



A REVIEW ON POTENTIAL HEALTH BENEFITS OF BEETROOT

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DOI: <https://doi.org/10.59551/IJHMP/25832069/2024.5.1.130>

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Received: 17 April, 2024, Decision for Acceptance: 23 May, 2024

Abstract

Beetroot (*Beta vulgaris*) is celebrated for its culinary versatility and abundant bioactive compounds, offering a myriad of health benefits. This review delves into its therapeutic applications, food processing, preservation methods, and emerging nanoformulation strategies. With its rich composition of minerals, amino acids, phenolic acids, flavonoids, betaxanthins, and betacyanins, beetroot stands out as a functional food with antioxidant, antibacterial, antiviral, and analgesic properties.

Of particular interest are betalains and nitrates, key bioactive components in beetroot. Betalains combat oxidative stress, prevent DNA damage, and exhibit antitumor effects, while nitrates contribute to reducing blood lipids, glucose, and pressure, as well as enhancing athletic performance. These compounds showcase beetroot's potential in combating various health conditions, from cardiovascular diseases to cancer.

The uses of beetroot go beyond just eating it raw; they are widely employed in the food business as a natural food coloring and in other high-quality goods. Beetroot powder, obtained through drying methods, is highly versatile in applications such as beverages, jams, candies, and processed meats. Moreover, its leaves, containing beta-carotene and other carotenoids, provide additional nutritional benefits. Research efforts are focused on maximizing the nutritional quality of beetroot and its by-products through various extraction methods, while exploring new avenues like nanoformulations to further enhance its therapeutic potential. It will take further study to completely understand the molecular mechanisms and some disease-specific effects of beetroot components, but doing so will open the way for more focused therapeutic usage and help realize its promise in improving human health and welfare.

Keywords: Beta Vulgaris, Antioxidant, Cardiovascular Health, Nitrates, Dietary Supplement, Detoxification, Weight Management, Skin Health, Phytochemical Analysis, Bioavailability, Clinical Trials, Nutritional Composition, Food Processing



