

Bioavailability of Different Forms of Vitamin C (Ascorbic Acid)...

Quick links:

- [C Cleanse](#)
- [Quercetin dehydrate / OPC polyphenolic write up](#)
- [AlkWay guide](#)
- [PERQUE.com/Potent C Guard](#)
- [PERQUE.com/WheyGuardRepair.com](#) & [PERQUE Repair Guard](#)
- [PERQUE.com/FAQ](#) on ascorbate/polyphenolic or flavanoids

In the rapidly expanding market of dietary supplements, it is possible to find vitamin C in many different forms with many claims regarding its efficacy or [bioavailability](#). Bioavailability refers to the degree to which a nutrient (or drug) becomes available to the target tissue after it has been administered. We reviewed the literature for the results of scientific research on the bioavailability of different forms of vitamin C.

Natural vs. synthetic l-ascorbic acid

Natural and synthetic L-ascorbic acid are chemically identical, and there are no known differences in their biological activity. The possibility that the bioavailability of L-ascorbic acid from natural sources might differ from that of synthetic ascorbic acid was investigated in at least two human studies, and no clinically significant differences were observed. A study of 12 males (6 smokers and 6 nonsmokers) found the bioavailability of synthetic ascorbic acid (powder administered in water) to be slightly superior to that of orange juice, based on blood levels of ascorbic acid, and not different based on ascorbic acid in [leukocytes](#) (white blood cells) (1). A study in 68 male nonsmokers found that ascorbic acid consumed in cooked broccoli, orange juice, orange slices, and as synthetic ascorbic acid tablets are equally bioavailable, as measured by [plasma](#) ascorbic acid levels (2, 3).

Note added: While natural and synthetic l-ascorbic acid are chemically identical, most 'ascorbic acid' or 'vitamin C' that is sold is 50% l-form and 50% d-form. The d-form is neither absorbed by the human body nor useful to the body because of its different stereochemistry. When d-ascorbate builds up in the intestine, it is known to irritate the digestive tract often accompanied by diarrhea.

Most studies are done small amounts, up to a few grams a day of ascorbate or vitamin C intake. Experience with the C Cleanse to determine individual current need confirms that many people use ascorbate up much more rapidly than others and therefore need to take in proportionately more to achieve the same level of ascorbate in the blood plasma. This is consistent with what is known about increased exposure to oxidative free radical generating toxins as well as people's total allostatic and homeostatic load of stress.

Further, ascorbate needs to be made under a nitrogen blanket to avoid air (oxygen) oxidation that damages the molecule leaving it no longer an antioxidant. Oxidized ascorbate can be considered anti-ascorbate in that it is not an anti-oxidant and has potential to be a pro-oxidant.

Different forms of ascorbic acid

The [gastrointestinal](#) absorption of ascorbic acid occurs through an active transport process, as well as through passive diffusion. At low gastrointestinal concentrations of ascorbic acid active transport predominates, while at high gastrointestinal concentrations active transport becomes saturated, leaving only passive diffusion. In theory, slowing down the rate of stomach emptying (e.g., by taking ascorbic acid with food or taking a slow-release form of ascorbic acid) should increase its absorption. While the

bioavailability of ascorbic acid appears equivalent whether it is in the form of powder, chewable tablets, or non-chewable tablets, the bioavailability of ascorbic acid from slow-release preparations is less certain.

A study of three men and one woman found 1 gram of ascorbic acid to be equally well absorbed from solution, tablets, and chewable tablets, but the absorption from a timed-release capsule was 50% lower. Absorption was assessed by measuring urinary excretion of ascorbic acid after an intravenous dose of ascorbic acid and then comparing it to urinary excretion after the oral dosage forms (4).

A more recent study examined the plasma levels of ascorbic acid in 59 male smokers supplemented for two months with either 500 mg/day of slow-release ascorbic acid, 500 mg/day of plain ascorbic acid, or a placebo. After two months of supplementation no significant differences in plasma ascorbic acid levels between the slow-release and plain ascorbic acid groups were found (5). A second placebo-controlled trial also evaluated plain ascorbic acid versus slow-release ascorbic acid in 48 male smokers (6). Participants were supplemented with either 250 mg plain ascorbic acid, 250 mg slow-release ascorbic acid, or placebo twice daily for four weeks. No differences were observed in the change in plasma ascorbate concentration or area under the curve following ingestion of either formulation.

