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The Antioxidant Power of *Beta vulgaris L.* Natural Health Booster: A Review

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Abstract:
Previously, beetroot is mainly consumed as a food additive. In recent years, the beet-root, especially the betalains (betanin) and nitrates it contains, now has received in-creasing attention for their effective biological activity. Betalains have been proven to eliminate oxidative and nitrative stress by scavenging DPPH, preventing DNA damage, and reducing LDL. It also has been found to exert antitumor activity by inhibiting cell proliferation, angiogenesis, inducing cell apoptosis, and autophagy. In some chronic diseases, nitrate is the main component for lowing blood lipids, glucose, and pressure, while its role in treating hypertension and hyperglycemia has not been clearly stated. Moreover, the intake of nitrate-rich beetroot could enhance athletic performance and attenuate muscle soreness in certain types of exercise.
The objective of this review is to provide sufficient evidence for the clarification of health benefits of beetroot, especially in the aspect of bio-oxidation, neoplastic diseases, some chronic diseases, and energy supplementation.

Keywords: Beetroot, Betanin, Antioxidant activity, Saffron, Nitrate

INTRODUCTION

Nowadays, a large number of consumers have a strong preference for the “functional foods” for the improvement of their eating diet and maintenance of their health (Jeffery, 2005; Shashirekha et al., 2015). Accordingly, fruits and vegetables are important parts of the healthy diet with the capacity of preventing several diseases (Jeffery, 2005; Shashirekha et al., 2015). In recent years, the beetroot (Beta vulgaris L.) has become popular as a potential “functional food” within this context (Frank et al., 2005). In spite of the fact that the beetroot has long been used as a traditional cuisine in Europe, the understanding of the applied value is very limited. Today, with the development of preclinical trials, consumers have increased knowledge about the biological activity of beetroot. The beetroot is now widely cultivatedto meet the increase in demand (Maity et al., 2016). In addition to being known as fresh vegetables, or as food additives in cattle prod-ucts, beverages, candies, and dairy products (Georgiev et al., 2010; Vieira Teixeira da Silva et al., 2019), beetroot has also been found to possess the potential of treating and preventing multiple dis-eases. According to the database displays in the US Department of Agriculture Agricultural Research Service, beetroot is not only rich in proteins (1.68 g), carbohydrates (9.96 g), fat (0.18 g), amino acids (1.216 g), fatty acids (0.119 g), phytosterols (0.025 g), minerals (0.483 g), and fibers (2 g) per 100 g of wet weight, but also containsa lot of biologically active phytonutrients (Figure 1). The contents of vitamins and nitrate are 4.805 mg and 25 mg per 100 g of wet weight respectively. 3.976 g/100 g of betalains (2.075 g/100 g of betacyanins and 1.901 g/100 g of betaxanthins) and 0.1899 g/100 g of phenolic are produced in dry extract of beetroot. These bioactive phytonutrients have been proven as key ingredients for the treatment of some chronic diseases including cardiovascular and cerebrovascular diseases, cancer, diabetes, and chronic respiratory diseases. For instance, betalains (mainly betanin) are the effective antioxidant extracted from beetroot. Several lines of evidence have shown that betalains might reduce the risk of some cancers, cardiovascular and cerebrovascular diseases, liver and kidney damage (Kavitha et al., 2013). The nitrate also has great nutritional value in beetroot. A lot of consumers tend to take oral fresh beetroot juice to supplement nitrate and thus to positively affect the physiological reaction, reduce the risk of cardiovascular, and cerebrovascular dis-eases (Webb et al., 2008). The beetroot has now been widely used as a common vegetable for athletes to replenish energy.
Although a wide variety of researches have highlighted the bio-activity of beetroot in antioxidant, anti-inflammatory, antitumor, hepato-protective, cognitive improvement, blood pressure regulation, the value of its application is limited to natural colorant and functional beverage, overall. The main reason for such a situation is that the current researches on beetroot are still mainly concentrated at the cellular and animal level, lacking scientific, and credible clinical data. In spite of this, as a convenient, safe, and edible vegetable, the clinical verifi-cation of beetroot for health promotion is possible only a matter of time. In this article, we aim to review the related biological activity of the main active ingredients, hoping to provide some references for the future beetroot application in food manufacturing and medical care.

