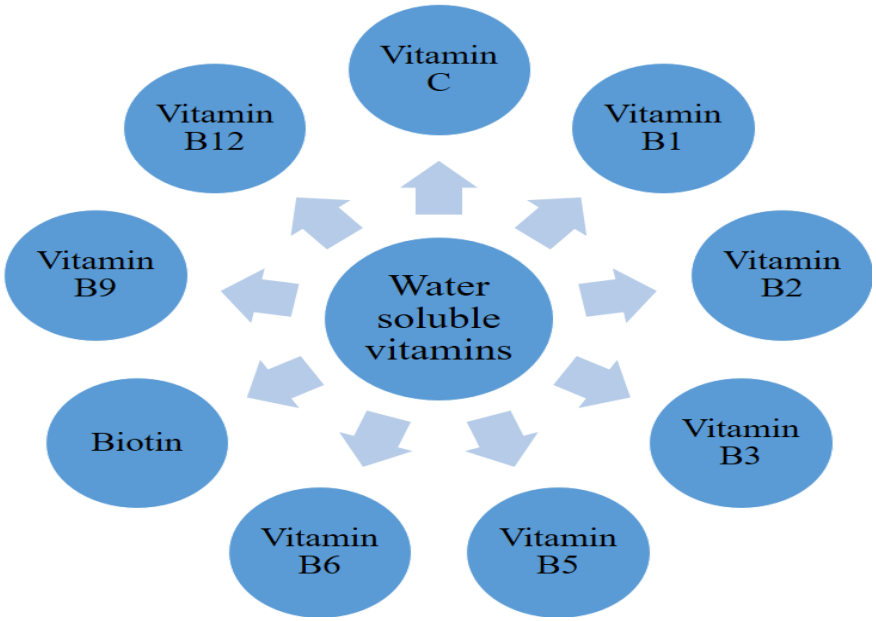

Figure 2: Water Soluble vitamins

Vitamin-B1 (Thiamin)

Introduction:

Vitamin B1 is the member of vitamin B complex and also known as thiamin. Vitamin B1 has important roles in human health. Vitamin B1 involves in the energy production from carbohydrates and fats (Kala and Prakash, 2003).

Biological importance:

Importance of vitamin B1 can be realized with the fact that it acts as gate keeper among the carbohydrate breakdown (less energy step), Kreb cycle (high energy step) and electron transport chain. So, this vitamin is central in energy metabolism and its deficiency can seriously impair the energy metabolism. Deficiency of vitamin B1 can seriously affect the nervous system, digestion and heart. Brain is most energy demanding organ of the body and resultantly severely impaired by vitamin B1 deficiency (Ba, 2008).

Parkinson's, Alzheimer's and alcohol-related brain diseases are also linked with vitamin B1 deficiency. Structure development and integrity of brain cells are dependent on vitamin B1. In case of diabetes, gastrointestinal disease, heart failure and elderly peoples, there is higher risk of vitamin B1 deficiency (Keogh et al., 2012). Alcohol is inhibitor for the vitamin B1 nutrition as most of amount of this vitamin is used for detoxification of the alcohol. Different vitamins form a vitamin B complex have the overlapping functions and supportive role for improving the functionality of other members in complex. Diabetes, congestive heart failure, alzheimer's disease, beri-beri, wernicke's encephalopathy, liver failure, alcoholism, pulmonary hypertension and HIV/AIDS are the diseases which are either cause or effect of the vitamin B1 deficiency (WHFoods, 2017).

Daily requirement:

Daily intake requirement for females is 1 milligram whereas for males it is 1.2 milligram (WHFoods, 2017).

Dietary sources:

Thiamine dietary sources are asparagus, sunflower seeds, green peas, flax seeds, Brussels sprouts, beet greens, spinach, cabbage, eggplant, romaine lettuce, mushrooms, navy beans, black beans, barley, dried peas, lentils, pinto beans, lima beans, oats, sesame seeds, kidney beans, peanuts, sweet potato, tofu, tuna, pineapple, oranges, broccoli, green beans, onions, collard greens, fortified cereals, dried beans, lean meats,

soy foods and whole wheat grain (WHFoods, 2017).

Vitamin-B2 (riboflavin)

Introduction:

This vitamin is also known as riboflavin and higher level of B2 in urine turn it into yellow color so, this is the only vitamin which provides us with visual clue of its abundance. Word *flavin*is derived from Latin word *flavus* means yellow. Like other B complex vitamins, this vitamin also involves in energy metabolism (WHFoods, 2017).