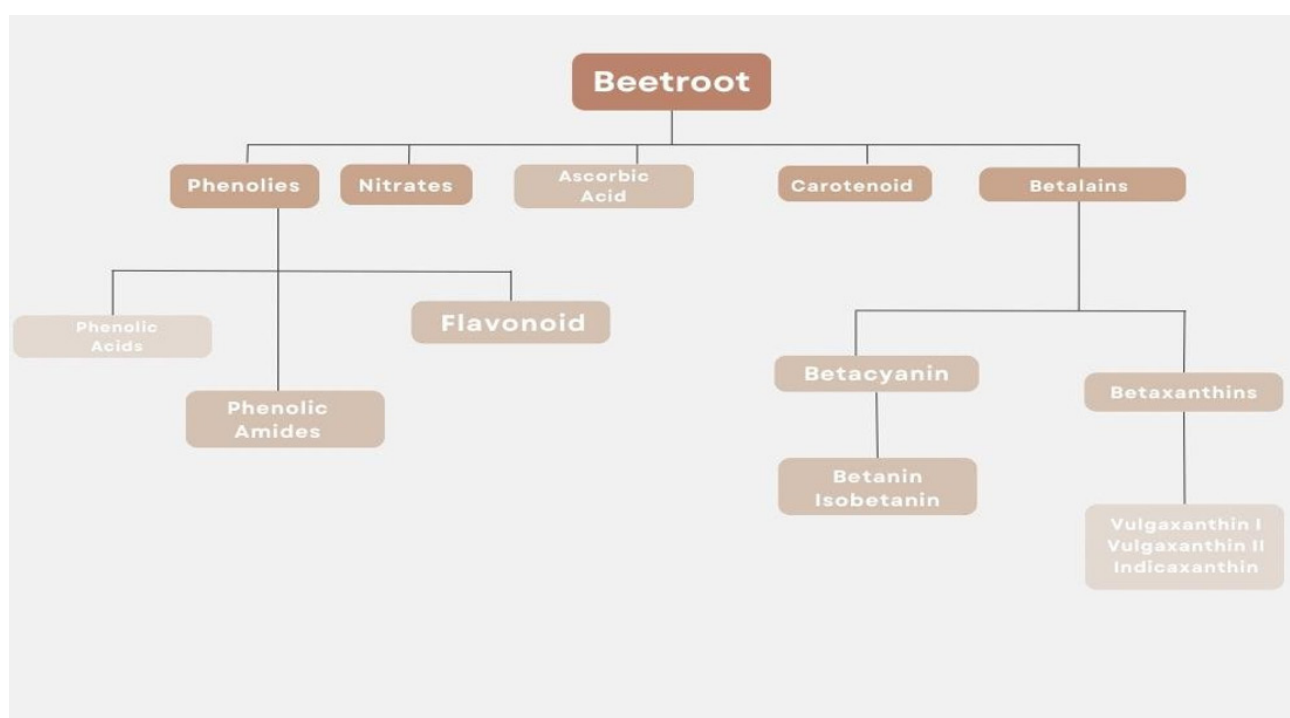
1. Introduction

Presently the trends are suggesting that people are looking for safer means of improving their general health and quality of life, which includes a healthy diet that involves so-called “fortified foods,” which is gaining increasing traction. The health benefits of eating a diet high in fruits and vegetables may seem infinite. These include heart health, protection from free radicals, malignancies of the mouth, throat, prostate, and colon; constipation; and maybe a prophylactic against diverticulosis (the development of tiny, easily irritated pouches inside the colon). Beetroot (*Beta vulgaris* L.), a vegetable plant, belongs to the Amaranthaceae family. Beets provide vitamin C, dietary fiber, and certain important minerals including potassium and manganese. For normal neuron and muscle function, potassium is necessary. Beetroot also contains vitamin B, which helps clean the liver and blood. It contains naturally occurring minerals that provide bone strength. For these reasons, beetroot has long been used to cure a wide range of illnesses in traditional Arab medicine. It is a great nutritional supplement since it is high in vitamins, minerals, and other nutrients, and it also contains special phytoconstituents that have a number of therapeutic benefits. It boasts strong antioxidant qualities. Beet root was utilized as an aphrodisiac and was thought to improve human sex hormones in the past. Therefore, beetroot

juice was ingested as a home cure for a sexual deficiency. Kidney and bladder stones are also treated with this. When infused into drinking water, beetroot extracts also significantly reduce the development of tumors in a variety of animal models. Because beetroot increases blood flow to the brain, it also helps to lessen the effects of dementia. Additionally, beetroot has been shown to help older people who are losing their memory. A number of the plant’s parts, including its antioxidant, carminative, diuretic, anti-inflammatory, anti-microbial, antifungal, and expectorant properties, are employed in medicine. Additionally demonstrating its potential to shield protein from denaturation, beetroot has therapeutic benefits. The pH range of 5.5 to 6.2 is preferred by this plant species for Soil that are high in organic matter. Depending on the cultivars and way of agriculture, the production cycle could take anywhere from 60 to 100 days over the summer winter. The plant has a major root system as well as several smaller, laterally branching roots that can reach a depth of 60 centimeters It grows largely on the soil’s surface and has a tuberous, purplish-red portion that is globular in shape and delicious to taste. Since the beetroot crop is biennial, it needs a prolonged period of extreme cold to complete its reproductive cycle. Minerals are also abundant in beetroot. The manner in which beet root is ingested affects the mineral content. The following are the quantities of metals: iron

(Fe), zinc (Zn), potassium (Na), sodium (Na), potassium (K), magnesium (Mg+2), phosphorus (P), and magnesium (Mg-2). One hundred grams of raw beetroot contains mostly folic acid. Twenty milligrams of beta-carotene, five milligrams of vitamin C, 0.12-0.10 mg of beetroot, 0.03-0.04 mg of vitamin B6, a thiamine dosage of 0.01-0.04 milligrams, riboflavin (0.01-0.02 milligrams), 0.1 milligrams of niacin, with different quantities. There are trace amounts of vitamin B12, vitamin D, and retinol. Beet root's primary component that gives it its red color is betalains. Moreover, it has 13% proteins, 34% sucrose, and 1.0% trimethylglycine and betaine. Beet root also contains Cyclo-DOPA (dihydroxyphenylalanine), L-tryptophan, Potassium coumarate acid, Ferulic acid, feruloyl glucose, amino acid carboxyl dihydroxyindole, flavonoids, beta vulgaris, and phenolic amides. These findings were made using high performance liquid chromatography (HPLC). Its traditional name is "blood building tonic". Antiproliferative activity of beet root has also been demonstrated. India's main market for beetroot is the Mettupalayam Vegetable Commission in Mandy, Tamil Nadu. As such,

