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Vitamin C and Skin

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Abstract

Vitamin C (VC) is one of nine water-soluble vitamins. VC is known as ascorbic acid (AA), which is a reduced form of VC. AA plays some essential roles in the human body: (1) protecting skin against UV damage; (2) preventing hyperpigmentation of the skin; (3) improving skin inflammation and reducing photocarcinogenesis; (4) increasing collagen fiber; (5) reducing oxidative stress; and (6) immuno-modulating effects. AA deficiency affects collagen and vessels structure, wound healing and hemostasis, and scurvy. VC and AA are essential for life. We hope development of new medicines using VC or AA because of few adverse side effects of VC and AA.

Keywords: Vitamin C; Skin; Ascorbic acid; Pigmentation; Collagen fiber; Aging; Ultraviolet; Dermatoses

Introduction

There are 13 vitamins, nine of which are water-soluble, with the remaining four being lipid-soluble. Vitamin C (VC) is one of the water-soluble vitamins. The body weight of VC is 176.12, and its chemical structure, $C_6H_8O_6$, is shown in Figure 1.

VC localizes in the mitochondria, peroxisomes, and other subcellular compartments of tissues [1]. VC is absorbed *via* the gastrointestinal tract and enters the blood. The saturated concentration of VC is 400 mg/day, and this concentration is controlled by excretion through the kidneys, reuse in the living body, and absorption from the gastrointestinal tract.

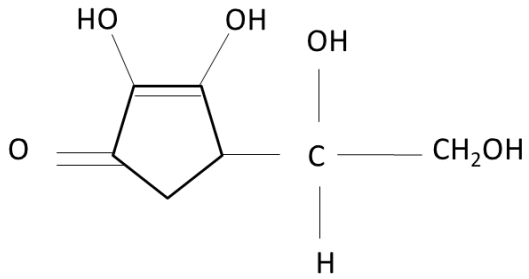

Figure 1: The structure of Vitamin C.

VC is known as ascorbic acid (AA), which is a reduced form of VC. There are four types of AA: (1) L-AA; (2) sodium L-ascorbate; (3) L-ascorbyl stearate; and (4) L-ascorbyl palminate. L-AA and sodium L-ascorbate are water-soluble compounds, and they are often used as enrichments, improving agents, and antioxidants in snacks and beverages. Because L-AA derivatives become L-AA in the skin after permeating through the stratum corneum, we apply these derivatives to skin whitening.

L-ascorbyl stearate and L-ascorbyl palminate are lipid-soluble compounds, and are used as enrichments and antioxidants in fat-soluble foods (batter, cheese and baby foods) or edible fat and oil.

AA deficiency affects collagen and vessels structure, wound healing and hemostasis, and scurvy. AA is related to the prevention or delay of certain organ disorders, including reducing the incidence of age-related cataracts [2], ameliorating atherosclerosis (early stage) [3], and decreasing the risk of diabetes mellitus [4]. AA plays some essential roles in the human body: (1) protecting skin against UV damage; (2) preventing hyperpigmentation of the skin; (3) improving skin inflammation and reducing photocarcinogenesis; (4) increasing collagen fiber [5,6]; (5) reducing oxidative stress [5,7]; and (6) immuno-modulating effects.

Protect skin against UV damage

UV radiation leads to skin damage due to free radical oxygen [8,9]; such events are related to activation protein-1, growth factor–beta, and nuclear factor–B [10]. These factors trigger the collapse of collagen structure in the skin, resulting in wrinkles, solar elastosis, and coarse texture [11].

VC inhibits such sun-damage-related factors. Farris [12] reported that VC inhibited the biosynthesis of elastin fiber. UV decreased VC of the skin, but topical VC reduced UVB damage in mouse skin [13]. VC modified skin structure and ultrastructure from photo-damaged skin [14]. Skin disorders due to UV damage may increase due to the decreasing ozone layer; thus, we should intake VC or AA as protection against UV.

Prevent skin hyperpigmentation

Skin hyperpigmentation is observed with inflammation, injury, and aging. Keratinocytes release many melanin granules by stimulating inflammatory mediators. This melanin deposits in the epidermis, and some drips into the dermis and then into macrophage phagocytes (melanophage).

There are two types of melanin, oxidized and reduced. The roles of VC or AA are to reduce deep or dark colored (oxidized hyperchromic) melanin to colorless (achromasia) reduced melanin. L-AA or AA act at the tyrosinase active site and reduce oxidized dopaquinone in the melanin synthetic pathway [15,16]. From these, we use VC or AA for skin whitening by intake and/or iontophoresis. The disadvantage of VC and AA is their lack of fast-acting properties.