Biological importance:

Glutathione is most important antioxidant which provides antioxidative protection to body, and this antioxidant is recycled in the human body by vitamin B2. This vitamin promotes iron metabolism and its deficiency also increase the risk of anemia as iron is important element for red blood cell production. Deficiency of this vitamin increase the risk of migraine headache, iron deficiency anemia, high homocysteine, congestive heart failure, parkinson's disease, cataract and hypertension (WHFoods, 2017).

Daily requirement:

About 1.3 milligram for males and 1 milligram vitamin B2 for females is needed on daily basis (WHFoods, 2017).

Dietary sources:

Vitamin B2 dietary sources are spinach, beet greens, asparagus, sea vegetables, eggs, cow's milk, collard greens, broccoli, swiss chard, green beans, mushrooms, bokchoy, turnip greens, kale, mustard greens, bell peppers, soybeans, yogurt, almonds, turkey, green peas, sweet potato, sardines, tuna, winter squash, brussels sprouts, grapes, cabbage, carrots, summer squash, romaine lettuce, cauliflower, celery, chili peppers, lentils, peas, dairy products, nuts and fortified cereals (WHFoods, 2017).

Vitamin-B3 (Niacin)

Introduction:

Vitamin B3 and Niacin are interchangeable terms as niacin is the group of compounds having vitamin activity. Vitamin B3 comprised of nicotinic acid, nicotinamide and numerous enzymatic forms. Pellagra disease is caused by deficiency of vitamin B3. Energy production and antioxidative defense are the key functions of this vitamin for human health (Lanska, 2010). Nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) are two distinct forms of vitamin B3 and essentially involve in production of energy from dietary proteins, carbohydrates and fats (Leskova, 2006).

Biological importance:

Starch is synthesized from niacin and stored in liver and muscles as energy source. NAD, NADP and niacin containing enzymes are also quenchers of free radicals and protect the tissues from oxidative damage. Vitamin B3 deficiency is also associated with alcoholism. Vitamin B3 is associated with numerous diseases like, high cholesterol, pellagra, osteoarthritis, reynaud's disease, acne vulgaris, schizophrenia and type-1 diabetes (Lanska, 2010).

Daily intake:

Daily vitamin B3 requirement for males is 16 milligrams whereas, for teenager females is 14 milligrams (WHFoods, 2017).

Dietary sources:

Dietary sources for vitamin B3 aretuna, chicken, turkey, mushroom, salmon, lamb, beef, asparagus, tomatoes, bell peepers, sardines, peanuts, shrimps, brown rice, sweet potato, sunflower seeds, barley, green peas, potatoes, cod, corn, carrots, cantaloupe, mushrooms, collard greens, winter squash, brussels sprouts, summer squash, spinach, broccoli, green beans, bokchoy, beet greens, soy sauce, kale, chili peppers, swiss chard, mustard greens, eggplant, turnip greens, cabbage, fennel, cauliflower, sea vegetables and parsley (WHFoods, 2017).

Vitamin-B5 (Pantothenic acid)

Introduction:

Pantothenic acid is derived from Greek word "*pantothen"* which means "on all sides" or "from all "quarters". Common presence of this vitamin in foods is the reason for naming it as pantothenic acid (WHFoods, 2017).

Biological importance:

Use of carbohydrates, fats and proteins as energy source is impaired, hormone production is abandoned and immune system can collapse in case of pantothenic acid deficiency. Pantothenic acid is incorporated into Coenzyme A (CoA) which has central position for energy metabolism. Deficiency of this vitamin is associated with acne vulgaris, chronic fatigue, high cholesterol and diabetes-related foot ulcers (WHFoods, 2017).

Daily requirement:

Daily vitamin B5 requirement for human body is 10 milligrams. However daily intake requirement is also variable depending upon the age, gender and health conditions of the individuals (WHFoods, 2017).

Dietary sources:

Dietary sources for vitamin B5 are mushrooms, cauliflower, sweet potato, broccoli, beet greens, asparagus, turnip greens, bell peppers, cucumber, celery, avocado, lentils, dried peas, chicken, turkey, yogurt, salmon, rye, beef, eggs, potatoes, wheat, corn, shrimps, papaya, winter squash, cow's milk, collard greens, raspberries, brussels sprouts, grapefruit, pineapple, watermelon, carrots, oranges, swiss chard, spinach, summer

squash, cabbage, fennel, mustard greens, tomatoes, sea vegetables, romaine lettuce and bokchoy (WHFoods, 2017).

