



AIS SPORTS SUPPLEMENT FRAMEWORK

VITAMIN C (ASCORBIC ACID OR ASCORBATE)

What is it?

- > Vit. C is a water-soluble antioxidant vitamin that acts as an electron donor for numerous biochemical reactions in the body. Vit. C plays important roles as a cofactor for enzymes involved in collagen hydroxylation, plus carnitine and catecholamine biosynthesis. Vit. C also aids in iron absorption. A deficiency of Vit. C is rare given relatively low recommended dietary intake (45 mg per day) and wide distribution in fresh fruit and vegetables.
 - As an antioxidant, Vit. C reacts with potentially damaging reactive oxygen species (ROS) and reactive nitrogen species (RNS) and has been shown to protect plasma lipids against oxidative damage.¹ Vit. C also strengthens the cellular antioxidant network by helping to maintain Vit. E and glutathione levels.²⁻⁴
 - Vit. C is very labile and thus content in food varies according to season, transport, shelf life and storage time, cooking practices and chlorination of water. Cutting, bruising, heating and exposure to copper, iron or mildly alkaline conditions can destroy ascorbate. It can also be leached into water during cooking.⁵
- > Vit. C may enhance immune function through effects on epithelial barriers, white blood cells and inflammatory mediators.⁶ Through enhancement of immune cell function, Vit. C may be able to prevent and treat respiratory and systemic infections.⁶ Vit. C supplements are promoted to reduce the duration and severity of colds, although the evidence supporting this is mixed:
 - Vit. C supplementation (200-2000 mg per day) has been found to reduce the duration of the common cold by 8% and reduce the severity of cold symptoms.⁷ Neither acute nor chronic Vit. C supplementation influences the incidence of upper respiratory tract infections.
 - Some studies in military personnel and school boarders have found a reduction in incidence of pneumonia by 80-100% with Vit. C supplementation⁹, although findings of these studies cannot be extrapolated to other groups.
- > Vit. C may have benefits for athletes undertaking intense exercise. During exercise, our muscles produce increased amounts of ROS and RNS. Excess ROS and RNS can promote damage to proteins, lipids, and DNA, and potentially impair physical performance, recovery, and immune function. Vit. C supplements may act to neutralize some of the damaging effects of exercise-induced ROS and RNS, although studies report mixed findings on exercise-related outcomes:
 - A systematic review found that regular Vit. C supplementation (250-1000 mg per day) reduced the risk of the common cold by over 50% in athletes such as marathon runners and skiers who are exposed to short periods of extreme physical stress.⁷
 - Some evidence from randomized controlled trials indicate Vit. C supplementation (500-2000 mg per day) can prevent exercise-induced bronchoconstriction.⁹
 - Studies of effects of Vit. C supplementation on muscle function following a bout of intense fatiguing exercise have yielded mixed findings¹⁰⁻¹⁵, drawing into question its use for recovery of muscle function.
 - There is compelling evidence to suggest chronic ingestion of single high dose antioxidants such as Vit. C (1000 mg per day for 8 weeks) can impede training adaptations¹⁶, yet when the same amount of Vit C is ingested via whole food sources, performance may actually improve.¹⁷ Collectively this supports a food first approach to achieving Vit. C and other antioxidant nutrient needs, except in unique circumstances

What does it look like?

- > Vit. C is found naturally in a wide range of fruits and vegetables, including citrus fruits, berries, kiwifruit, tomatoes, broccoli, potatoes, capsicum, and sprouts. Vit. C food sources are presented in Table 1.
- > Vit. C (as ascorbic acid and/or sodium ascorbate) is also widely available in oral supplement forms including capsules, tablets, powders or drops. Vit. C may also be intravenously infused if medically indicated. Oral Vit. C powder (as ascorbic acid) is white to off-white or light yellow in colour.
- > On average, Australian adults consume approximately 110 mg Vit. C per day⁵, ~40% of which comes from vegetables, 19% from fruit and 27% from fruit and vegetable juices. Oral Vit. C supplements typically contain Vit. C in the range of 200 – 2000 mg per capsule or tablet.



How and when do I use it?

