

Vitamin C

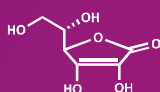


Synonyms:

L-(+)- Ascorbic Acid, E300 ascorbic acid, E301 sodium ascorbate, C₆H₈O₆, E302 calcium ascorbate, E303 potassium ascorbate, E304 fatty acid esters of ascorbic acid ((i) ascorbyl palmitate, (ii) ascorbyl stearate).

Chemistry:

L-ascorbic acid (2,3-endiol-L-gulonic acid- γ -lactone), dehydro-L-ascorbic acid (3-oxo-L-gulonic acid- γ -lactone).



Molecular formula of vitamin C



Food:

	mg/100g
Rose hip	2000
Acerolas	1600
Blackcurrants	200
Peppers	138
Broccoli	115
Fennel	95
Kiwis	71
Strawberries	64
Oranges	49

(Souci, Fachmann, Kraut)



Main functions:

- Antioxidant
- Immune stimulation
- Anti-allergic
- Collagen synthesis 'cement' for connective tissues
- Wound healing
- Teeth and gum health
- Regeneration of vitamin E
- Aids iron absorption
- Eye health

Vitamin C

Also known as ascorbic acid, vitamin C is a water-soluble vitamin that has several important functions including the protection of cells, maintaining healthy skin, blood vessels, bones and cartilage and wound healing, as well as supporting immunity. While most animals are able to synthesize vitamin C in the body, humans do not have the ability to make their own and must obtain it via the diet alone. Oranges and orange juice, as well as other fruits and vegetables, are considered a good source of vitamin C.



Functions

The most prominent role of vitamin C is its immune stimulating effect, which is important for the defense against infections such as the common cold. It also acts as an inhibitor of histamine, a compound that is released during allergic reactions. As a powerful antioxidant it can neutralize harmful free radicals and aids in neutralizing pollutants and toxins. This prevents the formation of potentially carcinogenic nitrosamines in the stomach, which mostly stem from the consumption of nitrite-containing foods, such as smoked meat. The reduction of oxidative stress has an impact on cardiovascular disease (CVD), as individuals experiencing oxidative stress have ascorbic acid blood levels lower than healthy individuals. Furthermore, vitamin C is also able to regenerate other antioxidants such as vitamin E.

As an enzyme co-factor, vitamin C is required for the synthesis of collagen, the intercellular 'cement' substance that gives structure to muscles, vascular tissues, bones, tendons and ligaments. Due to these functions, vitamin C, especially in combination with zinc, is important for the healing of wounds. It also contributes to the health of teeth and gums, preventing hemorrhaging and bleeding. Additionally, it improves the absorption of iron and is needed for the metabolism of bile acids, which may have implications for blood cholesterol levels and gallstones. Vitamin C plays an important role in the synthesis of several peptide hormones, neurotransmitters and carnitines as well. Finally, vitamin C is a crucial factor in the eye's ability to deal with oxidative stress and can delay the progression of advanced age-related macular degeneration (AMD) and vision-loss in combination with other antioxidant vitamins and zinc.

Dietary sources

Vitamin C is widely found in fruits and vegetables. Citrus fruits, peppers, green vegetables such as broccoli and Brussels sprouts, and fruits like strawberries, blackcurrants, guava, mango and kiwi are particularly rich sources. For example, depending on the season, one glass of fresh orange juice (100 g) yields between 15 mg and 35 mg of vitamin C. Potatoes, cabbage, spinach and tomatoes are also important sources to help meet essential vitamin C requirements.

Absorption and body stores

Intestinal absorption of vitamin C depends on the amount of dietary intake as it decreases with higher intake levels. For example, when consuming 30 to 180 mg, about 70 to 90 % is absorbed. In a single dose of 1 to 1.5g, this amounts to 50 % and in a single dose of 12 g to 16 %. Up to 500 mg can be absorbed via a sodium-dependent active transport process, while at higher doses, simple diffusion occurs.

The storage capacity of water-soluble vitamins is generally low compared to that of fat-soluble ones. Humans have an average tissue store of 20 mg vitamin C per/kg body weight. The highest concentration is found in the pituitary gland (400 mg/kg). Other tissues of high concentration are the adrenal glands, eye lenses, brain, liver and white blood cells (especially lymphocytes and leukocytes).

Measurement

Vitamin C can be measured in the blood plasma and other body tissues by various techniques. Dipstick tests to estimate vitamin C levels in the urine are also available. Less satisfying is the evaluation of analytical data concerning the true reflection of the body status. Threshold values are difficult to define and the subject of controversial discussion. Typical blood plasma levels are in the range of 20 to 100 µmol/L.