Note added: Plasma ascorbate concentration is easily measured, however, it is difficult to measure accurately at the low levels in the plasma while active tissues concentrate what is in the plasma 30 times. This means that small changes in plasma ascorbate link to large changes inside cells where measuring ascorbate is much more difficult and expensive.

Mineral ascorbates

Mineral salts of ascorbic acid (mineral ascorbates) are buffered, and therefore, less acidic. Thus, mineral ascorbates are often recommended to people who experience gastrointestinal problems (upset stomach or diarrhea) with plain ascorbic acid. There appears to be little scientific research to support or refute the claim that mineral ascorbates are less irritating to the gastrointestinal tract. When mineral salts of ascorbic acid are taken, both the ascorbic acid and the mineral appear to be well absorbed, so it is important to consider the dose of the mineral accompanying the ascorbic acid when taking large doses of mineral ascorbates. For the following discussion, it should be noted that 1 gram (g)= 1,000 milligrams (mg) and 1 milligram (mg) = 1,000 micrograms (mcg). Mineral ascorbates are available in the following forms:

- **Sodium ascorbate:** 1,000 mg of sodium ascorbate generally contains 111 mg of sodium. Individuals following low-sodium diets (e.g., for high blood pressure) are generally advised to keep their total dietary sodium intake to less than 2,500 mg/day. Thus, megadoses of vitamin C in the form of sodium ascorbate could significantly increase sodium intake (see Sodium Chloride).
- **Calcium ascorbate:** Calcium ascorbate generally provides 90-110 mg of calcium (890-910 mg of ascorbic acid) per 1,000 mg of calcium ascorbate. Calcium in this form appears to be reasonably well absorbed. The recommended dietary calcium intake for adults is 1,000 to 1,200 mg/day. Total calcium intake should not exceed the UL, which is 2,500 mg/day for adults aged 19-50 years and 2,000 mg/day for adults older than 50 years (see Calcium).

The following mineral ascorbates are more likely to be found in combination with other mineral ascorbates, as well as other minerals. It's a good idea to check the labels of dietary supplements for the ascorbic acid dose as well as the dose of each mineral. Recommended dietary intakes and maximum upper levels of intake (when available) are listed after the individual mineral ascorbates below:

- **Potassium ascorbate:** The minimal requirement for potassium is thought to be between 1.6 and 2.0 g/day. Fruit and vegetables are rich sources of potassium, and a diet rich in fruit and vegetables may provide as much as 8 to 11 g/day. Acute and potentially fatal potassium toxicity (hyperkalemia) is thought to occur at a daily intake of about 18 g/day of potassium in adults. Individuals taking potassium-sparing diuretics and those with renal insufficiency (kidney failure) should avoid significant intake of potassium ascorbate. The purest form of commercially available

potassium ascorbate contains 0.175 grams (175 mg) of potassium per gram of ascorbate (see [Potassium](#)).

- **Magnesium ascorbate:** The recommended dietary allowance ([RDA](#)) for magnesium is 400-420 mg/day for adult men and 310-320 mg/day for adult women. The upper level ([UL](#)) of intake for magnesium from supplements should not exceed 350 mg/day (see [Magnesium](#)).
- **Zinc ascorbate:** The RDA for zinc is 11 mg/day for adult men and 8 mg/day for adult women. The upper level (UL) of zinc intake for adults should not exceed 40 mg/day (see [Zinc](#)).
- **Molybdenum ascorbate:** The RDA for molybdenum is 45 micrograms (mcg)/day for adult men and women. The upper level (UL) of molybdenum intake for adults should not exceed 2,000 mcg (2 mg)/day (see [Molybdenum](#)).
- **Chromium ascorbate:** The recommended dietary intake ([AI](#)) for chromium is 30-35 mcg/day for adult men and 20-25 mcg/day for adult women. The maximum upper level (UL) of intake has not been determined by the US Food and Nutrition Board (see [Chromium](#)).
- **Manganese ascorbate:** The recommended dietary intake (AI) for manganese is 2.3 mg/day for adult men and 1.8 mg/day for adult women. The upper level (UL) of intake for manganese for adults should not exceed 11 mg/day. Manganese ascorbate is found in some preparations of glucosamine and chondroitin sulfate, and following the recommended dose on the label of such supplements could result in a daily intake exceeding the upper level for manganese (see [Manganese](#)).

