

## Beetroot-Based Value-Added Products: A New Frontier

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Beetroot (*Beta vulgaris subsp. vulgaris conditiva*) is herbaceous, flowering biennial plant belonging to the Chenopodiaceae family, recognized for its vibrant crimson color. The edible taproot section of the beet plant is known as beetroot. It is one of the richest sources of folate and contains vitamins A, B1, B2, B6, and C. Additionally, beetroot is a good source of calcium, magnesium, copper, phosphorus, sodium, and iron. The presence of heterocyclic nitrogen-based, water-soluble pigments betacyanin and betaxanthin (betalains) are responsible for the purple-red color of the tuber. Historically, beetroots have been used for medicinal purposes, particularly for liver disorders, as they aid in stimulating the liver's detoxification processes. The plant pigment betacyanin, responsible for beetroot's rich purple-crimson color, is a powerful compound believed to suppress the development of certain cancers. Beetroot is also rich in highly bioactive phenolics, such as rutin, epicatechin, and caffeic acid, known for their excellent antioxidant properties. It is a significant source of health-promoting phytochemicals. The polyphenols, carotenoids, and vitamins in beetroot exhibit antioxidant, anti-inflammatory, anticarcinogenic, and hepatoprotective activities and also offer anti-diabetic, cardiovascular disease-lowering, antihypertensive, and wound-healing benefits. Due to these nutrients and bioactive compounds, beetroot and its value-added products provide various health benefits and may help prevent and manage several disorders and diseases (Mudgal *et al.*, 2022).

Beetroot is a prominent root vegetable packed with a rich array of nutrients, including proteins, sucrose, carbohydrates, vitamins (B complex and C), minerals, and fiber. It also contains significant amounts of phenolic compounds, betalains, and antioxidants such as coumarins, carotenoids, sesquiterpenoids, triterpenes, and flavonoids, all of which offer numerous health benefits. Red beetroot is particularly rich in minerals like manganese, iron, sodium, potassium, magnesium, and copper. The

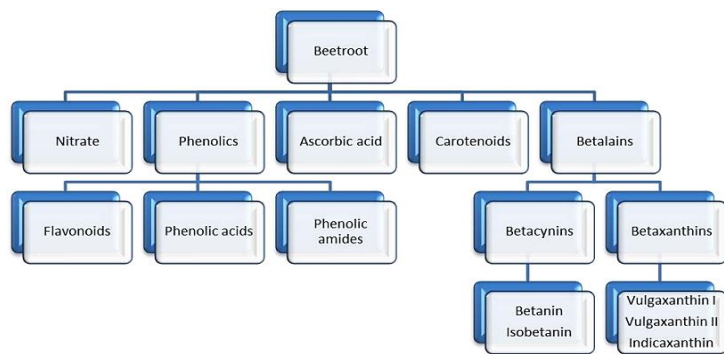
nutritional composition of red beetroot varies depending on the plant's anatomical parts (leaf, stem, root, peel).

**Table 1 Chemical composition and nutritional profile of beetroot**

Nutrients	Value per 100 grams	Nutrients	Value per 100 grams
Energy (KJ)	180	Calcium (mg)	16
Water (gm)	87.6	Phosphorus (mg)	40
Protein (gm)	1.61	Potassium (mg)	325
Total lipid (gm)	0.17	Vitamin C (mg)	4.9
Ash (gm)	1.08	Vitamin B1 (mg)	0.031
Carbohydrate (gm)	9.56	Vitamin B2 (mg)	0.04
Sucrose (gm)	6.76	Vitamin B5 (mg)	0.334
Fiber (gm)	2.8	Vitamin A (IU)	33
Sodium (mg)	78	Vitamin E (mg)	0.30

For example, carotenoids are more concentrated in beet leaves than in the tubers. Beetroot is abundant in antioxidants, vitamins (A, B, C), fiber, and natural dyes, which help protect against heart disease and certain cancers (such as colon cancer). Additionally, beetroots are rich in other valuable compounds like glycine betaine. Beetroot also exhibits potent antioxidant, anticarcinogenic, hepatoprotective, antimicrobial, and anti-inflammatory properties, along with vascular

protective and immune regulatory effects (Chhikara *et al.*, 2019).



**Fig. 2 Potentially bioactive compounds present in beetroot**

### Bioactive compounds in beetroot

Beetroot contains highly active pigments, betalains, ascorbic acid, carotenoids, polyphenols, flavonoids, saponins and high levels of nitrate (644–1800 mg/kg). Some bioactive compounds have been found at low levels such as glycine, betaine and folate.

- **Betalains:** These are pigments responsible for the vibrant red color of beetroot. Betalains possess antioxidant and anti-inflammatory properties, which may help protect cells from oxidative damage and reduce inflammation.
- **Nitrate:** Beetroot is particularly high in dietary nitrate, which has been linked to various health benefits, including improved cardiovascular function, lower blood pressure, and enhanced exercise performance.
- **Phenolic Compounds:** Beetroot contains phenolic compounds such as flavonoids and phenolic acids, which have antioxidant properties and may help protect against chronic diseases such as heart disease and cancer.
- **Carotenoids:** While present in smaller amounts compared to other vegetables, beetroot contains carotenoids such as beta-carotene and lutein, which have antioxidant properties and are beneficial for eye health.
- **Glycine Betaine:** This compound, also known as trimethyl glycine, is found in beetroot and has been studied for its potential health benefits, including supporting liver function and reducing the risk of cardiovascular disease.

