

Role of Vitamin C and Vitamin E in Health and Disease

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Abstract

Vitamin C has antioxidant property. It is the component of plasma and extracellular fluids and so can control lipid peroxidation of cellular membranes, thus maintaining the redox integrity of cells. Vitamin C along with Zinc enhances the immunity of the body. It has therapeutic potential against neurodegenerative disease like Alzheimer's disease. It has effects on increasing incidence of respiratory infection caused by heavy physical stress. Deficiency of Vitamin C can lead to scurvy. Vitamin E, being an anti-inflammatory agent provides skin photo protective and anti photo aging properties. α -tocopherol is a Vitamin E has beneficial effects with regard to cardiovascular disease. Vitamin E protects PUFAs against oxidative damage. Vitamin E and C supplements protect against vascular dementia and improve the cognitive function in late life. A combination of α -tocopherol (Vitamin E) and Vitamin C reduces the histologic inflammation and fibrosis.

Keywords: Vitamin C ; Vitamin E ;antioxidant ;lipid peroxidation ; scurvy; ascorbic acid; immunity; dementia.

INTRODUCTION

Vitamin is an organic compound which is a vital nutrient required in limited amount. There are 13 vitamins which interact with our cell enzymes to regulate a variety of essential body functions. They play a major role in metabolic processes, and in building and maintaining bones, teeth, skin, blood and many other vital body tissues. They include Vitamin A, Vitamin B1 (Thiamin), Vitamin B2 (Riboflavin), Vitamin B3 (Niacin), Vitamin B5 (Pantothenic Acid), Vitamin B6 (Pyridoxine), Vitamin B9 (Folic acid, Folate), Vitamin B12 (Cobalamin), Vitamin C, Vitamin D, Vitamin E, Vitamin H (Biotin), Vitamin K. This review article will deal with the role played by Vitamin C and Vitamin E in health and in disease.

Vitamin C is micronutrient which is essential for normal metabolic functioning of the body. (1) Vitamin C is plentiful especially in citric fruits and vegetables. (2) A lack of vitamin C in the diet causes the deficiency disease scurvy. (3) Vitamin C, being water-soluble is an antioxidant in biological fluids (4,5) An antioxidant has been defined as "any substance that, when present at low concentrations compared to those of an oxidizable substrate (e.g., proteins, lipids, carbohydrates and nucleic acids), significantly delays or prevents oxidation of that substrate" (6). Vitamin C readily scavenges reactive oxygen and nitrogen species, like superoxide and hydroperoxyl radicals, aqueous peroxy radicals, singlet Oxygen, ozone, peroxy nitrite, nitrogen dioxide, nitroxide radicals, and hypochlorous acid (6), thus effectively protecting other substrates from oxidative damage. Vitamin C is predominantly found in the brain in neuron rich areas.

Vitamin E is the term given to a group of tocopherols and tocotrienols, of which α -tocopherol has the highest biological activity. Some of the important sources of Vitamin E include tomatoes, sweet potatoes, spinach, brussels, sprout, blackberries, mangoes, olive oil, sunflower oil, mackerel, and salmon. The antioxidant activity of vitamin E gives it the ability to prevent chronic diseases, especially those believed to have an oxidative stress component such as cardiovascular

diseases, atherosclerosis, and cancer. Vitamin E functions as a chain-breaking antioxidant that prevents the propagation of free radical reactions (7, 8, 9-12). Overt vitamin E deficiency occurs only rarely in humans and virtually never as a result of dietary deficiencies.

VITAMIN E

CHEMISTRY

Vitamin E can either exist as the tocopherol and tocotrienol structures. Both of these structures are similar except for the presence of double bond on the isoprenoid units of the tocotrienol.

About eight tocopherols are identified among which one form, α -tocopherol, is the most active form in nature (13), and has the highest biological activity regarding fetal resorption assays (14-16), and reverses vitamin E deficiency symptoms in humans (17-21). Tocopherols are basically the derivatives of 6-hydroxy chromane ring with three isoprenoid units which forms the side chain. Its antioxidant property is due to the presence of chromane ring.