The key function of nutrients:

(1) Cardiovascular Health,
(2) Anti-Inflammatory Effects,
(3) Anti-Oxidant Activity,
(4) Cognitive Function,
(5) Cancer Prevention,

❖ The antioxidant properties of Beta vulgaris L. translate into various health benefits:

(I) **Cardiovascular Health:** The nitrates in beetroot are converted to nitric oxide in the body, which helps to lower blood pressure and improve cardiovascular function,
(II) **Anti-Inflammatory Effects:** Beetroot's antioxidants can mitigate inflammation by neutralizing free radicals and reducing the production of pro-inflammatory cytokines,
(III) **Cognitive Function:** There is emerging evidence suggesting that the antioxidant and nitrate content of beetroot can enhance cognitive function by improving cerebral blood flow. Studies have found that beetroot juice consumption is associated with improved cognitive performance in older adults.
(IV) **Cancer Prevention:** Some research indicates that the antioxidants in beetroot may have potential anti-cancer effects by reducing oxidative damage and modulating cell signaling pathways involved in cancer progression.

2. Literature Review

1. Beet Root (*Beta vulgaris L.)*

Beetroot (Beta vulgaris L.) is crop belonging to the Chenopodiaceae family having, bright crimson colour. It is famous for its juice value and medicinal properties; and known by several common names like beet, spinach beet. It is widely consumed in traditional western cooking but rarely used in West Africa.

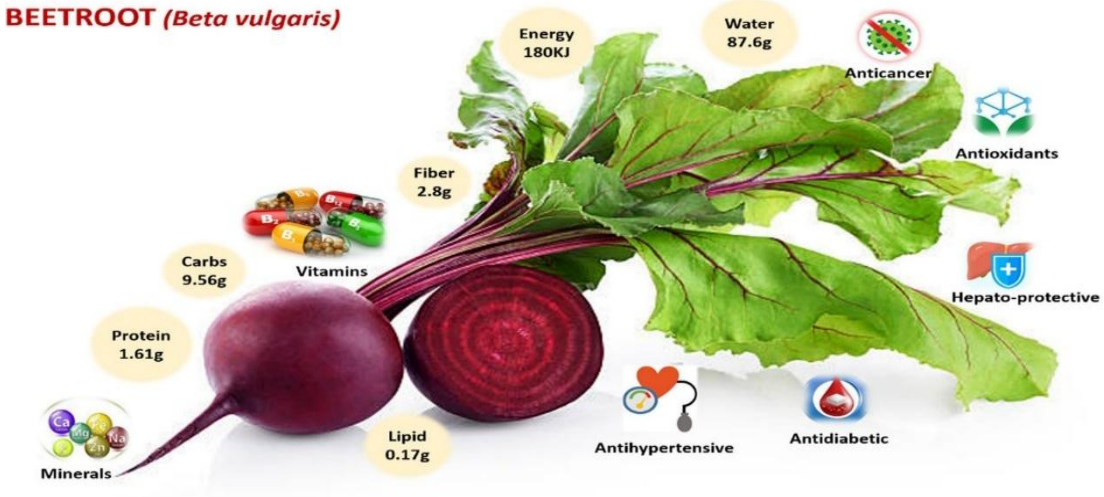


Figure 1.1 Nutritional profile of beetroot.

It can be eaten as a cooked vegetable; by using different types of heat treatment or extracted for its juice to make Beetroot juice. The natural and harmless pigments are also useful in the food industry. Beetroot is a rich source nutrients. The vitamins include folic acid, vitamins A and C, vitamin B6, niacin, and biotin. The minerals content are iron, magnesium, selenium, potassium, calcium, zinc, phosphorus, and sodium. The intense red color of beetroots derives from high concentrations of betalains. Betalains are used as natural colorants by the food industry, The claimed therapeutic use of beetroot includes its antitumor, carminative, emmenagogue and hemostatic and renal protective properties and is a potential herb used in cardiovascular conditions.

