

Vitamin C

Physiological Functions

Vitamin C (ascorbic acid) is a water-soluble antioxidant that is responsible for maintaining iron in its reduced state thus preserving activity of the hundreds of enzymes that contain iron at the catalytic site. The most well-documented of these enzymes are the iron-containing prolyl and lysyl hydroxylases that catalyze the post-translational hydroxylation of proline and lysine. Hydroxyproline and hydroxylysine provide sites for cross-linking of collagen fibrils responsible for tensile strength and elasticity in connective tissue. Tissues most sensitive to Vitamin C status are those which contain large amounts of collagen such as blood vessels and capillaries, bone, and scar tissue. Vitamin C dependent reactions cover a broad range of functions that include phagocytic activity, neurotransmitter synthesis, and hepatic production of bile from cholesterol.

Vitamin C extends vitamin E activity by reducing oxidized tocopherol so that it may again function as an antioxidant. It also improves bioavailability of inorganic dietary iron by maintaining the reduced form which is more soluble and readily absorbed.

Consumption of more than 100 mg vitamin C daily in supplement form may reduce the severity and duration of colds when consumed with onset of symptoms.

Factors Affecting Availability

Vitamin C is sensitive to destruction by exposure to light, heat, air, or prooxidant minerals such as iron or copper. To maximize vitamin C content of dietary sources, these foods should be stored in sealed containers under refrigeration and prepared by methods requiring low temperatures and minimal cooking time. Addition of acidic cooking liquids should be avoided.

Deficiency

Vitamin C is labeled ascorbic acid because it was initially identified as the anti-scorbutic factor missing in the diets of sailors who did not have access to fresh fruits and vegetables while away at sea. Scurvy is the clinical expression of vitamin C deficiency disease which is observed within 45-80 days of consuming inadequate amounts of the vitamin. Signs and symptoms of scurvy include lesions in mesenchymal tissues that contribute to impaired wound healing, edema and hemorrhage. Connective tissue is also weakened by poorly formed collagen. This defect accounts for gingival bleeding and petichiae (pin-point bruising) which occur early in a vitamin C deficiency because weakened capillary membranes cause blood to seep into interstitial spaces. Signs of advanced vitamin C deficiency include tooth loss, muscular atrophy, lethargy, and fatigue.

Marginal vitamin C intakes may be responsible for increased susceptibility to infections and contribute to elevations in serum cholesterol levels. Smokers have lower serum levels of vitamin C due to increased demands for antioxidants to counter free radical damage produced as byproducts of smoking tobacco products. To maintain serum vitamin C levels in smokers, 100 mg of vitamin C daily is required.

Toxicity

Limited evidence suggests that intakes of vitamin C of 1000 mg daily or greater may produce toxic effects. In addition, gastrointestinal symptoms, especially diarrhea, may develop when intakes are excessive. When high intakes of vitamin C are consumed over long periods, the plasma level associated with appearance of the vitamin in the urine (renal threshold) is lowered to eliminate excess vitamin once tissue saturation levels have been achieved. Consequently, changing from high to low doses should be made gradually to avoid precipitation of a deficiency resulting from high urinary levels.

- ❖ *The upper limit of safety for daily vitamin C intake established by the Food and Nutrition Board of the Institute of Medicine is approximately 1,000 mg for adults. See table below for age-specific guidelines.*

Vitamin C Tolerable Upper Intake Levels	
Life Stage	Vitamin C (mg/day)
Infants	
0-6 mo	N/A
7-12 mo	N/A
Children	
1-3 y	400
4-8 y	650
Males, Females	
9-13 y	1200
14-18 y	1800
19-70 y	2000
70 y	2000
Pregnancy	
< 18 y	1800
19-50 y	2000
Lactation	
< 18 y	1800
19-50 y	2000

Requirements

The Daily Reference Intakes (DRI) for vitamin C are found in the table below.

Life Stage	Vitamin C
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	(mg)
Infants	
0-6 mo	40
7-12 mo	50
Children	
1-3 y	15
4-8 y	25
Males	
9-13 y	45
14-18 y	75
19-30 y	90
31-50 y	90
51-70 y	90
70 y	90
Females	
9-13 y	45
14-18 y	65
19-30 y	75
31-50 y	75
51-70 y	75
70	75
Pregnancy	
18 y	80
19-30 y	85
31-50 y	85
Lactation	
18 y	115
19-30 y	120
31-50 y	120

Dietary Sources

Vitamin C is found only in foods of plant origin. Fruits and vegetables are the best sources. See table for a detailed listing of vitamin C.

Dietary Sources of Vitamin C	
FOOD	Vitamin C (mg)
Orange juice, fresh, 1 cup	124
Orange juice, frozen, diluted can, 1 cup	97
Grapefruit juice, fresh, 1 cup	94
Papaya, fresh cubed, 1 cup	86
Strawberries, fresh, sliced, 1 cup	86
Orange, navel, fresh, medium	75

Kiwi, 1 medium	74
Red bell pepper, raw, chopped, _ cup	71
Cantaloupe, cubed, 1 cup	68
Tomato-vegetable juice	67
Mango, medium	57
Pepper, hot chili, raw, 1/4 cup	54
Brussel sprouts, fresh, cooked, _ cup	48
Strawberries, _ cup	42
Honeydew melon, 1 cup	42
Grapefruit, _	39
Broccoli, fresh/frozen, cooked, _ cup	37
Brussel sprouts, frozen, cooked, _ cup	35
Grapefruit juice, unsweetened, _ cup	36
Lemon, 1	31
Green pepper, raw, chopped, _ cup	33
Cauliflower, from fresh, cooked, _ cup	27
Red cabbage, ckd, _ cup	26
Collard greens, fresh/fzn, ckd, _ cup	22
Tomato, fresh, 1	23
Turnip greens, from raw, cooked, _ cup	20
Potato, baked, with skin, 1 medium	20