beetroot has garnered significant interest as a functional food that promotes health. A normal beetroot contains 35 calories. Beetroot's rich red hue is derived from the pigment betacyanin. By doing this, colon cancer is avoided. Its abundant supply of silica helps the body use calcium to its fullest potential and is essential for strong, healthy bones, skin, and hair. The first formulation for dietary NO₃-supplementation was beetroot juice. It has been used as a prime for the majority of innovative formulations that have been presented recently, depending on the goals of pre-clinical or clinical investigations as well as the test population including volunteers. In a food centrifuge processor, beets are mixed without the addition of water to generate fresh and concentrated beetroot juice. Purolite-520E resin was utilized in anion-exchange chromatography to remove NO₃⁻, resulting in reduced NO₃-beetroot juice in placebo-controlled trials. It is impossible to identify depleted-NO₃-rich beetroot juice from NO₃-rich beetroot juice in terms of color, taste, texture, or other sensory attributes.



1.1 Body

Beta vulgaris L. ssp. *maritima* gave rise to beetroot through hybridization with *B. patula*. Sand loams or deep well-drained loams are best for growing beetroot. Due to the creation of a soil crust following irrigation or rain, heavy clayey soils cause poor crop germination and stand. In thick soils, roots might get distorted and fail to grow correctly. A pH of 6-7 is good for beetroot, which is quite sensitive to soil acidity. Just a few vegetables can be cultivated successfully in salty soils, including beet root. Beets are a vegetable that grows for a long time in the cool season. While they can withstand some heat and some ice, they thrive in cool areas. Between 15.5 and 18.3°C (60–65°F) is the ideal temperature range for their Should be planted in full sun optimal growth. Beets prefer sandy, well-draining soil that has a pH of 6.2 – 6.8, and they should be planted in full sun for optimal growth. Beetroot is grown in lowlands during the winter, and in hills by March or April, it is harvested as a spring crop. Beetroot has a broad range of physiologically active phytochemicals, including flavonoids, polyphenols, betacyanins, and saponins, in addition to being a valuable source of several minerals, notably potassium, chlorine, phosphorous, magnesium, calcium, copper, iron, zinc, and manganese. It is commonly consumed as extra juice, powdered form, bread, gel, prepared, dried in the oven, pickled, pureed, or processed in a jam in a variety of culinary traditions. Beetroot is among the most effective ten plants in terms of antioxidant properties. The main commercial origin of betalains, which are present in confections, meat, dairy, and poultry-derived products, powder, and natural colors, is believed to be this. The beetroot organs are arranged in the following sequence, based on the highest to lowest concentration of NO₃: petiole, stem, leaf, root, tuber, bulb, fruits and seeds. In addition, beetroot has a rather high oxalic acid content. Due to its high sucrose content, even though red beet is used to make industrial food, the sugar beet variety is produced commercially for its sugar content. The therapeutic characteristics of *Beta vulgaris* Linn. The effects of ethanol extract

(BVVE) of leaves on anxiety, depression-like actions and cellular oxidative stress were investigated in response to acute restraint stress (ARS). BVVE exhibits anxiolytic and antidepressant qualities.

2. Methodology

Red beets are a low in fat, moderately caloric food that is high in soluble fiber, soluble carbohydrates, proteins, and sugars. Beet roots are rich in the vitamins A, C, E, and K. Strong antioxidants such as betalains, phenolic compounds, carotenoids, flavonoids, and folic acid are present, as well as a significant amount of B vitamin supplements (B1-thiamine, B2-riboflavin, B3-niacin, B5-pantothenic acid, and B6-pyridoxine). Alkaloids, tannins, amino acids, and saponins are some of the other bioactive substances present in beets.

