Vitamin C (Ascorbic acid)

Sources and Physiological Functions

Vitamin C, a water-soluble vitamin, is a collective term that refers to L-ascorbic acid (functional form of the vitamin), dehydro-L-ascorbic acid (oxidized form), and monodehydro-L-ascorbic acid (free radical form). More than 95% of vitamin C in human plasma exists as ascorbic acid (Jacob 1990). The most abundant dietary sources of vitamin C are orange juice, grapefruit juice, peaches, sweet red peppers, and papayas, followed by a variety of other fruits, vegetables, and fortified cereals. Vitamin C is a powerful antioxidant and a cofactor in various reduction reactions (Institute of Medicine 2000). It is a known electron donor for at least eight human enzymes involved in the hydroxylation of collagen and the biosynthesis of carnitine, hormones, and amino acids. Humans and a few other mammals, such as monkeys and guinea pigs, are unable to biosynthesize vitamin C from glucose and must obtain the vitamin from outside sources.

Approximately 70%–90% of the ascorbic acid consumed is absorbed by the human body at usual intakes of 30–180 milligrams per day (mg/d). Bioavailability of vitamin C from food or supplemental sources is equivalent. Vitamin C administered after the plasma has reached a point of saturation (approximately 70 µmol/L) will likely be excreted as unmetabolized ascorbic acid in the urine (Institute of Medicine 2000).

Health Effects

The clinical manifestation of vitamin C deficiency is scurvy, which can occur if intake is below 10 mg/d for many weeks. Important signs and symptoms of scurvy include coiled hairs, follicular hyperkeratosis, fatigue, bleeding gums, and delayed wound-healing (Institute of Medicine 2000). Too much vitamin C can cause gastrointestinal upset, which is generally seen only at an intake exceeding 2 gram/d and usually disappears within one to two weeks of discontinuation. High intakes of vitamin C supplements have the potential to increase urinary oxalate excretion, which is a risk factor for the formation of calcium oxalate kidney stones, but evidence is conflicting (Institute of Medicine 2000).

Vitamin C, in combination with other supplements, including vitamin E, zinc, and *beta*-carotene, has been shown to slow the progression of age-related macular degeneration. However, no effect was seen for the development or progression of age-related lens opacities (Age-Related Eye Disease Study Research Group 2001a and 2001b). The role of vitamin C in disease prevention and its therapeutic potential has been reviewed (Alberts 2025). There is conflicting evidence for the reduction of risk of cardiovascular disease (CVD) mortality by vitamin C supplementation and its effect on cardiovascular health in general (Shekelle 2003). A Mendelian randomization study found no association between genetically predicted blood concentrations of vitamin C and CVD events, suggesting that vitamin C supplementation may not help prevent CVD (Zhu 2021). Another Mendelian randomization study found an association between plasma vitamin C and the risk of cardioembolic stroke, but no association with other CVD events (Chen 2021). The role of vitamin C in the prevention and treatment of cancer is an ongoing area of research (Villagran 2021). A Mendelian randomization study showed no evidence of a causal association of plasma vitamin C with any of the cancers studied (lung, breast, prostate, colon, and rectal) in European populations (Fu 2021).

Intake Recommendations

The recommended dietary allowance (RDA) of vitamin C for adults is 120% of the EAR (estimated average requirement), which was determined by the maximally protective neutrophil vitamin C concentration. For men, this equates to 90 mg/d, with 75 mg being the appropriate daily amount for women (Institute of Medicine 2000). RDAs range from 15–25 mg/d for children ages 1–8 years, 45–75 mg/d for boys ages 9–18 years, and 45–65 mg/d for girls ages 9–18 years. For infants ages 0–12 months, the adequate intake (AI) is set at the amount of vitamin C commonly received through regular breastfeeding and the additional amount obtained through solid foods during the 7–12 month period (an average of 45 mg/d). A number of factors, such as bioavailability, interactions with other nutrients, smoking status, age, and gender, affect the amount of vitamin C required by humans. For example, people who smoke require an additional 35 mg/d of vitamin C due to the increased ascorbic acid needed to repair oxidant damage (Institute of Medicine 2000).