Vitamin-B6 (Pyridoxine)

Introduction:

This water soluble vitamin exists in different forms *i.e.,* pyridoxal (PL), pyridoxine (PN), pyridoxal 5'-phosphate (PLP), pyridoxamine (PM), pyridoxine-5'-phosphate (PNP) and pyridoxamine 5'-phosphate (PMP) (WHFoods, 2017).

Biological importance:

Functionally B6 is very important vitamin as it is involved in red blood cell production, carbohydrate metabolism, liver detoxification, brain and nervous system health (Combs, 2007). Hemoglobin is oxygen career protein in blood and its function is dependent on heme whereas, heme production is based on availability of vitamin B6. Vitamin B6 is also associated with rare types of anemia known as sideroblasticanemias. Several steps of carbohydrate metabolism are governed by vitamin B6. Retrieval of glycogen from carbohydrate of cells is relying on this vitamin (Combs, 2007).

This vitamin is also involved in production of messaging molecules in brain and nervous system, known as neurotransmitter. Dopamine, GABA and serotonin are key neurotransmitters whose biosynthesis is dependent on vitamin B6. Interference in function of vitamin B6 through genetic mutation induces a rare and distinct type of condition known as pyridoxine-dependent epilepsy. In this condition brain is under developed and epileptic seizures are prevailing during infancy (Combs, 2007; Gregory et al., 2013).

Depressed mode is also found to be linked with deficit intake of vitamin B6 however, this association of depression and vitamin B6 is further pronounced by folic acid deficiency. In recent studies, vitamin B6 deficiency was also found to be linked with attention deficit disorder. Liver detoxification is accomplished by this vitamin and feeding the rats on pyridoxine-depleted foods cause the liver dysfunctioning (Gregory et al., 2013). Chronic inflammatory conditions appeared to be linked with vitamin B6 deficiency. Metabolism of tryptophan, other amino acids, proteins and development of immunity are also among the key functions of this vitamin. Vitamin B6 deficiency can provoke numerous diseases like, fibrocystic breast disease, premenstrual syndrome, carpal tunnel syndrome, anemia, epilepsy, asthma, seborrheic dermatitis, morning sickness, depression, high homocysteine and attention deficit syndrome (Combs, 2007; Gregory et al., 2013).

Daily requirement:

Young males require 1.3 milligrams and young females require 1.2 milligrams on daily basis (WHFoods, 2017).

Dietary sources:

Vitamin B6 dietary sources are tuna, spinach, cabbage, bokchoy, bell peppers, turnip greens, garlic, cauliflower, turkey, beef, chicken, salmon, sweet potato, potatoes, banana, winter squash, broccoli, brussels sprouts, collard greens, beet greens, kale, carrots, swiss chard, asparagus, mustard greens, tomatoes, leeks, summer squash, chili peppers, sunflower seeds, pinto beans, avocado, lentils, green peas, lima beans, onions, shrimps, pineapple, cod, mushrooms, cantaloupe, corn, beets, eggplant, turmeric, green beans, celery, strawberries, watermelon, romaine lettuce, sea vegetables, spinach and fortified cereals (WHFoods, 2017).

Vitamin B9 (Folate)

Introduction:

In last decade extensive research work was done on folate and concluded that folates have critical importance for human health. There are different forms of folates which are present in the foods *i.e.,* dihydrofolates, methylfolates, polyglutamylfolates and monoglutamylfolates (Crider et al., 2011).

Biological importance:

Well-known role of folates is to support the brain health. Messengers molecules are produced which are used by nerves to send the signals in whole body. BH_4 cycle (tetrahydrobiopterin) revealed that there is close association between folates and neurotransmitters especially serotonin and dopamine. BH_4 and folates used same mechanism to cross the brain blood barrier. Folates support the cardiovascular system and nervous system in human (Crider et al., 2011).

Folates regulate the homocysteine level in blood and this amino acid is marker for cardiovascular diseases as higher level of homocysteine showed the increased risk of cardiovascular diseases. Higher level of homocysteine in blood is known as hyperhomocysteinemia whereas, optimum folates in blood especially in the form of 5-methyltetrahydrofolate (5-MTHF) lower down the level of homocysteine in blood so, it's concluded that higher intake of folates can control the risk of cardiovascular diseases (Hayden and Tyagi, 2004; Crider et al., 2011).