The beetroot (Beta vulgaris) being an alkaline food with pH from 7.5 to 8.0 has been acclaimed for its health benefits, in particular for its disease fighting antioxidant potential, B eets are native to the Mediterranean. Although the leaves have been eaten since before written history, the beetroot was generally used medicinally and did not become a popular food until French recognized their potential in the 1800's. Beet powder is used as a coloring agent for many foods. Beets were domesticated in the ancient Middle East, primarily for their greens, and were grown by the Ancient Egyptians, Greeks and Romans. By the Roman era, it is thought that they were cultivated for their roots as well. From the middle Ages, beetroot was used as a treatment for a variety of conditions, especially illnesses relating to digestion and the blood. Bartolomeo Platina recommended taking beetroot with garlic to nullify the effects of "garlic-breath".

Nutritional Profile of *Beta vulgaris L.*

Nutrients	Value per 100 grams (g)
Energy (Kilo Joules, KJ)	180
Nutrients (g) Water	87.6
Protein	1.61
Total Lipid	0.17
Carbohydrate (by difference)	9.56
Sucrose	6.76
Fiber (Total)	2.8

Table 1.1. Nutritional value of beetroot.

Chemical Composition:
Beet root is a leading root vegetable with an exquisite cradle of nutrients, including proteins, sucrose, carbohydrates, vitamins (B complex and vitamin C), minerals, fiber ,They contain an appreciable amount of phenolic compounds and their specific health benefits, as well as some additional aspects of its chemical composition.
Detailed Components and Their Benefits;

Water Content (Hydration)

The high water content in beetroot helps maintain hydration,especially when consumed raw or in juices.

Carbohydrates (Energy Source)

The natural sugars provide a quick source of energy, making beetroot a great option for athletes. Blood Sugar Regulation:
Soluble fiber can help regulate blood sugar levels by slowing down the absorption of sugar.

Vitamins (Folate (B9)

Crucial for pregnant women as it helps prevent neural tube defects in the developing fetus.

Minerals.

Potassium:
Helps balance electrolytes, which is essential for muscle contractions and nerve signaling.

Magnesium:
Plays a role in over 300 biochemical reactions in the body, including protein synthesis and muscle function.
Iron:
Important for energy production and metabolism; can help prevent anemia.

Antioxidants (Betalains)

Anti-inflammatory Properties:
May reduce inflammation and oxidative stress in the body.
Liver Health:
Some studies suggest that betalains may support liver function and detoxification processes.
Cardiovascular Health:
May help lower blood pressure and improve overall heart health by reducing oxidative stress.

Nitrates

Cardiovascular Benefits:
Nitrates are converted to nitric oxide, which can improve blood flow and lower blood pressure.
Exercise Performance:
Some studies indicate that dietary nitrates can enhance exercise performance by improving oxygen utilization.

