Nutrition and Food in Health and Disease Vol 12, No 3, Jul-Sep 2025, pages: 11-14

Review Article

Clinical Significance of Beetroot Juice: A Comprehensive Review of the Juice Health Benefits and Therapeutic Potentials

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Received: March 2025 **Accepted:** April 2025

ABSTRACT

Beetroot (*Beta vulgaris* L.) is a nutrient-dense vegetable addressed for its vibrant crimson colour and significant health benefits. Rich in essential vitamins, minerals, antioxidants and dietary nitrates, beetroot juice has been popular for its therapeutic potentials. This comprehensive review investigated clinical significance of beetroot juice, highlighting its antioxidant, anti-inflammatory and cardiovascular benefits. Beetroot is rich in betalains, which show strong antioxidant and anti-inflammatory characteristics, protecting cellular components from oxidative stress and modulating inflammatory pathways. Its high nitrate content supports blood pressure regulation through nitric oxide production, enhancing vascular function and decreasing risks of cardiovascular diseases. Additionally, beetroot juice helps in improving endothelial function, decreasing blood lipids and managing blood glucose levels, making it beneficial for metabolic disorders such as hypertension, diabetes and obesity. Its role in weight management is linked to decreasing oxidative stress and inflammation- thus, improving mitochondrial efficiency and glucose tolerance. Furthermore, beetroot juice supports athletic performance by decreasing muscle soreness and inflammation, promoting faster recovery. The juice effectiveness in enhancing nitric oxide synthesis contributes to better circulation and endurance. In conclusion, beetroot juice is a valuable dietary addition, offering a wide range of health benefits- from improving cardiovascular health to supporting metabolic and athletic performance. Its natural composition makes it a safe, effective- holistic option for maintaining overall health.

Keywords: *Beta vulgaris* L, BRJ (Beetroot juice), NO (Nitric oxide), NF-κB, CR (Calorie restriction)

Highlights

- Beetroot juice is rich in dietary nitrates and betalains, supporting antioxidant and anti-inflammatory activities.
- Regular intake helps lower blood pressure, improve endothelial function, and enhance nitric oxide bioavailability.
- Beetroot supplementation mitigates oxidative stress, aids glucose regulation, and improves lipid profiles.
- It contributes to weight management and athletic recovery by reducing inflammation and enhancing mitochondrial efficiency.

Introduction

Beta vulgaris L., or beetroot, is a member of the Chenopodiaceae family. It is a vivid shade of crimson. Common names for beetroot include beet, chard, spinach, sea, garden, white and chukander (in Hindi). Its highly therapeutic qualities include certain beneficial effects on the human body. Beeroot can be consumed raw, boiling, steamed or roasted. The minerals of magnesium, manganese, sodium, potassium, iron and copper are rich in red beetroots (1).The Middle Eastern species of edible taproots known as the beetroot, which is an annual or biannual cultivated version of *B. vulgaris subsp. vulgaris*, has been developing worldwide, reaching Europe, Asia and the USA (2).

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[DOI: 10.61882/nfsr.12.3.11]

In addition to its flavor, nutritional values and wonderful flavor, beetroot and its juice are frequently consumed globally. Beetroot currently yields 20–25 t/ha of fruits annually in India. Due to consumer's increasing awareness of synthetic dye dangers, people are becoming further interested in using natural food color. In contrast to anthocyanins and carotenoids, betalains are less commonly used in food processing, even they are water soluble and stable at pH 3-7. Tomato pastes, sauces, jams, jellies and ice are made redder by adding fresh beetroots and beet powders and their extracted colors (3).

Nutritional Values

Beetroot contains several biologically active phytonutrients in addition to its incredibly rich proteins (1.68 g), carbohydrates (9.96 g), fat (0.18 g), amino acids (AA) (1.216 g), fatty acids (FA) (0.119 g), phytosterols (0.025 g), minerals (0.483 g) and fibers (2 g) per 100 g of wet weight, according to the US Department of Agriculture Agricultural Research Service's database. For every 100 g(ww) beetroot, there are 4.805 mg of vitamins and 25 mg of nitrate. A dry extract of beetroot yields 3.976 g/100 g1 betalains (2.075 g/100 g1 betacyanins and 1.901 g/100 g1 betaxanthins) and 0.1899 g/100 g1 phenolic (4).

Certain components of plants, including seeds, leaves and roots, have been used in conventional medicine because of their anti-inflammatory, hepatoprotective, nephroprotective, purgative, carminative, emmenagogue and wound-healing characteristics (5).

High quantities of biologically active compounds, such as betalains and inorganic nitrate- are detected in *B. vulgaris* L. It was detected that the overall betalain content, which made up 70–100% of the total phenolic content, varied 0.8-1.3 g/l-1 fresh juice (nearly 60% betacyanins and 40% betaxanthins). Hydroxycinnamic acids were another type of phenolic that were detected; they made up 2.6% of all phenolics. The nitrate content of individual cultivars varied tenfold. Each variety included a similar sugar composition, with 95% sucrose making up the average total content of roughly 7.7%. There were slight variations within the types or oxalic acid (0.3–0.5 g/l-1 fresh juice). In addition, the nitrate level of four powders and sixteen commercial juices were assessed (6).

Betacyanin, a plant pigment that provides beetroots with their deep purple-crimson color, is a powerful compound that may prevent development of several cancers (7).