Balanced nitric oxide (NO) levels of blood is essential for regulation of cardiovascular health. NO plays important role in regulation of blood pressure, blood flow and prevents clumping of platelet cells. Nitric oxide synthase (NOS) enzyme is involved in generation of NO with the help of

BH_4 (tetrahydrobiopterin). As BH_4 regulate the functioning of NOS enzyme whereas, under insufficient availability of BH_4, NOS impair the cardiovascular health by producing free radical superoxide. Dihydrofolatereductase (DHFR) enzyme helps to keep the enough level of BH_4 in the blood and convert folates into most bioactive form called tetrahydrofolate (THF). It is also reported that folate is known as central nutrient for cardiovascular health (Feng and Tollin, 2009; Crider et al., 2011).

Folate is important for production of red blood cells and its deficiency alongwith deficiency of copper, iron, vitamin B6 and vitamin B12 can spoil the production of red blood cells. Folate deficiency in females during pregnancy induced the problems in neural tube which severely effects the nervous system of fetus. Defects in neural tube can also lead to the loss of pregnancy in females. Risk of cancer is also lowered in human by higher intake of folates, especially in females, risk of breast cancer is reduced. Deficiency of folate increases the risk of depression, birth defects, high blood pressure, pregnancy, anemia, cancer prevention, gingivitis, ulcerative colitis, cognitive decline, osteoporosis and psoriasis (Crider et al., 2011).

Daily requirement:

Young males and females are requiring 400 microgram folates on daily basis (WHFoods, 2017).

Dietary sources:

Dietary sources for folates are Lentils, asparagus, spinach, turnip greens, broccoli, beets, romaine lettuce, bokchoy, cauliflower, parsley, pinto beans, garbanzo beans, black beans, navy beans, kidney beans, papaya, Brussels sprouts, green peas, bell peppers, green beans, celery, cabbage, summer squash, strawberries, tomatoes, leeks, fennel, lima beans, dried peas, avocado, peanuts, sunflower seeds, quinoa, winter squash, oranges, cantaloupe, onions, collard greens, pineapple, raspberries, carrots, beet greens, mushrooms, kiwifruit, kale, Swiss chard, mushrooms, basil, eggplant, mustard greens, lemons, limes, orange juice, cereals and fortified bread (WHFoods, 2017).

Vitamin B12 (Cobalamin)

Introduction:

Like other members of vitamin B complex, B12 vitamin also plays important role in energy metabolism and other biological processes but differently from B complex vitamins, this has some unique functions (WHFoods, 2017) *i.e.*

- Vitamin B12 can be stored in body for many years whereas, most of other B vitamins can't be stored for such a long time.
- It is larger molecule and has complex structure
- This vitamin is only synthesized by microorganisms like bacteria and fungi. Mushroom, a fungus, have this vitamin.
- This vitamin is difficult to absorb
- Daily intake requirement of this vitamin is very low.
- This vitamin contains heavy metal cobalt that's why it is also called cobalamin.

Biological importance:

Besides these distinctions, this vitamin is also very important for cardiovascular health of human. Vitamin B12 is involve in production of red blood cells which are oxygen carrier throughout the blood stream with the help of hemoglobin pigment. Succinyl-CoA is the building block for hemoglobin and this building block is dependent on the vitamin B12. B12 deficiency anemia, is special type of anemia caused by deficiency of vitamin B12. Vitamin B12 prevent the increase in level of homocysteine. Higher blood homocysteine is associated with numerous diseases like, peripheral vascular disease, stroke and coronary heart disease. Actually, vitamin B12 converts homocysteine into methionine with the help of methionine synthase enzyme to control the level of homocysteine (WHFoods, 2017).

SAMe (S-adenosylmethionine) is also simultaneously recycled parallel of homocysteine conversion by vitamin B12. SAMe is known as universal donor of methyl group. Some neurotransmitters are dependent on methyltransferases enzymes for synthesis and these enzymes are dependent on methyl groups for synthesis. So, methyl metabolism is another key role imparted by vitamin B12 in brain health.

Vitamin B12 is necessary co-factor for DNA synthesis which is necessary molecule for every life. Vitamin B6, vitamin B9 and vitamin B12 are necessarily needed for DNA synthesis. Division of blood cells is effected by deficiency of vitamin B12 which leads to production of abnormally large blood cells and this phenomenon is called macrocytosis (WHFoods, 2017).