BIOLOGICAL FUNCTIONS

Vitamin E acts as a chain-breaking antioxidant which plays a crucial role in preventing the propagation of free radical reactions (7, 8, 9-12). Attempts were made to compare α -tocopherol and α -tocotrienol in microsomal membrane systems and it was concluded that tocotrienols are better antioxidants when compared to tocopherols (22), but in more chemical systems they are said to be near equivalent (23,24). When α -tocopherol interrupts the peroxy radical, and as a result of which a lipid hydroperoxide (F2-isoprostanes) is formed from the free radical-mediated oxidation of arachidonic acid. Here arachidonyl hydroperoxide acts as the intermediate in F2-isoprostane formation (25, 26). Thus potentially, for every F2-isoprostane formed, an α -tocopherol has interrupted a peroxy radical. So, the effect of α -tocopherol as an antioxidant might be estimated from lipid peroxidation biomarkers. Elevated levels of lipid

peroxidation products are associated with numerous diseases and clinical conditions(27). Vitamin E is primarily found within the phospholipid bilayer of cell membranes. Another major biological role of Vitamin E is to protect PUFAs and other components of cell membranes and low-density lipoprotein (LDL) from oxidation by free radicals. Vitamin E inhibits platelet aggregation by inhibiting the production of prostaglandins. (28). Vitamin E also acts as an inhibitor of cellular proliferation. Kline and Sanders (29) showed that α -tocopheryl succinate inhibited T cell proliferation in the presence of a non specific esterase inhibitor. They also noted that other antioxidants do not inhibit proliferation. These results suggest that α -tocopheryl succinate may have specific and important antiproliferative effects. In addition to its role as a free-radical scavenger, Vitamin E at high intakes enhances the body's immune response. It also inhibits the conversion of nitrites to nitrosamines in the stomach (30). While the chromane group of Vitamin E is responsible for its antioxidant activity, the phytyl group largely determines the kinetics of transport to, and retention within, membranes. For example, addition of α -tocopherol in non peroxidizable dimyristoylphosphatidyl choline liposomes does not prevent the oxidation of either liposome containing polyunsaturated fatty acids (soybean lecithin) or rabbit red blood cells (31, 32). Animal studies have indicated that Vitamin E is depleted in case of cerebral ischemia and that vitamin E helps prevent peroxidative damage associated with ischemia and reperfusion (33, 34). Oxidative mechanisms are the major cause for development of cataract, which in turn is the leading cause of impaired vision and blindness in elderly people (35). Research has shown that Vitamin E delays or minimizes development of induced cataract and also has a protective effect against cataract formation induced by radiation, glucose, or galactose (36-38). Animal research has demonstrated the effectiveness of Vitamin E supplementation in inhibiting the elevation of free-radical concentrations related to arthritis (39). A study says that Vitamin E supplementation was significantly more effective than placebo in relieving pain (40). It also has a crucial association in reproduction as they prevent sterility due to the ability to reserve and maintain the germinal epithelium of gonads for their proper functioning. It also helps in storage of creatine in skeletal muscles and optimum absorption of amino acids from the intestine.

DEFICIENCY MANIFESTATIONS

Vitamin E deficiency symptoms was first reported in the 1960s (41) in various case studies of patients with abnormalities of lipoprotein and subsequently in fat malabsorption syndromes, but because these patients had malabsorption of other nutrients as well, especially long chain fatty acids, it was not clear which symptoms could be attributed to deficiency of Vitamin E. But later on the cause of this form of human Vitamin E deficiency was identified as a defect in the gene for the α -TTP (42, 43, 44). Neurologic findings in Vitamin E deficiency follow a particular pattern of

progression that can be considered as early and late stages. Early findings include hyporeflexia, decreased proprioception, decreased vibratory sense, distal muscle weakness, night blindness, and normal cognition. Whereas continued deficiency may lead to truncal and limb ataxia and diffuse muscle weakness. Further eye problems may also develop, including limited upward-gaze dissociated nystagmus (involuntary eye movement) and rarely Retinitis pigmentosa. Late manifestations include dysphagia and dysarthria, ophthalmoplegia, and possible blindness. Cognition may be affected in later stages, due to the condition of dementia. (45)

VITAMIN C

CHEMISTRY

Ascorbic acid is the major component of Vitamin C. L-ascorbic acid is a dibasic acid with a consists of an enediol group built into a heterocyclic lactone ring which is five membered. The chemical and physical properties of ascorbic acid are related to its structure (46, 47, 48). The ascorbic acid molecule consists of two asymmetric carbon atoms, at C-4 and C-5 (47).

