

# The Skin Benefits of Topical Vitamin C

Vitamin C is a naturally occurring vitamin and antioxidant. It is the most abundant antioxidant in human skin [1]. Most plants and animals are able to synthesize vitamin C from glucose. However, humans lack the enzyme L-glucono-gamma lactone oxidase required for its synthesis [2]. Therefore, they must acquire it from natural sources such as citrus fruits and leafy green vegetables. Vitamin C deficiency causes Scurvy and the word “Ascorbus” means “no Scurvy”. Traditionally, vitamin C-rich foods like lemons were carried by sailors on long journeys to avoid Scurvy, which is a disease of bleeding gums caused by reduced collagen synthesis leading to connective tissue and blood vessel fragility. In 1937, Dr. Albert Szent Goyrgi was awarded the Nobel Prize for his work in isolating the vitamin C molecule from red peppers and identifying its role in Scurvy [3].

## Topical Vitamin C vs. Oral Vitamin C

The absorption of oral vitamin C through the small intestine is limited by an active transportation mechanism and, therefore, a finite amount of the drug is absorbed despite high oral doses [4]. In addition, the bioavailability of vitamin C in the skin is inadequate when it is administered orally [5,6]. Topical application of ascorbic acid will cross the epidermis into the underlying dermis because of its low molecular weight. In addition, formulations with a pH of 3.5 or less aid in the absorption of ascorbic acid, mainly due to the transformation from the charged to the uncharged form of the molecule [7]. For all of these reasons, topical vitamin C is used to benefit the skin.

## Vitamin C Levels in Skin

Vitamin C is a normal skin constituent that is found at high levels in both the dermis and epidermis [8,9]. Aging, however, causes a decline in vitamin C content in the skin [9]. In one study, intrinsically aged skin was shown to have 70% less concentration of several antioxidants including L-ascorbic acid compared with young skin [10]. In addition, exposure to oxidative stress via UV radiation, pollution and smoking can further lower vitamin C content [11].

## Vitamin C is an Antioxidant

Vitamin C is the most abundant antioxidant in human skin. Being water-soluble, it protects aqueous compartments of the cell from reactive oxygen species (ROS)[4].

When the skin is exposed to UV light, ROS such as the superoxide ion, peroxide and singlet oxygen are generated. Vitamin C protects the skin from oxidative stress by sequentially donating electrons to neutralize free radicals. The oxidized forms of vitamin C are relatively non-reactive [4]. Furthermore, they can be converted back to vitamin C by the enzyme dehydro ascorbic acid reductase in the presence of glutathione if they have not further degraded.

## Vitamin C and Photoprotection

Sunscreens prevent UV-induced erythema and thymine dimer mutations that contribute to skin cancer. However, sunscreens only block 55% of the free radicals produced by UV exposure. To optimize UV protection, it is important to use sunscreens combined with topical antioxidants. Vitamin C does not absorb UV light but rather exerts a UV-protective

effect by neutralizing free radicals. In laboratory studies, 10% topical vitamin C showed a statistical reduction of UVB-induced erythema by 52% and sunburn cell formation by 40 to 60% [4].

## Vitamin C and Vitamin E

Although vitamin C on its own provides antioxidant and photoprotection, it works best in conjunction with vitamin E, which potentiates the action of vitamin C four-fold [12,13]. Hydrophilic vitamin C also helps to regenerate vitamin E, a lipophilic antioxidant [4,5,14]. Thus, vitamin C and vitamin E work together to protect the hydrophilic and lipophilic compartments of the cell.

## Vitamin C and Collagen Synthesis

Vitamin C is essential for collagen production. It increases type 1 and 3 pro-collagen messenger RNA levels in fibroblasts [5,6]. Vitamin C is also required for the cross linking of collagen fibres into its strong rope-like triple helix structure [15]. Vitamin C acts as a co-factor for the enzymes prolyl and lysyl hydroxylase, which are responsible for stabilizing and cross-linking the collagen molecules [6].

Topical L-ascorbic acid in concentrations between 5 and 15% has an anti-aging effect by inducing the production of collagen-1, and collagen-3, as well as enzymes important for the production of collagen, and inhibitors of matrixmetalloproteinase 1 (MMP 1/collagenase 1) [16,17].

One double-blind placebo-controlled study on 10 subjects using 10% topical L-ascorbic acid over a 12-week period showed a statistically significant reduction in photoaged scores and improvement in wrinkling in the vitamin C treated patients compared with the placebo group [18]. A significant improvement in wrinkles on skin histology and clinical appearance was also seen in another double-blind, placebo-controlled study using 5% topical vitamin C on 20 subjects over a 6-month period [19].

## Vitamin C and Melanogenesis

Vitamin C decreases melanin production by interacting with copper ions at the tyrosinase-active site, which inhibits the action of the enzyme tyrosinase [20]. A clinical study that examined the effect of a topical formulation containing 5% vitamin C and a penetration enhancer reported a significant decrease in pigmentation caused by melasma after 16 weeks [21].

### Vitamin C and Inflammation

Vitamin C inhibits NFκB (nuclear factor kappa light chain enhancer of activated B cells), which is responsible for the production of a number of pro-inflammatory cytokines such as TNF-α, IL1, IL6 and IL8 [4,6]. Therefore, vitamin C has anti-inflammatory activity and can be used in conditions such as acne, rosacea and post-inflammatory hyperpigmentation [4,6].

