



AIS SPORTS SUPPLEMENT FRAMEWORK

DIETARY NITRATE / BEETROOT JUICE

What is it?

- > Dietary nitrate may be used to enhance the availability in the body of a molecule called nitric oxide (NO). NO is important for a variety of functions that are essential to life, and important to exercise performance, including the regulation of blood pressure and blood flow, mitochondrial respiration, muscle contraction and immune function.
- > In our bodies, nitrate is produced continuously because it is formed when the amino acid, arginine, is oxidized to generate NO. Until recently, it was believed that this nitrate had no biological function, but it has now been discovered that it can be recycled to form NO. Specifically, nitrate can be converted into nitrite (this process relies principally on the action of bacteria in the mouth) and then to NO. This nitrate-nitrite-NO pathway might be particularly important when oxygen is in short supply such as in muscle during exercise.
- > In addition to the nitrate that is produced within our bodies, the amount of nitrate and nitrite carried in our blood, and stored in our muscles and other organs, can be greatly augmented by the consumption of nitrate in our diet. The main dietary sources of nitrate are vegetables (particularly leafy greens) and some fruits, along with processed meats (where it is added as a preservative) and drinking water.
- > Increasing dietary nitrate intake, or using a nitrate supplement, may increase NO bioavailability and have the potential to enhance exercise performance in situations where NO production might otherwise be compromised.¹
- > The average dietary intake of adults in the US, Europe and Australia is 1-2 mmol/d (~60-120 mg/d) with vegetables providing about 80% of the total. Vegetarians are likely to consume higher nitrate intakes and people who follow "heart-friendly" eating plans such as the Dietary Approaches to Stop Hypertension ("DASH") diet are also likely to achieve higher nitrate intakes.
- > Interest in beetroot juice for enhancing sports performance arises principally from research by Professor Andy Jones and colleagues (University of Exeter, UK) which has used this juice as a rich source of dietary nitrate.
- > Nitrate consumed in the diet is rapidly absorbed via the stomach and small intestine, with plasma nitrate levels peaking ~ 1 hour after nitrate ingestion. A significant proportion of the plasma nitrate enters the entero-salivary system and is extracted by the salivary glands and concentrated in the saliva. Bacteria in the mouth convert nitrate to nitrite as part of their metabolism and this nitrite is subsequently swallowed. Some of the nitrite is converted to NO and other reactive nitrogen species in the acidic stomach environment but the remainder enters the small intestine and is absorbed into the blood where it can be transported around the body and reduced to NO if required.
- > Plasma nitrite concentrations peak at ~ 2.5 h following the intake of dietary nitrate. Factors that interfere with salivary nitrate handling - such as the use of antibacterial mouthwashes to reduce mouth levels of bacteria - may markedly limit this rise in plasma nitrite and blunt any subsequent physiological effects.
- > Nitrate supplementation has been shown to enhance some of the effects of NO, even in healthy people. For example, supplementation with dietary nitrate sources or nitrate salts (such as sodium or potassium nitrate) has been shown to reduce blood pressure even in individuals with normal blood pressure.
- > Original and subsequent studies have reported that both chronic (3-15 d) and acute (single dose prior to exercise) beetroot juice supplementation can enhance exercise economy (i.e. reduce the oxygen cost of exercise), exercise capacity and sports performance.¹
- > Aerobic fitness levels influence the efficacy of dietary nitrate, with highly-trained endurance athletes (with VO₂max greater than 65 ml/kg/min) not benefitting significantly from nitrate supplementation.² Few studies have investigated the impact of nitrate supplementation on female athletes.
- > Recent studies indicate that dietary nitrate supplementation can enhance muscle power, sprint, multiple-sprint, and high-intensity intermittent exercise performance, thereby widening the potential application of nitrate supplementation to a greater number of both individual and team sports.³



What does it look like?

- > Nitrate is abundant in green leafy vegetables; increasing the dietary intake of these vegetables is one way to augment nitrate intake. Table 1 summarizes the nitrate content of a range of vegetables, with the best sources being green leafy plants and vegetables grown in low light conditions such as plant roots. The nitrate content of a specific vegetable source can vary considerably from plant to plant and will depend on factors such as climate, soil conditions and time since harvest.
- > Typical nitrate dose used in recent studies of sports/exercise performance: ~ 6-8 mmol or ~350-500 mg nitrate provided by a single serve of beetroot juice concentrate, consumed ~ 2-3 hours pre-exercise. As an example, a 70ml shot of Beet It Sport Nitrate [James White, UK, Oz Beet It, Australia] contains 400mg nitrate.
- > Preparation of own beetroot sources [i.e. cooked vegetable, relish, juice] may not result in a reliable or sufficiently high nitrate dose for targeted acute supplementation pre-exercise. However, encouraging a higher daily vegetable intake is likely to have numerous benefits, including an increased daily nitrate intake
- > Nitrate may also be purchased as sodium or potassium nitrate which is used as a fertilizer and preservative of meats, but this is not recommended, and it is essential not to confuse nitrate with nitrite.
- > Based on research demonstrating that nitrate can enhance exercise performance, a large number of beetroot-based supplements are now marketed to athletes, including juice concentrates, gels and powders. Few of these have been independently tested to determine their nitrate content. Preliminary research supports preferential use of beetroot juice concentrates.^{4,5}
- > It is important that the product is guaranteed to contain at least 5-6 mmol nitrate for it to be effective. Preliminary research indicates however, taking more than 10-12 mmol is no more effective than taking 6-8 mmol.⁶