Beet roots are a beneficial source of minerals, such as potassium, magnesium, sodium, phosphorus, manganese, ferrous, zinc, copper, boron, silica, and selenium (important for bone health). The variation of chemical composition and spatial arrangement of the nutritional components of red beetroot are determined by the variety and anatomical parts of the plant (leaf, stem, root, and peel). The leaves of beetroot contain more carotenoids than the tubers do. This is explained by the build-up of carotene in the chloroplasts of green plant tissue, which include α - with β -carotene and β -cryptoxanthin. Blood pressure can be lowered by using beetroot leaves. A notable source of polyphenols is red beet, which when combined with betalains exhibit strong antioxidant properties and the ability to scavenge radicals. The primary bioactive component of the red and yellow pigment class that red beets may have is betalain. The two types of pigments present in betalain are betacyanins as, which are purple pigments, and betaxanthins, which are yellow to orange pigments. The pharmacological properties of betalains, particularly betacyanins, as antioxidants, anti-inflammatory, anti-cancer, hepatoprotective, anti-lipidemic, and antibacterial agents, make them significant for human health. They can also prevent the growth of cancerous cells in humans

and inhibit the in vitro growth of cells related to cervical, ovarian, and bladder cancer. Ingesting red beetroot reduced the incidence of esophageal, colon, liver, lung, and skin malignancies. Because of its inherent colorant qualities, high water solubility, and lack of toxicity, betalains are employed as food additives. This colorant's primary source is thought to be red beetroot. Food can be enhanced in flavor or kept from discoloring by adding betalains. Add powdered or fresh beetroot to tomato paste-based soups, salsas, deserts, whipped cream, candies, and breakfast cereal to enhance their red color. In addition to being high in fiber and vitamin C, beets also have important minerals like potassium and manganese. The body's primary energy source, adenosine triphosphate, also known as ATP which is required for regular neuron and muscle activity, is used less by the muscles when potassium is present.

In addition to preventing constipation, fiber aids in the movement of waste through the intestines. Likewise, beetroot's antioxidant components offer protection against colon cancer. The prevention of macular degeneration, which is associated with carotenoids and is known to lower the incidence of cataract development, is another significant benefit of eating red beetroot. Vitamins and nutrients can be used to treat dietary deficiencies, diseases of the kidneys and liver, and the buildup of deposits of fat in the hepatitis caused by alcohol abuse, inadequate protein, or diabetes. They also aid in the cleansing of the blood and liver. Naturally occurring nutrients in beetroot provide bone strength. Our knowledge of the influence of both acute and ongoing beetroot juice consumption upon blood pressure along with circulation is rapidly expanding thanks to clinical studies. We looked at a sizable number of human research for this evaluation. More research has been done than not to encourage the hypotensive and hypertensive patients in different phases of health who benefit from these medications' ability to lower blood pressure. There is emphasis on the roles played by bioactive substances and the nitrate-nitrite pathway. It appears that physiological and medical status have a significant impact on

the hypotensive action of beetroot. It was found that administering beetroot juice to hypertension patients had a much higher effect on blood pressure than to not hypertensive subjects. Erythrocyte xanthine oxidase, also known as erythrocytic xanthine oxidoreductase (XOR), is an enzyme involved in the reduction of NO₂ in active NO, and its greater expression rates in hypertension states can be used to explain this impact. Aortic pulse wave velocity (aPWV) and ultrasonography flow-mediated dilatation measurement (FMD) were the main techniques used to look into the possible effect of beetroot diet on vascular function, whether long or short-term. After receiving a six-week treatment with NO₃-rich beetroot juice, there was a small improvement observed in measures of arterial stiffness, the aPWV and the augmentation index, and FMD. Beyond other bioactive substances like betacyanins, it is proposed that the physiological effects of beetroot are directly correlated with its NO₃ level. Beetroot juice's possible hypoglycemic impact has been previously researched in both healthy individuals and patients with a range of conditions. P-value = 0.004 indicates a significant drop in blood glucose levels and a good effect on insulin and glycemic responses; many processes were identified, with a key role played by bioactive chemicals (polyphenols, flavonoids, nitrate, etc.). The lipid profile was also briefly reviewed in conjunction with this section because it contributes as a complimentary component to the incidence of glycemic disorders.