Note added: We recommend a careful balance of potassium, calcium, magnesium, and zinc. This improves taste perception and uptake. This also means that if individuals's need 1 or 10 or 100 g of ascorbate, they also receive a balanced intake of the essential macro minerals that a majority of Americans lack according to the NHANES surveys.

Vitamin C with bioflavonoids

Bioflavonoids or [flavonoids](#) are polyphenolic compounds found in plants. Vitamin C-rich fruit and vegetables, especially citrus fruit, are often rich sources of flavonoids as well. The effect of bioflavonoids on the bioavailability of ascorbic acid has been recently reviewed ([7](#)).

Results from the 10 clinical studies comparing the absorption of vitamin C alone or vitamin C in flavonoid-containing foods showed no appreciable differences in bioavailability of ascorbic acid. Only one study, which included five men and three women, found that a 500-mg supplement of synthetic ascorbic acid, given in a natural citrus extract containing bioflavonoids, proteins, and carbohydrates, was more slowly absorbed and 35% more bioavailable than synthetic ascorbic acid alone, when based on plasma levels of ascorbic acid ([8](#)). The remaining studies showed either no change or slightly lower plasma ascorbate levels in subjects who consumed vitamin C with flavonoids compared to flavonoids alone ([7](#)).

Another assessment of vitamin C bioavailability is measuring urinary ascorbate levels to approximate rates of vitamin C excretion. One study in six young Japanese males (22-26 years old) showed a significant reduction in urinary excretion of ascorbic acid in the presence of acerola juice, a natural source of both vitamin C and flavonoids ([9](#)). However, three separate studies showed that urinary levels of vitamin C were increased after consumption of kiwifruit ([10](#)), blackcurrant juice ([11](#)), or orange juice ([1](#)). Overall, the impact of flavonoids on the bioavailability of vitamin C seems to be negligible; however, there is a need for carefully controlled studies using specific flavonoid extracts ([7](#)).

Note added: We recommend specific bioflavonoids: Quercetin dihydrate (flavonoid) and soluble OPC (flavanol) in combination ± evaporated pomegranate juice (ellagic acids). The better uptake and utilization of these forms have been recommended for over 25 years. Evidence continues to accumulate on the better efficacy and safety of these forms. The amounts of ascorbate needed by individuals (based on individual C Cleanse or C Calibration) vary considerably and differently from amounts of bioflavonoids needed. We

recommend taking fully buffered, fully reduced 100% l-ascorbates as needed and separately that bioflavonoids be taken also as needed.

Ascorbate and vitamin C metabolites (Ester-C®)

Ester-C® contains mainly calcium ascorbate, but also contains small amounts of the vitamin C metabolites, dehydroascorbic acid (oxidized ascorbic acid), calcium threonate, and trace levels of xylonate and lyxonate. In their literature, the manufacturers state that the metabolites, especially threonate, increase the bioavailability of the vitamin C in this product, and they indicate that they have performed a study in humans that demonstrates the increased bioavailability of vitamin C in Ester-C®. This study has not been published in a peer-reviewed journal. A small published study of vitamin C bioavailability in eight women and one man found no difference between Ester-C® and commercially available ascorbic acid tablets with respect to the absorption and urinary excretion of vitamin C (12). Ester-C® should not be confused with ascorbyl palmitate, which is also marketed as "vitamin C ester" (see below).

Note Added: Ester C contains the doubly oxidized, irreversibly damaged product of ascorbate known as diketo-gulonic acid (DKG). This confirms that the product is exposed to air during production. This wounded form of ascorbate is not recommended.