Table 1: Typical nitrate content of vegetables [taken from Bryan NS and Hord NG (2010). Dietary Nitrates and nitrites: in: Bryan N (ed), Food Nutrition and the Nitric Oxide pathway. Destech Pub Inc: Lancaster, PA, pp 59-77]

Nitrate	Content [per kg fresh vegetable]	Common Vegetables
Very High	2500 mg/40 mmol	Beetroot and beetroot juice, celery, lettuce, rocket, spinach
High	1000-2500 mg/18-40 mmol	Chinese cabbage, celeriac, endive, leek, parsley, kohlrabi,
Moderate	500-1000 mg/9-18 mmol	Cabbage, dill, turnips, carrot juice
Low	200-500 mg/3-9 mmol	Broccoli, carrot, cauliflower, cucumber, pumpkin, V8 vegetable juice,
Very low	<200 mg/< 3 mmol	Asparagus, artichoke, broad beans, green beans, peas, capsicum, tomato, watermelon, tomato, sweet potato, potato, garlic, onion, eggplants, mushroom

How and when do I use it?

Recent studies have identified several situations in which exercise capacity or performance has been enhanced by the pre-exercise consumption of beetroot juice/nitrate: these include cycling and running events of 4-30 minutes duration² as well as intermittent exercise protocols designed to reflect the demands of team sports.³

- > Supplementation may also be useful in supporting training, and perhaps also during exposure to hypoxic conditions e.g. altitude training.
- > It is recommended that a 6-8 mmol (~350-500mg) nitrate dose is consumed 2-3 hours prior to the commencement of exercise or competition. Consuming 6-8 mmol of nitrate daily for several days prior to competition is another possible strategy⁷. As an example, an ingestion protocol used successfully amongst spring kayakers includes the following, with athletes informed to avoid the use of mouthwashes as this can moderate conversion of nitrate to NO...
 - 1 x Beet It Sport shot am & pm for 3 days pre-race
 - 2 x Beet It Sport shot 2.5 hrs pre-race

Are there any concerns or considerations?

- > During the 1960s, health authorities became concerned about the nitrate and nitrite content of foods, blaming nitrite for health issues including "blue baby syndrome" in infants and an increased risk of colon cancer based on studies in rats. As a consequence, some countries have limits on the permitted levels of nitrate in foods and drinking water.
- > In contrast to these previous concerns about the safety of intake of nitrate and nitrite, which are in any case disputed, there is now evidence of benefits to cardiovascular and metabolic health. Indeed, it has been suggested that some of the health benefits of a diet high in vegetables are due, at least in part, to its nitrate content.

- > Consuming nitrate in its natural form (i.e., in vegetables and fruits), where it is found alongside antioxidants and polyphenols, rather than via processed meats, is likely to prevent or suppress the formation of any potentially-harmful compounds.
- > While it is unlikely that consumption of beetroot juice or other vegetable sources of nitrate is harmful (and may, in fact, may offer other health benefits), chronic use of nitrate supplements has not been well studied.
- > Beetroot juice, particularly in concentrated form and larger doses, sometimes causes mild gastrointestinal discomfort. Athletes who are inclined to use nitrate supplementation pre-competition are advised to first practice in training.
- > The consumption of beetroot/juice may cause a temporary pink coloration of urine and stools. This is a harmless side-effect.
- > Use of sodium nitrate supplements may be associated with a greater risk of misjudging dosages. Some athletes may also mistakenly (or deliberately) use sodium or potassium nitrite as a supplement and therefore expose themselves to toxic effects such as methemoglobinaemia.

Where can I find more information?

Sports Dietitians Australia

www.sportsdietitians.com.au/factsheets/supplements/beta-alanine-%ce%b2-alanine

Gatorade Sports Science Institute

www.gssiweb.org/docs/default-source/sse-docs/stellingwerff_sse_208_a03.pdf?sfvrsn=2

Supplement safety information

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

References

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7. Jones, A. M., Vanhatalo, A., Seals, D. R., Rossman, M. J., Piknova, B., & Jonvik, K. L. (2020). Dietary Nitrate and Nitric Oxide Metabolism: Mouth, Circulation, Skeletal Muscle, and Exercise Performance. *Med Sci Sport Exerc*, doi: 10.1249/MSS.0000000000002470.

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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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