3. Results and Discussion

Natural elements include the composition of the soil, total yearly rainfall, the regional climate, and amount of sunlight all have an impact on the accumulation of nutrients and phytochemicals in plant parts and fruits. The tested beet types were cultivated on a single field in order to reduce the impact of these outside influences. to show that the soil's components are evenly distributed over the field. For each soil specimen, trace particles Al³⁺, Cu²⁺, Fe²⁺, K⁺, Mn²⁺, Ni²⁺, and Zn²⁺, were quantified. These seven varieties

of beets cultivated for this study are typical of the majority of varieties produced in Austria, across commercial as well as backyard farming, with an approximate annual harvest production of 6,000 tons (Austria, 2013). According to Austria (2013), beetroot yields in conventional farming averaged 4.3 kg/m² in 2013. For Austrian farming, the beet root varieties such as Mona Lisa, Forono, as well as Robuschka are especially important according to Saatgut, Linz, Austria, a significant seed source. Robuschka beets were the smallest, averaging 214 g, or 58% of the total weight of beets, which was consistent with the lower output. Overall, it was discovered that the yield outcomes shown fit into a comparable range to what had been documented in earlier studies. The amount of betalain substance and the overall phenolic content in liquids prepared via seven different varieties of beetroot were tested in the study. All varieties had a ratio of roughly 1.75 to 1, which suggests that the betalain composition was consistent across types with only variations in the total contents. Other beetroot types have previously been found to have a comparable ratio of betacyanins to betaxanthins. Within a variety, there were less variations amongst individual beets. In line with previously published data, the betalain content thus seemed to be variety-specific. Beetroots have demonstrated a significant antioxidant ability. The amount of phenolic compounds in beetroot juice affects its antioxidant activity, which varies depending on the variety under study. There are a tonne of beetroot juices and powders on the market right now. We examined the nitrate, sulfate, and chloride concentrations of 16 different beetroot juices that are presently on the market in Austria: Two of the samples were juice extracts that were particularly advertised for their capacity to enhance efficiency, and the remaining fourteen were unadulterated beetroot drinks (both traditional and ecological). The nitrate's purportedly advantageous effects are the primary selling point for those goods. Should this impact be real, the ultimate product's nitrate concentration is crucial for achieving the intended result. The high sugar content (62.0–

92.0 g/L) of the processed beetroot juices is an important consideration that needs to be made. The World Health Organization advises that a grownup with a typical Body Mass Index (BMI) consumes between 25 and 50 grams of sugar per day. 300–600 mL of the produced juice is sufficient, per these recommendations, to meet the daily maximum for sugar intake. Therefore, developing products with lower sugar content will be crucial to maximizing the health benefits of beetroot products without creating an issue with overconsumption of sugar.

4. Conclusion

Numerous metabolic conditions, including obesity, hypertension, elevated insulin levels, and renal failure, may be treated therapeutically using beetroot and its metabolites, in accordance with research. Research on humans indicates that beetroot supplementation has reno-protective effects, drops systolic and diastolic blood pressure, inhibits platelet aggregation, improves vascular and endothelial function, lowers blood glucose, and enhances insulin homeostasis. Beetroot is high in important minerals and phytochemicals, and it has a lot of inorganic NO₃. Bioactive molecules, which are assumed to have significant functions within the molecular paths, are regarded to be the source of the potential therapeutic advantages. However, our subgroup analyses demonstrate that beetroot juice might possess a blood pressure-lowering effect even in lack of NO₃, and they suggest an alternative hypothesis for the dose-dependent link between inorganic NO₃ and its diuresis-lowering effects. In hypertensive patients with predetermined stages of elevated blood pressure, more long-term clinical trials with larger sample sizes and longer durations are needed to confirm whether bolstering with beetroot juice could be a safe nutritional treatment for treating hypertension. These studies should use standardized beetroot food supplements for NO₃ content and other bioactive compounds. Beetroot has the potential to be a sustainable, cost-effective, and all-natural means of promoting health and preventing disease. Patients with type 2 diabetes who feed on raw red beetroot for

eight weeks experience advantages in their glucose metabolism, cognitive function, and other metabolic markers. Through nitrate-nitrite-NO cascade, dietary nitrate has significant vascular effects. These results are encouraging and suggest that dietary nitrate may be the cause of the apparent health benefits of diets high in vegetables, like the Mediterranean and Japanese diets. These are surrogate endpoints, though, so more extensive research with hard outcomes will eventually be required to verify the advantages and demonstrate that they surpass the possibility of cancer risk. The amount of nitrate consumed is primarily a personal choice, contingent on need, unless such data are available. However, in order to optimize beetroot's application in preventive and therapeutic approaches, additional study is necessary to completely comprehend the physiological processes underlying its benefits.

Conflict of Interest: None

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Cite this article Aarti et al, A Review on Potential Health Benefits of Beetroot. *Indian Journal of Health Care, Medical & Pharmacy Practice*.2024; 5(1) 96-102.