Ascorbyl palmitate

Ascorbyl palmitate is a fat-soluble [antioxidant](#) used to increase the shelf life of vegetable oils and potato chips (13). It is an amphipathic molecule, meaning one end is water-soluble and the other end is fat-soluble. This dual solubility allows it to be incorporated into [cell membranes](#). When incorporated into the cell membranes of human red blood cells, ascorbyl palmitate has been found to protect them from oxidative damage and to protect alpha-tocopherol (a fat-soluble antioxidant) from oxidation by free radicals (14). However, the protective effects of ascorbyl palmitate on cell membranes have only been demonstrated in the test tube. Taking ascorbyl palmitate orally probably doesn't result in any significant incorporation into cell membranes because most of it appears to be hydrolyzed (broken apart into palmitate and ascorbic acid) in the human digestive tract before it is absorbed. The ascorbic acid released by the hydrolysis of ascorbyl palmitate appears to be as bioavailable as ascorbic acid alone (15). The presence of ascorbyl palmitate in oral supplements contributes to the ascorbic acid content of the supplement and probably helps protect fat-soluble antioxidants in the supplement. The roles of vitamin C in promoting collagen synthesis and as an antioxidant have generated interest in its use on the skin (see the article, [Vitamin C and Skin Health](#)). Ascorbyl palmitate is frequently used in topical preparations because it is more stable than some aqueous (water-soluble) forms of vitamin C (16). Ascorbyl palmitate is also marketed as vitamin C ester," which should not be confused with Ester-C® (see above).

D-Isoascorbic acid (Erythorbic acid)

Erythorbic acid is an [isomer](#) of ascorbic acid. Isomers are compounds that have the same kinds and numbers of atoms, but different molecular arrangements. The difference in molecular arrangement among isomers may result in different chemical properties. Erythorbic acid is used in the US as an antioxidant food additive and is generally recognized as safe. It has been estimated that more than 200 mg erythorbic acid per capita is introduced daily into the US food system. Unlike ascorbic acid, erythorbic acid does not appear to exert vitamin C activity, for example, it did not prevent scurvy in guinea pigs (one of the few animal species other than humans that does not synthesize ascorbic acid). However, guinea pig studies also indicated that increased erythorbic acid intake reduced the bioavailability of ascorbic acid by up to 50%. In contrast, a series of studies in young women found that up to 1,000 mg/day of erythorbic acid for as long as 40 days was rapidly cleared from the body and had little effect on the bioavailability of ascorbic acid, indicating that erythorbic acid does not diminish the bioavailability of ascorbic acid in humans at nutritionally relevant levels of intake (17).

Other formulations of vitamin C

PureWay-C® is composed of vitamin C and [lipid metabolites](#). Two cell culture studies using PureWay-C® have been published by the same investigators ([18, 19](#)), but *in vivo* data are currently lacking. A small study in healthy adults found that [serum](#) levels of vitamin C did not differ when a single oral dose (1 gram) of either PureWay-C® or ascorbic acid was administered ([20](#)).

Another formulation of vitamin C, liposomal-encapsulated vitamin C (e.g., Lypo-spheric™ vitamin C) is now commercially available. However, data regarding the bioavailability of liposomal-encapsulated vitamin C are not currently available.

Large-scale, [pharmacokinetic](#) studies are needed to determine how the bioavailability of these vitamin C formulations compares to that of ascorbic acid.

Note added: Exotic forms have novelty. Exotic forms almost always lack sufficient data. Absence of data is not data of absence. However, before we know more, a good story can take ‘wings’. Exotic forms of ascorbate have lower amounts of active ascorbate and suitable for those who believe rather than those who want evidence.

