

## VITAMIN C

Vitamin C, also known as L-ascorbic acid, is a water-soluble vitamin that is naturally present in some foods. Vitamin C is also involved in protein metabolism [1,2].

- Collagen is an essential component of connective tissue, which plays a vital role in **wound healing**.
- Vitamin C is also an important **physiological antioxidant** [3] and has been shown to regenerate other antioxidants within the body, including alpha-tocopherol (vitamin E) [4].
- Ongoing research is examining whether vitamin C, by limiting the damaging effects of free radicals through its antioxidant activity, might help **prevent or delay the development of certain cancers, cardiovascular disease**, and other diseases in which oxidative stress plays a causal role.
- Vitamin C plays an important role in **immune function** [4] and improves the **absorption of nonheme iron** [5], the form of iron present in plant-based foods.
- Insufficient vitamin C intake causes **scurvy**, which is characterized by fatigue or lassitude, widespread connective tissue weakness, and capillary fragility [1,2,4,6-9].



## WOUND HEALING

The major function of [vitamin C](#) (ascorbic acid) in wound healing is **assisting in the formation of collagen**, the most important protein of connective tissue. Vitamin C, a water-soluble **vitamin** found in water-filled foods, dissolves in water and is transported in the bloodstream.

Excess amounts are excreted in the urine; however, since the body does not store vitamin C, food sources should be consumed on a regular basis. **Vitamin C deficiency is manifested by decreased collagen synthesis, which can result in delayed healing and capillary fragility. Wounds may fail to heal because scar tissue doesn't form. Ascorbic acid deficiency is also associated with impaired immune function, which can decrease the ability to fight infection.**

Vitamin C supplementation has been shown to **increase tensile strength and collagen synthesis by assisting in the hydroxylation of lysine and proline, major constituents of collagen.**

## Groups at Risk of Vitamin C Inadequacy

### ***Smokers and passive “smokers”***

Studies consistently show that smokers have lower plasma and leukocyte vitamin C levels than nonsmokers, due in part to increased oxidative stress [8]. For this reason, the IOM concluded that smokers need 35 mg more vitamin C per day than nonsmokers [8]. Exposure to secondhand smoke also decreases vitamin C levels. Although the IOM was unable to establish a specific vitamin C requirement for nonsmokers who are regularly exposed to secondhand smoke, these individuals should ensure that they meet the RDA for vitamin C [4,8].

### ***Infants fed evaporated or boiled milk***

Most infants in developed countries are fed breastmilk and/or infant formula, both of which supply adequate amounts of vitamin C [8,16]. For many reasons, feeding infants evaporated or boiled cow’s milk is not recommended. This practice can cause vitamin C deficiency because cow’s milk naturally has very little vitamin C and heat can destroy vitamin C [6,12].

### ***Individuals with limited food variety***

Although fruits and vegetables are the best sources of vitamin C, many other foods have small amounts of this nutrient. Thus, through a varied diet, most people should be able to meet the vitamin C RDA or at least obtain enough to prevent scurvy. People who have limited food variety—including some elderly, indigent individuals who prepare their own food; people who abuse alcohol or drugs; food faddists; people with mental illness; and, occasionally, children—might not obtain sufficient vitamin C [4,6-9,11].

***People with malabsorption and certain chronic diseases***

Some medical conditions can reduce the absorption of vitamin C and/or increase the amount needed by the body. People with severe intestinal malabsorption or cachexia and some cancer patients might be at increased risk of vitamin C inadequacy [29]. Low vitamin C concentrations can also occur in patients with end-stage renal disease on chronic hemodialysis [30].

## **Vitamin C and Health**

Due to its function as an antioxidant and its role in immune function, vitamin C has been promoted as a means to help prevent and/or treat numerous health conditions. This section focuses on four diseases and disorders in which vitamin C might play a role: cancer (including prevention and treatment), cardiovascular disease, age-related macular degeneration (AMD) and cataracts, and the common cold.

***Cancer prevention***

Most case-control studies have found an inverse association between dietary vitamin C intake and cancers of the lung, breast, colon or rectum, stomach, oral cavity, larynx or pharynx, and esophagus [2,4]. Plasma concentrations of vitamin C are also lower in people with cancer than controls [2].

### ***Cancer treatment***

Oral administration of vitamin C, even of very large doses, can raise plasma vitamin C concentrations to a maximum of only 220 micromol/L, whereas **IV administration can produce plasma concentrations as high as 26,000 micromol/L [49,50]. Concentrations of this magnitude are selectively cytotoxic to tumor cells in vitro [1,69].** Research in mice suggests that pharmacologic doses of IV vitamin C might show promise in treating otherwise difficult-to-treat tumors [51]. A high concentration of vitamin C may act as a pro-oxidant and generate hydrogen peroxide that has selective toxicity toward cancer cells [51-53]. Based on these findings and a few case reports of patients with advanced cancers who had remarkably long survival times following administration of high-dose IV vitamin C, some researchers support reassessment of the use of high-dose IV vitamin C as a drug to treat cancer [3,49,51,54].

### ***Cardiovascular disease***

Vitamin C has been shown to reduce monocyte adherence to the endothelium, improve endothelium-dependent nitric oxide production and vasodilation, and reduce vascular smooth-muscle-cell apoptosis, which prevents plaque instability in atherosclerosis [2,59].

### ***Age-related macular degeneration (AMD) and cataracts***

AMD and cataracts are two of the leading causes of vision loss in older individuals. Oxidative stress might contribute to the etiology of both conditions. Thus, researchers have hypothesized that vitamin C and other antioxidants play a role in the development and/or treatment of these diseases.

High dietary intakes of vitamin C and higher plasma ascorbate concentrations have been associated with a lower risk of cataract formation in some studies [2,4].

### ***The Common Cold***

In trials involving marathon runners, skiers, and soldiers exposed to extreme physical exercise and/or cold environments, prophylactic use of vitamin C in doses ranging from 250 mg/day to 1 g/day reduced cold incidence by 50%. In the general population, use of prophylactic vitamin C modestly reduced cold duration by 8% in adults and 14% in children. When taken after the onset of cold symptoms, vitamin C did not affect cold duration or symptom severity.

Overall, the evidence to date suggests that regular intakes of vitamin C at doses of at least 200 mg/day do not reduce the incidence of the common cold in the general population, but such intakes might be helpful in people exposed to extreme physical exercise or cold environments and those with marginal vitamin C status, such as the elderly and chronic smokers [83-85]. The use of vitamin C supplements might shorten the duration of the common cold and ameliorate symptom severity in the general population [82,85], possibly due to the anti-histamine effect of high-dose vitamin C [86]. However, taking vitamin C after the onset of cold symptoms does not appear to be beneficial [83].

## Health Risks from Excessive Vitamin C

Vitamin C has low toxicity and is not believed to cause serious adverse effects at high intakes [8].

The most common complaints are:

- diarrhea
- nausea
- abdominal cramps
- and other gastrointestinal disturbances due to the osmotic effect of unabsorbed vitamin C in the gastrointestinal tract [4,8].

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