Amino Acids

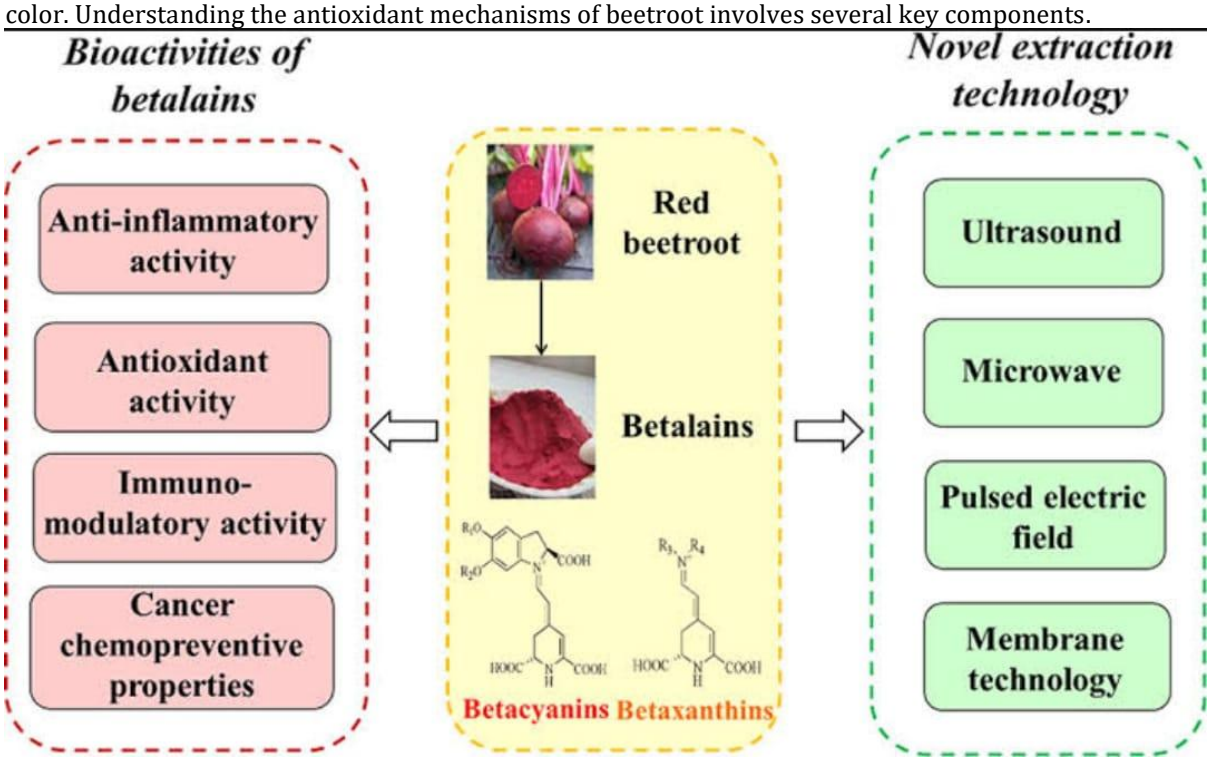
Although beetroot is not a significant source of protein, it does contain amino acids that contribute to overall protein intake when combined with other foods.

Organic Acids

Citric Acid:
Contributes to flavor and may play a role in energy metabolism.
Oxalic Acid:
Present in smaller amounts; while it can bind to minerals like calcium and affect absorption, its levels in beetroot are generally not a concern for most people when consumed in moderation.

Antioxidant Mechanisms of *Beta vulgaris L.*

Beetroot (Beta vulgaris L.) is rich in various antioxidants, primarily betalains, which are responsible for its vibrant red color. Understanding the antioxidant mechanisms of beetroot involves several key components.



Tabel 1.2. Antioxidant Mechanisms of Red beetroot

(1) Betalains :

Betalains are divided into two groups: betacyanins (red-violet pigments) & betaxanthins (yellow-orange pigments).

Mechanism :

Betalains scavenge free radicals, which are unstable molecules that can cause oxidative stress and damage to cells. By neutralizing these radicals, betalains help prevent cellular damage and inflammation.

(2) Vitamin C

Beetroot contains ascorbic acid (Vitamin C), a well-known antioxidant that protects against oxidative stress.

Mechanism :

Vitamin C donates electrons to free radicals, stabilizing them and preventing cellular damage. It also regenerates other antioxidants, such as vitamin.