Improve skin inflammation and reduce photocarcinogenesis

AA is decreased in patients with cancer or inflammation, and Patterson [17] and Block [18] showed that VC-rich foods protect against the development of cancer. There have been reports of intravenous VC therapy used to inhibit angiogenesis [19], at toxicity against cancer cells [20], and as treatment for cancer [21]. High-dose AA acts as a free radical scavenger to kill cancer cells [22].

UV radiation causes skin inflammation, induces p53 gene mutation, and affects the repair of damaged DNA and apoptosis [12]. These events could lead to photocarcinogenesis, but VC reduces this risk [23]. VC decreased pro-inflammatory mediators, resulting in improved wound healing [24]. VC affects fibroblast proliferation and migration, and could shorten healing time in wounds [25,26]. High doses of VC or AA applied topically and/or by injection to the carcinoma or inflammation site may be effective.

Increase collagen fiber

VC aids production and stabilization of collagen synthesis [27]. The role of VC is to accelerate transcription of the collagen gene and/or stabilize collagen-mRNA *in vitro* [28,29]. VC is a fundamental factor in collagen fiber synthesis [6].

Philippe [14] reported that topical AA may activate dermal synthesis of elastic fibers. Sheldon [6] found that AA played essential roles in collagen production *via* hydroxylation of lysine and proline. Hydroxyproline and hydroxylysine are necessary for collagen helix formation and collagen cross-link formation, respectively [6]. Intake of VC or AA increased collagen fiber and consequently, decreased wrinkles.

VC promotes fibroblast proliferation for remodeling of skin tissue in wound healing [30]. The dysfunction or breaking of the skin barrier causes infection or invasion by foreign substances, and results in dermatoses or infection. VC is an essential factor of the epithelial barrier, and affects the skin barrier function by elevating the lipid synthesis of the skin barrier [31,32]. VC acts to produce and stabilize collagen synthesis [27]. Ponec [33] reported that VC plays important roles in reconstructed skin for the skin barrier of the stratum corneum. VC protects human tissue as a free-radical scavenger against various pollutants, superoxide, heavy metals, and chemical substances [34-36].

Reduce oxidative stress

We are exposed many oxidative stresses: UV, radiation, smoking, oxidative foods, ischemic conditions, physiological stress, physical stress, and others. These stresses increase active oxygen in the tissue, and this oxygen causes impairment of deoxyribonucleic acid (DNA), degeneration of proteins, deactivation of enzymes, and an excess of oxidative lipids. In turn, these alterations result in ischemic diseases or cancer.

The epidermis could be exposed to more foreign oxidant stress than the dermis, because the concentration of antioxidant molecules in the epidermis is higher than in the dermis, and the capacity of antioxidants in the epidermis is greater than that of the dermis [8,37]. VC is an antioxidant molecule [38] and reduces antioxidant stress. Nusgens [5] reported that an increase of VC could offer protection from free radicals.

The activity of VC is enhanced by vitamin E (VE) [39], and these vitamins are non-enzymatic antioxidant molecules. Murray [23] and Lin [40] reported that a topical solution of VC and VE added ferulic acid to protect from oxidative stress. There are two types of antioxidants, water-soluble and lipid-soluble. Water-soluble antioxidants in plasma include AA, glutathione, uric acid, pyruvate, glucose and bilirubin; the lipid-soluble antioxidants are lycopene, -carotene, alpha-tocopherol, ubiquinol-10, zeaxanthin and lutein [8]. Intake of antioxidants is more essential to protect against aging than elimination of active oxygen. One rule of VC is improvement of skin barrier against oxidative stress and/or foreign-body invasion.

Immuno-modulating effects

AA and VC are necessary against infection *via* the skin, in neutrophils/macrophages and the skin barrier. AA could possess immune-cell modulating effects [41]. VC enhances chemotaxis, the phagocytes of neutrophils, and uptake or clearance of macrophages [42]. VC plays important roles in the differentiation and maturation of immature T-cells [43] and natural killer cells [44]. It improved neutrophil chemotaxis [45-49], and in combination with VE, enhanced neutrophil functions, including chemotaxis [50]. Johnston proposed that the antihistamine effect of vitamin C was correlated with enhanced chemotaxis [51].

Other roles of VC against neutrophils include phagocytosis, microbial destruction, and oxidant generation [52]. Topical VC can prevent to decrease the number of CD-1a Langerhans cells in the skin due to UV exposure [52,53]. It is interesting that VC decreased histamine levels of allergic disease compared with infection in human studies [54,55]. VC may improve delayed hypersensitivity reactions and itching in dermatoses.

Conclusion

Vitamin C or Ascorbic Acid is essential for life. There are few adverse effects of Vitamin C or Ascorbic Acid and development of new medicines using Vitamin C or Ascorbic Acid should be pursued.

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