### Vitamin C and Immune Function

Vitamin C contributes to immune defense by supporting various cellular functions. Vitamin C supports epithelial barrier function against pathogens and protects against free radicals. Vitamin C accumulates in phagocytic cells, such as neutrophils, and can enhance chemotaxis, phagocytosis and microbial killing. It is also needed for apoptosis and clearance of the old neutrophils from sites of infection by macrophages. Vitamin C deficiency results in impaired immunity and a higher susceptibility to infections [22].

### L- vs. D- Ascorbic Acid

Ascorbic acid molecules have a D- or L- rotation. In nature, you will find equal parts of L- and D-ascorbic acid. L-ascorbic acid is the bioactive form of vitamin C, which describes this nutrient's ability to affect target tissues. In many products, vitamin C is found as a racemic mixture of D- and L- ascorbic acid together. However, D- ascorbic acid is only equal to L-ascorbic acid from an antioxidant standpoint.

### Other Forms of Vitamin C

Other forms of vitamin C including tetrahexyldecyl ascorbate and magnesium ascorbyl phosphate are not recognized by the body and must be converted to L-ascorbic acid by the skin in order for them to be used. The efficiency of this conversion is not known. L-ascorbic acid is the most biologically active and well-studied form of vitamin C [4].

### Stability and Purity

Vitamin C serums are inherently unstable. When exposed to air or light, the L-ascorbic acid oxidizes and the serum turns an orange or brownish colour. Vitamin C serums should be clear to straw coloured for optimal effectiveness. The stability of L-ascorbic acid is optimized by maintaining a pH of 3.5 or less. In addition, at this pH, the ionic charge on the molecule is removed and it is transported well across the stratum corneum [7].

The purity of L-ascorbic acid, the formulation and the packaging also affect the rate of oxidation. USP stands for United States Pharmacopeia, which is the highest pharmaceutical standard of purity. Vitamin C serums are often sold in amber bottles to help protect the vitamin C from light.

### What makes oxidized ascorbic acid turn yellow/orange/brown?

When L-ascorbic acid (LAA) oxidizes, it turns into Dehydroascorbic Acid (DHAA) as an initial step. At this point, DHAA can convert back into LAA via an enzymatic reaction, which requires the antioxidant amino acid, L-glutathione. However, any oxidation beyond DHAA, cannot be converted back to LAA.

Ascorbic acid inherently contains a ring formation, as does DHAA (Figure 1). As long as the ring formation is preserved, ascorbic acid in water will remain clear. However, over time ascorbic acid degrades (oxidizes) into linear molecules 2,3-diketo-L-gluconic acid (DKG), L-xyloic acid and L-lyxonic acid. Further degradation of DKG results

in L-xylose (Figure 2), oxalic acid and L-threonic acid. As these linear molecules are formed, the solution turns from clear to yellow and eventually orangey-brown.

These linear molecules no longer possess any antioxidant, brightening or collagen-stimulating power. They are not efficacious for the skin but they are not dangerous either, except for oxalic acid. Time in water determines the amount of oxalic acid that is formed. Oxalic acid is one of the strongest organic acids and prolonged skin contact can be harmful causing burns. The Environmental Working Group (EWG) gives oxalic acid a hazard rating of 4.

Figure 1: Ascorbic acid illustrating its ring formation

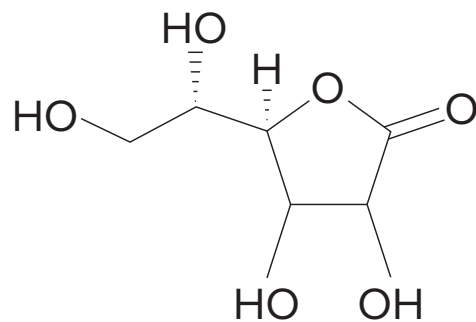
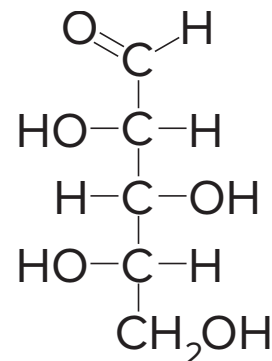


Figure 2: L-xylose showing its linear formation



### Using Vitamin C

Applying vitamin C to the skin can be 20 times more effective than taking it orally. Apply once daily after cleansing in the morning to utilize vitamin C's antioxidant and photoprotective properties. Use vitamin C and E together for increased antioxidant protection.

AlumierMD vitamin C products are specifically formulated to maximize their efficacy and stability delivering pure USP grade L-ascorbic acid to the skin.

EverActive C&E is a potent antioxidant serum to reduce the visible signs of aging for all skin types. A unique delivery system ensures the vitamin C complex is always optimally active. Many vitamin C serums oxidize in their bottles, turning a brownish color while they are on the shelf or at home. When oxidized, the vitamin C is no longer helpful for the skin. EverActive C&E is fresh because you only mix the vitamin C into the serum when you're ready to use it.

Vitamin Rich Smoother is a powerful multitasker that works as a primer by smoothing skin texture and delivering anti-aging vitamins C and E. This formulation is the perfect base for makeup; its silky consistency evens out skin texture, minimizes the appearance of fine lines and wrinkles, and leaves skin looking and feeling smooth.

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