Citric acid cycle is central cycle for aerobic energy production, whereas, succinyl-coA is key molecule in citric acid cycle. Vitamin B12 maintain the supply of succinyl-coA for citric acid, so this vitamin has key role in aerobic energy metabolism. B12 also maintain the bone health as incidence of osteoporosis is increased with deficiency of this vitamin. Vitamin B12 deficiency is associated with atrophic gastritis, pernicious anemia, fatigue, neuropathy, tinnitus, migraine, asthma, depression, memory loss, shingles, mascular degeneration, alzheimer's disease, kidney disease and multiple sclerosis (WHFoods, 2017).

Daily requirement:

Youngster either males or females needs 2.4 microgram vitamin B12 on daily basis (WHFoods, 2017).

Dietary sources:

Dietary sources for vitamin B12 are sardines, salmon, tuna, cod, lamb, scallops, shrimps, beef, yogurt, cow's milk, eggs, turkey, chicken, cheese, mushrooms and breakfast cereals (WHFoods, 2017).

Biotin (coenzyme R, vitamin H, and vitamin B7)

Introduction:

Previously this was known as coenzyme R, vitamin H, and vitamin B7 but now known as biotin, member of B-complex. Most importantly biotin plays a key role in sugar and fat metabolism (WHFoods, 2017).

Biological importance:

Insulin, hormone that maintains sugar balance, production and functioning on cell are impaired due to deficiency of biotin. Skin rachesare also caused by biotin deficiency as this is needed for fat deposition in the skin. These fats are prerequisite for keeping the skin moist and supple whereas, in case of deficit fats, skin becomes irritated and flaky or scaly. Symptoms of cradle cap can be reduced in nursing infants by increasing intake of biotin in food of lactating mothers. Skin rash, cradle cap, seborrheic dermatitis, hair loss, diabetes, brittle nails, pregnancy issues and seizures are the problems associated with deficiency of this vitamin (WHFoods, 2017).

Daily requirement:

Daily intake value is 30 micrograms biotin for males and females (WHFoods, 2017).

Dietary sources:

Biotin dietary sources are tomatoes, almonds, eggs, onions, carrots, romaine lettuce, cauliflower, sweet potato, oats, peanuts, walnuts, salmon, yogurt, banana, raspberries, cow's milk, strawberries, watermelon, grapefruit and cucumber (WHFoods, 2017).

Vitamin C (Ascorbic acid)

Introduction:

This vitamin is most familiar nutrient and citrus fruits are well known source of vitamin C. This vitamin is very commonly used nutritional supplement (WHFoods, 2017).

Biological importance:

This vitamin has antioxidant properties and protect the lens of eyes, molecules circulating in bloodstream and genetic material (DNA) from harmful effects of free radicals. This vitamin also transforms iron into a form which can be easily absorbed into intestines. This vitamin is needed for collagen production which is structural component of human body. Vitamin C deficiency induce the disease called scurvy. In case of scurvy, loss of bone strength, lose teeth and bleeding are most critical symptoms. Synthesis of certain neurotransmitters is also dependent on this vitamin. These neurotransmitters involve in signaling of feelings, thoughts, and commands throughout brain and nervous system. Vitamin C is also prerequisite for synthesis of serotonin, a hormone needed for proper functioning of endocrine system, nervous system, digestive system and immune system. Serotonin is also involved in moods, experiences of pain and stress, and daily body rhythms (sleep-wake cycles). In case of vitamin C deficiency, risk of scurvy, common cold, asthma, capillary fragility, gout, gingivitis, musculoskeletal injury, seasonal allergies and high blood pressure is increased (WHFoods, 2017).

Daily requirement:

Dietary recommended intake for youngster males and females are 75 milligrams on daily basis (WHFoods, 2017).

Dietary sources:

Dietary sources for vitamin C are papaya, bell peppers, broccoli, brussels sprouts, strawberries, pineapple, oranges, kiwifruit, cantaloupe, cauliflower, kale, cabbage, bokchoy, grapefruit, parsley, turnip greens, beet greens, mustard greens, collard greens, raspberries, swiss chard, tomatoes, lemons and limes, spinach, asparagus, sea vegetables, fennel, sweet potatoes, winter squash, green peas, blueberries, cranberries, watermelon, green beans, summer squash, carrots, plum, garlic, basil, dill, romaine lettuce, potatoes, avocado, onions, banana, apple, pear, beets, leeks, apricot, celery, cucumber and peppermint (WHFoods, 2017).

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