Bioactive compounds	Source	Mechanism
Betalains	Red Beetroot	➢ Strong antioxidant activity, ➢ Prevent cancer, ➢ reduce cardiovascular diseases, ➢ Strong anti-inflammatory agents, ➢ Anti- hypertensive effect, ➢ Therapeutic effects on metabolic syndrome, ➢ Chemopreventive potential,

		➢ Inhibited oxidative hemolysis in red blood cells,
Betanin Betanidine	Red Beetroot	➢ Inhibit lipid peroxidation, ➢ strong antioxidant activity, ➢ Inhibit breast, colon, ➢ stomach, lung cancer cell, ➢ Anti- hypertensive effect, ➢ Anti- inflammatory,
Betacyanin	Red beetroot	➢ Reduce blood pressure,
Phenolic compounds	Red beetroot	➢ Strong antioxidant activity, ➢ Prevent cancer, ➢ reduce cardiovascular diseases,

Tabel 1.3. The potential health effects of red beetroot.

2.Saffron

Saffron (Crocus sativus) is renowned not only for its culinary and medicinal uses but also for its potent antioxidant activity. The antioxidant properties of saffron have been a focal point of many studies, highlighting its potential in preventing and managing oxidative stress-related diseases. This review explores the antioxidant activity of saffron, focusing on its bioactive compounds, mechanisms of action, and potential therapeutic applications.

Figure 1.2 Nutritional profile of Saffron.

Saffron is derived from the flower of Crocus sativus, which belongs to the family Iridaceae. Here is the detailed taxonomy classification of saffron:

Common Name	Saffron
Kingdom	Plantae
Family	Iridaceae
Class	Liliopsida
Division	Magnoliophyta
Order	Asparagales
Superdivision	Spermatophyta
Genus	Crocus

Table 2.1 Taxonomy Classification,

Key Antioxidant Compounds of Saffron,

(A**) Crocin:**- A water-soluble carotenoid responsible for the yellow color of saffron. Crocin is one of the most potent antioxidants in saffron, scavenging free radicals and reducing oxidative stress in various biological systems.

(B) **Crocetin**:- A dicarboxylic acid derivative of crocin, which also exhibits significant antioxidant properties. It is less water-soluble than crocin but is effective in neutralizing reactive oxygen species (ROS).

(C) **Safranal**:- A volatile compound contributing to saffron' saroma. Safranal has been shown to have moderate antioxidant activity, protecting against lipid peroxidation and DNA damage.

(D) **Flavonoids**:- Saffron contains several flavonoids, which are known for their strong antioxidant effects. These compounds contribute to saffron's ability to scavenge free radicals and chelate metal ions.

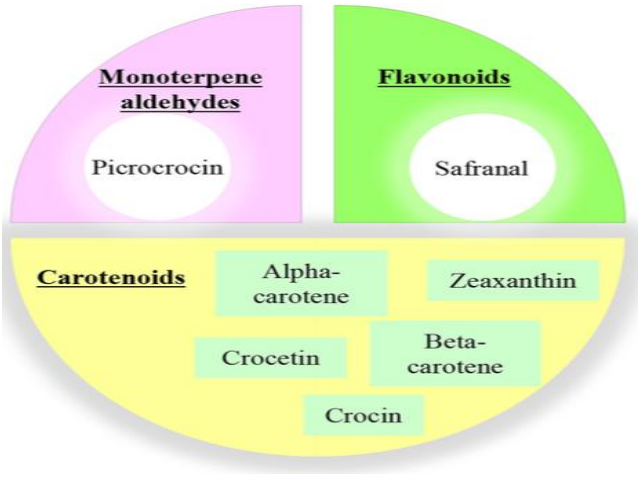


Figure 1.3 Antioxidant Compounds of Saffron

Mechanisms of Antioxidant Action,

The antioxidant mechanisms of saffron are multifaceted and involve several pathways that collectively protect cells from oxidative damage.

(A) **Enhancement of Antioxidant Enzymes:-** Saffron also boosts the activity of endogenous antioxidant enzymes like superoxide dismutase (SOD), catalase, and glutathione peroxidase. These enzymes play a crucial role in the detoxification of reactive oxygen species and in maintaining cellular redox balance.

(B) **Free Radical Scavenging:-** Saffron and its constituents, especially crocin, directly scavenge free radicals such as superoxide anions, hydroxyl radicals, and peroxylradicals. This scavenging activity helps in preventing the initiation of oxidative chain reactions that can lead to cell damage.