Therefore, in addition to L-ascorbic acid, there are three other stereo isomers namely: D-ascorbic acid, D-isoascorbic acid, and L-isoascorbic acid. All these three isomers have very little or no antiscorbutic activity (49-53).

BIOLOGICAL FUNCTIONS

Vitamin C acts as a toxic pro-oxidant and this activity is transition metal-dependent due to its reduction potential. In the absence of enzymes, vitamin C reduces free Fe⁺³ and Cu⁺² to reactive forms Fe⁺² and Cu⁺¹, which then participate in the radical-producing Fenton reaction (54). Vitamin C also helps in prevention and treatment of Non Scurvy Diseases in human. Clinical trials of vitamin C supplementation have demonstrated a protective effect of vitamin C in cardiovascular diseases. In fact, no other antioxidant vitamin supplementation has been shown to affect the risk of cardiovascular diseases (55-57). Vitamin C is effective in protection against oxidative damage in tissues, and also suppresses the formation of carcinogens like nitrosamines (58). Many studies have shown that vitamin C intake is inversely related to incidence of cancer, due to its protective effects on the lung, breast, pancreas, stomach, cervix, rectum and oral cavity. (59). Vitamin C is involved in synthesis of corticosteroids and also in collagen and bone formation. It is a part of many metabolisms namely: Iron and hemoglobin, Tryptophan, Tyrosine, Folic acid and cholesterol. It is a component of the electron transport chain; also it enhances the synthesis of immunoglobulin and increases the phagocytic activity of white blood cells.

DEFICIENCY MANIFESTATIONS

Low levels of plasma vitamin C are seen in several conditions like increased oxidative stress, such as cancer, diabetes mellitus, cataract, HIV infection, smoking habits (60-62): It

has been reported that diabetic individual have low levels of vitamin C in the plasma and in the white blood cells, which constitute our immune defense.(63): Deficiency of vitamin C can cause anemia, scurvy, infections, bleeding gums,(64); Nutrient intake in relation to muscle degeneration, poor wound healing, atherosclerotic plaques and capillary hemorrhaging.

Neurotic disturbances consisting of hypochondriasis, hysteria and depression followed by decreased psychomotor performances have been reported in ascorbic acid deficiency (65).Vitamin C deficiency is commonly associated with gingivitis. Scurvy is a major disorder seen in Vitamin C deficiency.Serum ascorbic acid level becomes undetectable 41 days after the initiation of the Vitamin C .Depletion of cells is seen after 121 days, and the first skin lesions develop after 132 days. Dental abnormalities occur after 6 months. The collections of clinical symptoms are expressed after 1–3 months of a diet containing poor source of vitamin C. At such a stage the total body pool falls below 300 mg and the serum ascorbic acid level decreases below 2.5 mg/l (66–68). Hypertrophy and bleeding of the gums occur only in patients with teeth, especially in patients with poor dental status. Periodontal lysis is a late feature responsible for loosening of the teeth and eventually loss of teeth.According to Health Canada's food and nutrition guidelines, the normal requirement of vitamin

C is between 75 and 90 mg per day. Clinical manifestations of scurvy can be seen within 8 to 12 weeks of irregular or inadequate intake of Vitamin C. Characteristics of this disease include: spongy and sore gums, loose teeth, anemia, fragile blood vessels, swollen joints decreased immunocompetence, delayed wound healing, osteoporosis, etc. Most of these symptoms are seen in case of impairment in collagen synthesis.

CONCLUSION

Vitamin E and Vitamin C are powerful antioxidants. Further research may be done to evaluate the significance of these vitamins in health and disease.

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