References

1. Pelletier, O. & Keith, M.O. Bioavailability of synthetic and natural ascorbic acid. Journal of the American Dietetic Association. 1974; 64: 271-275
2. Mangels, A.R. et al. The bioavailability to humans of ascorbic acid from oranges, orange juice, and cooked broccoli is similar to that of synthetic ascorbic acid. Journal of Nutrition. 1993; volume 123: pages 1054-1061. ([PubMed](#))
3. Gregory, J.F. Ascorbic acid bioavailability in foods and supplements. Nutrition Reviews. 1993; volume 51: pages 301-309. ([PubMed](#))
4. Yung, S. et al. Ascorbic acid absorption in humans: a comparison among several dosage forms. Journal of Pharmaceutical Sciences. 1982; volume 71: pages 282-285. ([PubMed](#))
5. Nyssonen, K. et al. Effect of supplementation of smoking men with plain or slow release ascorbic acid on lipoprotein oxidation. European Journal of Clinical Nutrition. 1997; volume 51: pages 154-163. ([PubMed](#))
6. Viscovich M, Lykkesfeldt J, Poulsen HE. Vitamin C pharmacokinetics of plain and slow release formulations in smokers. Clinical nutrition. 2004;23(5):1043-1050. ([PubMed](#))
7. Carr AC, Vissers MC. Synthetic or food-derived vitamin C-are they equally bioavailable? Nutrients. 2013;5(11):4284-4304. ([PubMed](#))
8. Vinson, J.A. & Bose, P. Comparative bioavailability to humans of ascorbic acid alone or in a citrus extract. American Journal of Clinical Nutrition. 1988; volume 48: pages 501-604. ([PubMed](#))
9. Uchida E, Kondo Y, Amano A, et al. Absorption and excretion of ascorbic acid alone and in acerola (Malpighia emarginata) juice: comparison in healthy Japanese subjects. Biol Pharm Bull. 2011;34(11):1744-1747. ([PubMed](#))
10. Carr AC, Bozonet SM, Pullar JM, Simcock JW, Vissers MC. A randomized steady-state bioavailability study of synthetic versus natural (kiwifruit-derived) vitamin C. Nutrients. 2013;5(9):3684-3695. ([PubMed](#))

11. Jones E, Hughes RE. The influence of bioflavonoids on the absorption of vitamin C. *IRCS Med Sci*. 1984;12:320.
 12. Johnston, C.S. & Luo, B. Comparison of the absorption and excretion of three commercially available sources of vitamin C. *Journal of the American Dietetic Association*. 1994; volume 94: pages 779-781.
 13. Cort, W.M. Antioxidant activity of tocopherols, ascorbyl palmitate, and ascorbic acid and their mode of action. *Journal of the American Oil Chemists' Society*. 1974; volume 51: pages 321-325.
 14. Ross, D. et al. Ascorbate 6-palmitate protects human erythrocytes from oxidative damage. *Free Radical Biology and Medicine*. 1999; volume 26: pages 81-89. ([PubMed](#))
 15. DeRitter, E. et al. Physiologic availability of dehydro-L-ascorbic acid and palmitoyl-L-ascorbic acid. *Science*. 1951; volume 113: pages 628-631.
 16. Austria R. et al. Stability of vitamin C derivatives in solution and in topical formulations. *Journal of Pharmacology and Biomedical Analysis*. 1997; volume 15: pages 795-801. ([PubMed](#))
 17. Sauberlich, H.E. et al. Effects of erythorbic acid on vitamin C metabolism in young women. *American Journal of Clinical Nutrition*. 1996; volume 64: pages 336-346. ([PubMed](#))
 18. Weeks BS, Perez PP. Absorption rates and free radical scavenging values of vitamin C-lipid metabolites in human lymphoblastic cells. *Med Sci Monit*. 2007;13(10):BR205-210. ([PubMed](#))
 19. Weeks BS, Perez PP. A novel vitamin C preparation enhances neurite formation and fibroblast adhesion and reduces xenobiotic-induced T-cell hyperactivation. *Med Sci Monit*. 2007;13(3):BR51-58. ([PubMed](#))
 20. Pancorbo D, Vazquez C, Fletcher MA. Vitamin C-lipid metabolites: uptake and retention and effect on plasma C-reactive protein and oxidized LDL levels in healthy volunteers. *Med Sci Monit*. 2008;14(11):CR547-551. ([PubMed](#))
-