(C) **Inhibition of Lipid Peroxidation:-** Lipid peroxidation is a process where free radicals attack lipids in cell membranes, leading to cell damage and death. Saffron has been shown to inhibit this process, primarily through the action of crocin and safranal, which protect cell membranes from oxidative stress.

Medicinal Uses,

Saffron has been widely studied for its potential therapeutic benefits. Traditional medicine systems, such as Ayurveda and Persian medicine, have used saffron for treating a variety of ailments, including respiratory disorders, pain, and menstrual issues. Modern research has expanded on these uses, focusing on saffron's effects on mental health, cardiovascular diseases, and cancer.

(A) **Antidepressant and Mood-Enhancing Effects:-** Several studies have shown that saffron has antidepressant effects comparable to conventional medications like fluoxetine. These effects are attributed to the presence of safranal and crocin, which influence neurotransmitter activity in the brain.

(B) **Antioxidant and Anti-inflammatory Properties:-** Saffron's high levels of crocin contribute to its potent antioxidant capacity, which helps in neutralizing free radicals and reducing oxidative stress. This property is valuable in preventing and managing conditions like cardiovascular diseases, diabetes, and neurodegenerative disorders.

(C) **Anti-cancer Potential:-** Research has indicated that saffron and its constituents may have anti-cancer properties, inhibiting the growth of various cancer cell lines, including those of breast, lung, and prostate cancers. These effects are mainly due to crocin's ability to induce apoptosis (programmed cell death) in cancerous cells.

Therapeutic Applications of Saffron's Antioxidant Activity,

The antioxidant properties of saffron have been explored in various therapeutic contexts, particularly in preventing and treating diseases associated with oxidative stress.

(A)Cardiovascular Health:- Oxidative stress is a key factor in the pathogenesis of cardiovascular diseases. Saffron's antioxidant activity helps in reducing oxidative damage to lipids, proteins, and DNA, thereby protecting the heart and blood vessels from damage. Studies have shown that saffron can reduce cholesterol levels, inhibit platelet aggregation, and improve overall cardiovascular health.

(B) **Neuroprotection:-** Neurodegenerative diseases like Alzheimer's and Parkinson's are associated with increased oxidative stress in the brain. Saffron's antioxidant compounds, particularly crocin, have demonstrated neuroprotective effects by reducing oxidative damage to neurons, improving memory, and delaying the progression of these diseases.

(C) **Anti-cancer Potential:-** The role of oxidative stress in cancer development is well-documented. Saffron has shown potential as an anti-cancer agent by inducing apoptosis in cancer cells and inhibiting the proliferation of various cancer cell lines. The antioxidant activity of saffron plays a crucial role in these effects by protecting normal cells from oxidative damage and inhibiting cancer cell growth.
(D) **Anti-inflammatory Effects:-** Oxidative stress often accompanies inflammation, and saffron's antioxidant properties contribute to its anti-inflammatory effects. By reducing oxidative stress, saffron can modulate inflammatory responses and reduce the production of pro-inflammatory cytokines, thereby alleviating conditions like arthritis and inflammatory bowel disease.

Conclusion

It could be finally concluded that beetroot and saffron is good source of protein, carbohydrate and dietary fiber. The beetroot is good source of betalain, which makes it potential source for exploration and value addition in food beverages in combination with various fruit juices. Saffron's antioxidant activity is a key factor in its therapeutic potential. The bioactive compounds in saffron, particularly crocin, crocetin, safranal, and flavonoids, work through various mechanisms to protect cells from oxidative damage, enhance the body's own antioxidant defenses, and prevent oxidative stress-related diseases.
As research continues to explore these properties, beetroot and saffron may play an increasingly important role in the prevention and management of various health conditions, particularly those linked to oxidative stress. Further clinical studies are needed to fully understand the scope of beetroot and saffron's antioxidant benefits and to optimize its use in therapeutic applications.

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