Clinical Significance

Antioxidant characteristics:

Beetroot (*B.vulgaris* L.) is addressed as one of the best plant sources for antioxidants (8). Although there are numerous bioactive substances in this vegetable, betalains are the primarymolecules that enable Beetroot to scavenge free radicals (9). In addition to several further health-promoting substances such as potassium, magnesium, folic acid, iron, zinc, calcium, phosphorus, sodium, niacin, biotin, vitamin B6 and soluble fibers, beetroot juice (BRJ) includes a high level of biologically accessible antioxidants (10).Red beetroot betalains and phenolic compounds have been verified to enhance low-density lipoproteins (LDL) resistance to oxidation and prevent cancers and cardiovascular diseases (CVD) by minimizing damages to lipids through oxidation by free radicals (11).

Effect on blood pressure

One established risk factor for CVDs is high blood pressure (hypertension). From dietary nitrate possible benefits, decreasing blood pressure has been well studied. Immediately, hypertension decreases when oral bacteria bio-convert dietary nitrate to nitrite and then to nitric oxide (NO) once BRJ is consumed. The NO is a potent vasodilator and BRJ has been shown to decrease the blood pressure (12).

Effects on oxidative stress

An effective technique for improving endogenous protective antioxidants and prevent cellular constituents from oxidative damages includes beetroot supplementation. Redox balance, or the equilibrium between decreasing (antioxidants) and oxidative (pro-oxidants) compounds, is the state of a cell biological environment under normal metabolic conditions (13). Molecular forms of antioxidants are frequent in beetroots. Several in vitro experiments have shown that the betalain pigments in juices protect the cellular constituents from oxidative damages. When consumed as a juice supplement, beetroot protects cells against oxidative damages to protein, lipid and DNA components. It is reported that two betalain metabolites, betanin and betanidin, decrease lipid membrane oxidation caused by H2O2- activated metmyoglobin and free iron (AA-Fe) and linoleate damages resulted from cytochrome C oxidase (14).

Anti-inflammatory characteristic

Inflammation is an advantageous process under normal conditions, controlling natural reactions to biologic or physical stressors such as infections, traumas and other pathogens that can damage the body and upset homeostasis (15). Relatively, beetroot extracts and betalains are potent anti-inflammatory compounds. They seem to interfere with pro-inflammatory signalling systems to mediate their anti-inflammatory functions. As it directly activates and transcribes a majority of gene targets that regulate and intensify the inflammatory responses (e.g; cytokines, chemokines, apoptotic and phagocytic cells), the nuclear

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factor-kappa B (NF-κB) cascades is the most essential of these responses. Thus, the processes of inflammation that appear in chronic diseases are greatly affected by NF-κB activation (16).

Effects on endothelial functions

The primary risk indicator for atherosclerotic coronary artery disease (e.g. CVD) is aging. This occurs majorly due to negative effects on arteries, which include dysfunction of the endothelial cells characterized by decreases in endothelium-dependent vasodilation. Due to its antithrombotic, anti-inflammatory, blood flow-promoting and vasodilatory characteristics, NO plays a critical role in cardiovascular health. One of the primary causes of vascular dysfunction of endothelial cells is bioavailability of the oxidative stress-induced reduced NO. Vascular dysfunction of endothelial cells is facilitated by inflammation in a bidirectional interaction with oxidative damages. The progression of atherosclerosis is accompanied by proinflammatory pathway activation, persistent oxidative stress and immune cell recruitment and adhering to the endothelium (17).

Effects on blood lipids and glucose

Additionally, beetroots have been shown to include the ability to prevent and treat a number of illnesses. Hyperglycaemia, hypertension and high blood lipids are common chronic disorders that pose severe threats to human health due to changes in social life conditions as well as other variables. Based on various studies, beetroots can help treat various illnesses with no adverse reactions, unlike synthetic drugs (18). It was shown that postprandial insulin response within 0–60 min phase and glucose response within 0–30 min phase significantly decreased in healthy volunteers, who consumed beetroots, suggesting that betalains, polyphenols and dietary nitrate might be helpful in treating hyperglycemia (19).

Effects on overweight

A complex disorder, obesity, can be defined by an excessive accumulation of body fat, which has been linked to increased chances of mortality and onsets of significant complications. Obesity-linked consequences include muscular disorders, hypertension, diabetes and CVDs (20). A dietary approach termed calorie restriction (CR) decreased intake of calories without leading to malnutrition. This, may help in weight loss, especially decrease of fat mass. Decreases in oxidative stress and inflammation, which improves mitochondrial efficiency, glucose tolerance and NO production, may be the mechanism; by which, CR extends life expectancy and optimizes vascular and cognitive capabilities (21).

Conclusion

The BRJ is an excellent additive to healthy diets as it provides a variety of health benefits. Its extensive nutritious composition, including vitamins, minerals, antioxidants and nitrates, provides it healing potentials. The BRJ is repeatedly shown in studies to enhance NO synthesis, which enhances circulation, decreases blood pressure and strengthens the functioning of blood vessels. Additionally, BRJ may help recovery post-exercises by decreasing muscle soreness and inflammation. This highlights BRJ as a popular choice by the athlete's seeking optimization of their performance and maintenance of their overall health.

Financial Disclosure

The authors declare no financial interests.

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