Stability

Vitamin C is sensitive to heat, light and oxygen which means that long storage or overcooking of food can partly or completely deplete vitamin C levels. Refrigeration can also substantially diminish vitamin C levels in food.

Influence of storage and preparation on vitamin C loss in foods

Food	Storage/ preparation	Vitamin C loss
Potatoes	1 month	50%
Fruits	1 month	20%
Apples	6 – 9 months	100%
Milk	UHT	25%
Fruits	Sterilization	50%
Fruits	Air drying	50 – 70%
	Canning	48%

Modified from Oberbeil, *Fit durch Vitamine, Die neuen Wunderwaffen*, Südwest Verlag GmbH & Co. KG, München 1993

Physiological interactions

- The presence of other antioxidants, such as vitamin E and β -Carotene, supports the protective antioxidant action of vitamin C. Other vitamins, such as B-complex vitamins (particularly B6, B12, folic acid and pantothenic acid) and some pharmacologically active substances, as well as the naturally occurring compounds known as bioflavonoids, may have a sparing effect on vitamin C i.e. vitamin C is freed up to fulfill other biological functions in the body.
- Due to toxic compounds in smoke, the vitamin C requirement for smokers and passive smokers is about 35 mg/day higher than for non-smokers. Several pharmacologically active compounds, including antidepressants, diuretics, birth control pills and aspirin (acetylsalicylic acid), deplete the tissues of vitamin C. This is also true for other habits, such as alcohol consumption and (passive) smoking.

Deficiency

Early symptoms of vitamin C deficiency are not very specific and could also indicate other diseases. Common symptoms include fatigue, lassitude, loss of appetite, drowsiness, insomnia, feeling rundown, irritability, low resistance to infections and petechiae (minor capillary bleeding).

Severe vitamin C deficiency leads to scurvy, characterized by weakening of collagenous structures which results in widespread capillary bleeding. Infantile scurvy also causes bone malformations. Usually, bleeding gums and loosening of the teeth are the earliest signs of clinical deficiency. Furthermore, hemorrhages under the skin can form and cause extreme tenderness of extremities and pain during movement. If left untreated, these symptoms can result in gangrene and in extreme cases, loss of life, although this rarely occurs in developed countries today. In 2013, European Food Safety Authority (EFSA) stated that the average requirement to keep bodily vitamin C at healthy levels is an intake of 90 mg/day for men and 80 mg/day for women.

Groups at risk

- Smokers and passive smokers are at a higher risk due to increased oxidative stress and metabolic turnover of vitamin C
- People suffering from illness (i.e. cancer, stroke or tinnitus), infectious and inflammatory diseases, allergies, arteriosclerosis, high blood pressure
- Mentally and physically stressed people
- Pregnant and breast-feeding women

Reducing disease risk: therapeutic use

Studies suggest that vitamin C plays a role in reducing the risk of health implications, with a selection presented below:

CVD (heart disease and stroke)

The data for vitamin C's protective benefits against CVD are inconsistent. While some studies have failed to find significant reductions in the risk of coronary heart disease (CHD), numerous prospective cohort studies have found inverse associations between dietary vitamin C intake or vitamin C plasma levels and CVD risk. Vitamin C may protect coronary arteries by reducing the build-up of plaque, as this helps to prevent the oxidation of LDL cholesterol (the 'bad' cholesterol), especially in combination with vitamin E. Some data has also shown that vitamin C may boost blood levels of HDL cholesterol (the 'good' cholesterol), which can prevent heart disease. The risk of a stroke may be reduced by an AI of vitamin C through fruits, vegetables and supplements. However, due to the inconsistency of the data and its lack of specificity to vitamin C, the interpretation of these results is difficult.



Cancer

The role of vitamin C and cancer has been studied extensively. A number of studies have associated higher intakes of vitamin C with a decreased likelihood of cancers of the upper digestive tract, cervix, ovary, bladder, and colon. Studies have also found a potential cancer-risk reduction after vitamin C supplementation has been used in cases of severe colds. This may be due to the antihistaminic action of very large doses of vitamin C.

Wound healing

During a postoperative period or during the healing process of superficial wounds, supplemental vitamin C contributes to the risk reduction of infections and promotes skin repair.

Blood pressure

Several studies have shown associated lower blood pressure levels with vitamin C supplementation at about 500 mg per day due to improved dilation of blood vessels.