Biochemical Indicators and Cutoff Values

Vitamin C status can be assessed by measuring total ascorbic acid (oxidized and reduced) in serum or plasma, buffy-coat, or leukocytes. Ascorbic acid in plasma is considered an index of the circulating vitamin available to tissues, and in leukocytes (particularly polymorphonuclear) it is believed to be a good indicator of tissue stores. Vitamin C deficiency is generally defined as plasma or serum concentrations less than 11.4 micromoles per liter (µmol/L), or the level at which signs and symptoms of scurvy may appear. Serum ascorbic acid concentrations between 11.4–23 µmol/L are considered low (Gibson 2005).

Analytical Methods

High-performance liquid chromatography (HPLC) methods with electrochemical detection, which provide necessary sensitivity and specificity, are generally used to quantitate serum vitamin C concentrations. Older spectrophotometric assays were susceptible to interferences from a number of substances, such as riboflavin and aspirin. The National Institute of Standards and Technology (NIST) multilevel standard reference material (SRM 970 Ascorbic acid in frozen human serum) is no longer commercially available. NIST has hosted inter-laboratory comparison studies directed at assuring high-quality measurements of serum vitamin C, but the studies have not yet been part of their Clinical Measurements Quality Assurance Program (ClinQAP).

Clinical laboratories generally use International System of units (SI) for vitamin C (µmol/L), but some use conventional units (mg per deciliter [mg/dL]). The conversion factor from SI to conventional units is 1 µmol/L = 0.0176 mg/dL.

Findings from NHANES

The National Health and Nutrition Examination Survey (NHANES) is the only source for nationally representative data on vitamin C for the U.S. population since 1976 (Pfeiffer 2026a). An analysis of 2003–2004 data from the National Health and Nutrition Examination Survey (NHANES) showed that children and older persons had the highest serum concentrations of vitamin C (Schleicher 2009). Mean concentrations among adult smokers were one-third lower than those of nonsmokers. The prevalence of vitamin C deficiency was significantly lower than that during NHANES III, but smokers and low-income persons were among those at increased risk of deficiency (Schleicher 2009). A newer analysis of serum vitamin C concentrations in NHANES 2017–2018 showed that the vitamin C status of the U.S. population has remained stable (Powers 2023; Pfeiffer 2026b). However, vitamin C deficiency remained high for those with low dietary intake and among people who smoke (Powers 2023).

A multiple regression analysis of NHANES 2003–2006 showed that sociodemographic (age, education, income, race and Hispanic origin, and sex) and lifestyle (alcohol consumption, body mass index, dietary supplement use, physical activity, and smoking) variables together explained 22% of serum vitamin C variability (Pfeiffer 2013). Age, sex, and race and Hispanic origin differentials in serum vitamin C concentrations observed in crude univariate analysis remained significant after adjusting for sociodemographic and lifestyle variables. Use of dietary supplements and smoking were important correlates of serum vitamin C (Pfeiffer 2013). A second multiple regression analysis of NHANES 2003–2006 showed that after controlling for demographic variables, smoking, supplement use, fasting, inflammation, and renal function, fasting was associated with significantly higher (3.4%) and inflammation with significantly lower (-8.2%) vitamin C concentrations. Impaired renal function was not associated (Haynes 2013). Pregnancy (in women ages 20–49 years) was associated with significantly higher (3.8%) vitamin C concentrations (Haynes 2013). A third multiple regression analysis of NHANES 2003–2006 evaluated sociodemographic, lifestyle, and physiologic factors as potential confounders or effect modifiers of the relationship between biomarker and intake. The investigation demonstrated that dietary supplement use explains more variance in serum vitamin C concentrations than 24-hour dietary intake from food only (Sternberg 2026).

For more information about vitamin C, see the Institute of Medicine's Dietary Reference Intake reports (Institute of Medicine 2000) and fact sheets from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/factsheets/VitaminC_pf.asp).

Data in the 2026 tables

Data presented are from univariate analysis that was not adjusted for demographic variables (e.g., age, sex, race and Hispanic origin) or other blood concentration determinants (e.g., dietary intake, supplement use, smoking, BMI). Data for serum vitamin C were available from three NHANES cycles (2003–2004, 2005–2006, and 2017–2018) for persons ages 6 years and older and were generated using an HPLC method with electrochemical detection (McCoy 2005). Because of the incorporation of an internal standard, this method had more accuracy and precision than the method used during NHANES III (1988–1994).

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