### Utilization of beetroot for preparation of various value-added products

Numerous red beetroot-derived dietary supplements and functional foods flood the market, including juices and juice blends, gels, fermented and fractionated juices, dried powders (available in capsules, tablets, and micro-encapsulated formulations), as well as beetroot-enriched bread.

- 1) **Beetroot Jam:** Jam is a product of intermediate moisture that is prepared using the pulp of fruits, sugar, pectin, acid, and other ingredients which lead to keep them for a long time. A good jam has a soft even consistency, without pieces of fruits, a bright color, good flavor, and a semi-jelled structure that is easy to spread. Beetroot is one of the ideal vegetables in preparation of vegetable jam due to its natural deep reddish-purple color. The jam prepared by the mild method with 60 % of raw beetroot pulp and added strawberry flavor (0.5 % w/w) was selected as the best. The TSS content of the final product was found to be 46.1 %, and the pH was 3.8. The developed jam was stored under refrigerated conditions for a period of six months without addition of any artificial preservative (Perumpuli *et al.*, 2018).
- 2) **Gels, juices, and beverages:** Beetroot in the pulp form can also be used as a functional ingredient in probiotic milk gels with enhanced antioxidant properties, total phenolic content, and anthocyanins content with enhanced growth *Lactobacillus acidophilus*. Furthermore, beetroot juice can also be converted into functional gels with high antioxidant properties. Consumption of functional beetroot gel suggests a new nutritional strategy to give high contents of bioaccessible nutrients (nitrate, antioxidants, and potassium) that are potentially relevant to improve cardiovascular health and exercise performance (Ozdemir and Ozcan, 2020).
- 3) **Beetroot Powder:** Beetroot in its fresh form has high water content thus it can be processed into powder form in order to enhance its shelf life. There is growing interest in the use of natural food colors, because synthetic dyes are becoming more and more critically assessed by the consumer. To improve the red color of tomato pastes, sauces,

soups, desserts, jams, jellies, ice creams, sweets and breakfast cereals, fresh beet/beet powder or extracted pigments are used. Use of beetroot extract and powder significantly prevented further development of lipid oxidation in sausages due to the antioxidant properties of beetroot, with a prevalence of betalains and phenolic compounds. Also, the use of beetroot extract and powder positively affected sensory appearance, color, flavor and overall acceptance of the sausages (Ibraheem *et al.*, 2016).

**4) Beetroot Beverages:** Beetroot juice contains antioxidants along with nitrates with potential health benefits and hence work as functional ingredients. Beetroot juice and its extract has wide range of application in many beverages, cereals jams, jellies, candies, ice cream, yoghurt, dairy products, sauces and processed meats. Beetroot juice is reported to help in purification of the blood and identified as a great blood builder being rich in iron content, regenerates and reactivates the red blood cells and delivers fresh oxygen to the body. It is utilized to coloring a variety of foods like dairy products, yogurts, processed cheese, and candy. It changes color on thermal treatment so it is used only in ice-cream, sweets, and another confectionary. Beetroot drink is a good approach for non-dairy probiotic, free from cholesterol and with health promoting components (Deshmukh *et al.*, 2018).

**5) Beetroot Cookies and Candy:** Beetroots are low in calories (about 45 Kcal per 100 g) and have zero cholesterol can be used to improve the nutritional qualities of cookies with fortification of different levels of beetroot powder. Nutritional analysis revealed that the increased substitution level of beetroot powder increased the nutritional content (crude protein, crude fiber and minerals) when compared to control cookies. Beetroot pomace is a good source of dietary fibre, especially the soluble fibre and could be utilized as a source of supplement. Beetroot can be processed into beet root candies. The beetroot candy is a healthy substitute nutritious, healthier and tasty as compared to the artificial flavoured candy available in the local market using ingredients like

pectin, sugar and citric acid in different proportions (Ingle *et al.*, 2017).

**6) Beetroot Bread:** Bread is a staple and economical food that is consumed by the majority of adults in western countries. In addition, bread provides an ideal matrix by which functionality can be delivered to the consumer in an accepted food. Beetroot and broccoli significantly improved bread storage life. Beetroot consistently showed positive effects suggesting its addition to bread could be particularly beneficial (Ranawana *et al.*, 2016).

## Conclusions

The utilization of beetroot in the development of value-added food products holds significant potential due to its rich nutritional profile and versatile applications. Beetroot's high content of vitamins, minerals, and antioxidants makes it an excellent ingredient for enhancing the health benefits of various foods. Its vibrant color and distinctive flavor can be leveraged to create appealing and innovative products that cater to the growing consumer demand for natural and functional foods. Moreover, incorporating beetroot into diverse culinary forms such as juices, snacks, and baked goods not only adds value but also promotes sustainable agricultural practices by maximizing the use of this nutrient-dense crop.

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