Recommended daily intakes (RDI) *

Group	Life stage	Dose/day**
Infants	0 – 6 months	40 mg (AI)
Infants	7 – 12 months	50 mg (AI)
Children	1 – 3 years	15 mg
Children	4 – 8 years	25 mg
Children	9 – 13 years	45 mg
Males	14 – 18 years	75 mg
Females	14 – 18 years	65 mg
Males	>19 years	90 mg
Females	>19 years	75 mg
Smokers, male	>19 years	125 mg
Smokers, female	>19 years	110 mg
Pregnancy	<18 years	80 mg
Pregnancy	>19 years	85 mg
Breastfeeding	<18 years	115 mg
Breastfeeding	>19 years	120 mg

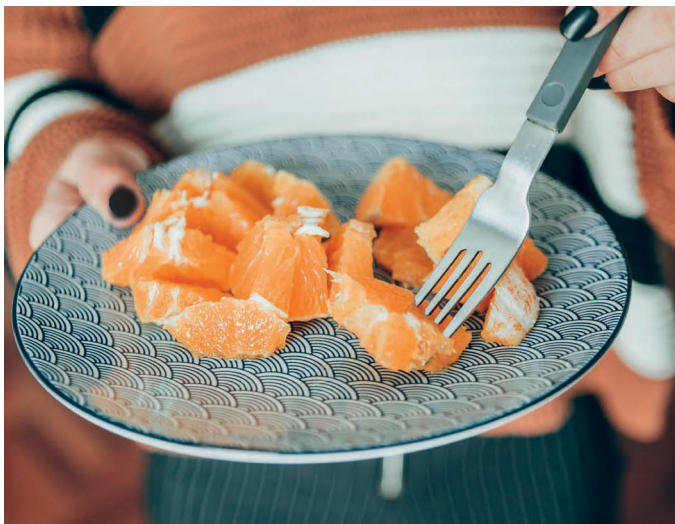
* Institute of Medicine (2001)

** Adequate intake (AI)

If not otherwise specified, this table presents Recommended Dietary Allowances (RDIs). Allowable levels of nutrients vary depending on national regulations and the final application.

Recommended Daily Intake (RDI)

The recommended daily intake of vitamin C varies according to age, sex, risk group and criteria applied in individual countries. In 2000, the US Food and Nutrition Board revised the RDI values for vitamin C upward to 90 mg/day for men and 75 mg/day for women, based primarily on the prevention of deficiency



disease, rather than the prevention of chronic disease and the promotion of optimum health. For smokers, these RDIs are increased by an additional 35 mg/day as smokers are under increased oxidative stress from the toxins in cigarette smoke and generally have lower blood levels of vitamin C. Higher amounts of vitamin C are also recommended for pregnant (80-85 mg/day) and breastfeeding women (115-120 mg/day).

Safety

Current recommendations state that doses above 2 g per day should be avoided to prevent side effects, including bloating and osmotic diarrhea. While the EFSA has decided that there is insufficient data to establish a tolerable upper intake level for vitamin C, one has been set by the U.S. Food and Nutrition Board in order to prevent most adults from experiencing diarrhea and disturbances in the digestive tract. Although a number of possible problems with very large doses of vitamin C have been suggested, none of these adverse health effects have been confirmed, and there is no reliable scientific evidence that large amounts of vitamin C (up to 10 g/day in adults) are toxic.

Supplements, food fortification and other applications

Vitamin C is offered in conventional, effervescent, chewable and time-release tablets, syrups, powders, granules, capsules, drops and ampoules, either alone or in multivitamin-mineral preparations. Buffered vitamin C forms i.e. highly absorbable vitamin C combined with minerals, are less acidic and allow higher doses to be administered without stomach upset. Vitamin C can also be used in the form of injections and various fruit juices, fruit-flavor drinks and breakfast cereals are enriched with vitamin C as well. On average, vitamin C supplements provide up to 8.3 % of the total vitamin C intake in Europe.

Uses in food technology

The food industry uses ascorbic acid as a natural antioxidant. This means that ascorbic acid, added to foodstuffs during processing or prior to packing, preserves color, aroma and nutrient content. For example, in meat processing, ascorbic acid makes it possible to reduce both the amount of added nitrite and the residual nitrite content in the product. The addition of ascorbic acid to fresh flour improves its baking qualities, thus saving the four to eight weeks of maturation flour would normally have to undergo after milling.

Production

The synthesis of ascorbic acid was achieved by Reichstein in 1933 and industrial production began five years later by Hoffman La Roche Ltd. The vitamin division, now called DSM Nutritional Products Ltd, produces synthetic vitamin C, identical to that occurring in nature, from glucose on an industrial scale by chemical and biotechnological synthesis.

History