- > The integration of unprocessed, Vit. C rich foods into the daily meal plan is key to achieving not only daily Vit. C needs, but other important nutrients like fibre and phytochemicals.
- > Only when directed by a sports dietitians or sports doctor, should an athlete consider acute Vit. C supplementation.
- > A daily total dose of between 500-1000 mg supplemental Vit. C may be safe to consume acutely (during illness) to support immune health for most athletes undertaking intense exercise.

Table 1: Dietary sources of vitamin C

Food	Portion size	Vitamin C content [mg]
Tomatoes	Raw, ½ cup	15
Cabbage	Cooked ½ cup	15
Cauliflower	Cooked ½ cup	25
Potato	Baked, 1 medium	25
Sweet potato	Baked, 1 medium	30
Snow peas	Fresh, cooked ½ cup	40
Grapefruit	½ fruit	40
Mango	1 cup sliced	45
Brussels Sprouts	Cooked ½ cup	50
Orange juice	½ cup	50
Apple juice (fortified)	½ cup	50
Rockmelon	¼ medium	60
Broccoli	Cooked, ½ cup	60
Red or green capsicum	Raw ½ cup	65
Papaw	100g	65
Orange	1 medium	70
Kiwi fruit	1 medium	70
Strawberries	1 cup sliced	95

Are there any concerns or considerations?

Possible impairment of exercise training adaptations

Some of the biological adaptations to training are stimulated by exercise-induced production of ROS and RNS. Antioxidant supplements that act to reduce ROS and RNS may therefore blunt these signals and make the training process less effective. Current uncertainty of evidence warrants an athlete discussing their training and performance goals with their coach and sports dietitian to manage the potential trade-off between possible acute immune-related benefits of Vit. C supplementation and possible impairments in training-induced adaptations. Achieving daily Vit. C intake goals via whole food sources should be a priority.

Side effects at higher doses

Gastrointestinal effects such as bloating and osmotic diarrhoea are the most common adverse effects associated with high doses of Vit. C (i.e. 2-6 g per day) given over a short period of time.¹⁹ However, these effects are attenuated through reduction of intake and adaptation to increased doses. International bodies have imposed a prudent upper limit of intake of 1000 mg Vit. C per day based on these side effects.²⁰

Increased risk of kidney stones or worsening kidney function

There is a concern that high dose Vit. C supplements might promote kidney stones. However, studies in humans using doses between 30 mg and 10 g per day have provided conflicting results^{21,22} and it is unclear if Vit. C plays a role in kidney stone formation. Nonetheless, it might be prudent to limit intake to <1000 mg Vit. C per day in individuals who are known kidney stone formers.²³ High dose Vit. C is probably contraindicated in patients with existing hyperoxaluria and end stage renal disease.²²

Excess iron absorption in genetically prone individuals

Concerns have been raised in relation to use of high dose Vit. C supplements by individuals with genetic iron-overload disorders (e.g. haemochromatosis). Since Vit. C is a known enhancer of dietary iron absorption, it has been suggested that excessively high iron levels could damage the liver and heart and promote diabetes. Moderation (or omission) of supplemental Vit. C intake to no more than 500 mg per day is prudent for those individuals with genetic iron overload disorders.²⁴ On the contrary, co-ingestion of 50-100 mg Vit. C with non-haem iron sources significantly increases iron absorption, and thus may be important to include fresh fruit and vegetables at most meals of the day amongst those with a history of impaired iron status.

Where can I find more information?

Supplement safety information

www.sportintegrity.gov.au/what-we-do/anti-doping/supplements-sport

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Athletes should be aware that the use of supplements may have doping implications. Athletes are reminded that they are responsible for all substances that enter their body under the 'strict liability' rules of the World Anti-Doping Code. Some supplements are riskier than others. The Sport Integrity Australia (SIA) app is a useful resource to help mitigate the risk of inadvertent doping by helping to identify supplements that have been batch-tested. The SIA App provides a list of more than 11,000 batch-tested products. We recommend that all athletes consult the educational resources of SIA regarding the risks associated with supplements and sports foods.. While batch-tested products have the lowest risk of a product containing prohibited substances, they cannot offer you a guarantee that they are not contaminated (www.sportintegrity.gov.au/what-we-do/supplements-sport).

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