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Chemical and functional properties of Beetroot (*Beta vulgaris* L.) for product development: A review

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Abstract

Beet root (*Beta vulgaris* L.) commonly known as 'chukander' are notable for their sweetness, they have the high sugar content, but they are very low in calories. The botanical classification of beetroot as an herbaceous biennial from *Chenopodiaceae* family. Fresh beetroot also supplies nutritional bonus, their green tops are an excellent source of beta-carotene, calcium and iron. It is basically the cool season vegetable crops grown throughout the world. Beetroot is fulfill with the sources as antioxidants and nutrients, including magnesium, sodium, potassium, vitamin C and betalaine and has several varieties with bulb colors ranging from yellow to red. Deep red-colored beet roots are the most popular for human consumption, both cooked and raw as salad or juice. Beetroots contain active compounds such as carotenoids, saponins, betacyanines, betanin, polyphenols and flavonoids. Therefore, beetroot ingestion can be considered a factor in cancer prevention. The betalains which available in beetroot are mainly betacyanins and betaxanthins. Betalains nutritional agent for the prevention and treatment of hypertension and cardiovascular diseases. They have antimicrobial and antiviral effects and also can inhibit the proliferation of cells in human tumor cells. Beetroot candy are also prepared by osmotic dehydration which can be used in bakery products, confectionary, in ice creams etc.

Keywords: Beetroot, betanin, health benefites, pigments

Introduction

The beetroot (*Beta vulgaris*) is an alkaline food with pH in range of 7.5 to 8.0. It is the taproot (bulb) portion of the beet plant. It is grown in temperate countries and biennial plant. The beetroot and its juice are freely consumed for its great taste, nutritional benefit and flavour content. At present its productivity is 20-25 t/ha fruit per year in India (Anonymous, 2013) [1]. Now a days there is growing interest among the people the use of natural food colors, because synthetic dyes are becoming more critically assessed by the consumer. Still, in food processing, as compared with anthocyanins and carotenoids, betalains are less commonly used, although these pigments are water soluble and stable between pH 3 and 7. To improve the red color of tomato pastes, sauces, jams, jellies, ice creams, sweets and breakfast cereals, fresh beetroot or beet powder or extracted pigments are used (Koul *et al.* 2002; Roy *et al.* 2004) [2, 3]. It contributes to consumers' health and wellbeing because it is known to have antioxidants because of the presence of nitrogen pigments called betalains, mainly comprise of red-violet-colored betacyanins (betanin, isobetanin, probetanin and neobetanin) and yellow-orange-colored betaxanthins (Alard *et al.* 1985; Kaur and Kapoor 2002) [4, 5].

In India it is mainly grown for its juice and vegetable value. It contains vitamins A, B1, B2, B6 and C. It is also a good source of calcium, magnesium, copper, phosphorus, sodium and iron (Mathlouthi, 2001) [6]. Its powder is used as a natural red food colorant which used to applied in dry mixes (soups, Indian curry mixes), sweets, jams, jellies, etc. The bright red color of beet root is due to the red pigments known as betalains (Gokhale and Lele, 2011) [7].

India is the second largest producer of vegetables after China with a production of 169.478 million tonnes of vegetables from an area of 9.542 million hectares. Beetroots are generally grown for food uses pickles, salad and juice. Betalains responsible for intense red colour in beet roots are used as natural colorants by the food industry, and also receiving attention due to possible health benefits in humans, especially their antioxidant and anti-inflammatory activities.

They have anti-microbial and anti-viral effects and also can inhibit the cell proliferation of human tumour cells (Georgiev *et al.*, 2010) ^[8].

Beetroot grows plentiful throughout the country, from the hills of south India to the chilly areas of north. India is the second largest producer of vegetable in the world, around 15 per cent vegetable of the world is produced in India. In India beetroot is grown in Uttar Pradesh, Maharashtra, Haryana, West Bengal and Himachal Pradesh on large scale. Dried beetroots can be consumed in the form of chips as a substitute of traditional snacks, that are rich in trans fatty acids (Aro *et al.*, 1998) ^[9] or after easy preparations as a component of instant food (Krejčova *et al.*, 2007) ^[10] Due to the beneficial effects, this vegetable should be consumed regularly in one or the other form. Therefore, there is a need of proper processing and preservation technique so as to get the maximum benefits from beetroot. Nowadays, the people are more health conscious and they want to know the pros and cons of the food which they are consuming. In recent years increased attention has been focused on utilization of healthy foods.

1. Climate

Optimum temperatures for growth and development of beetroot is 15°C to 18°C, with minimums of 5°C and maximums of 24°C. Although beetroot is a cool-season crop, it can tolerate the high temperatures, that soil moisture which is provided during irrigation is adequate. The plant can withstand moderate frosts, but growth will be affected.

2. Soil Requirements

Beetroot can be grown on a wide range of soils, but best results are obtained on well-drained sandy to loamy soils, with pH ranges from 6 to 8. Hard, compacted soils should be avoided, as they resist seedling emergence and symmetrical root development. Heavy clay soils or soils which crust after rain or irrigation may cause establishment problems and the production of misshapen roots. Beetroot prefers a soil pH of 5.8 to 7.0, but can tolerate a pH of up to 7.6. Acid soils are likely to create nutrient deficiency problems and should be avoided. Mature beets are fairly tolerant to salinity, whereas seedlings are relatively sensitive.

3. Growing Period

The growth period is 75 to 90 days in summer, and 105 days to 120 days or longer in winter.

4. Origin and Distribution

The beetroot is indigenous to Asia Minor and Europe. They were first used for food about the third century AD although they had been grown for thousands of years for medicinal purposes. Beetroot has been regarded as a laxative, a cure for bad breath, coughs and headaches, and even as an aphrodisiac. It is grown widely in Germany and France and in lesser amounts in other European countries, Africa, Asia, and South America. Beetroot is now a popular salad vegetable.

5. Rainfall

Beetroot requires a lot of water for fast growth. The volume needed could vary from 2 mm in a cold winter day to 8 mm in a hot summer day.

6. Soil Requirement

Beetroot does best on deep and well-drained, loose, loamy to sandy soils. (Anonymous 2013) ^[11].

7. Morphology of the plant

- **Roots:** The beetroot is a true biennial, producing thickened root and a rosette of leaves during the first year and flowers and seeds the second year. Beetroots are mainly grown for their swollen roots.
- **Stem:** The stem is short and plate, producing simple leaves that are arranged in a The stem is short and plate producing simple leaves that are arranged in a stem is short and plate, producing simple leaves that are arranged in a closed spiral.
- **Leaves:** the leaves are heart shaped. The leaves can also be eaten as spinach.
- **Flower:** Flowers are very small with a diameter of 3 to 5 mm and are produced in dense spikes. They are green or tinged reddish, with five petals.
- **Fruits:** the fruit is a cluster of hard nut lets and dark colour. (Anonymous) ^[12].

8. Varieties

1. Detroit Dark Red

The variety produces perfectly round beet with smooth uniform red skin. The interior colour is dark red with light red zoning. Flesh is tender and fine grained, tops small; leaves dark green tinged with maroon. It is a heavy yielding cultivar. Crop matures in 80-100 days.

2. Crimson Globe

Beet is globular to flatten in shape, medium red in colour with small shoulders. Flesh medium dark Crimson red with indistinct zoning top. Leaves are medium-large, bright green with and have a higher maroon shade. It is a high yielding cultivar.

3. Ooty 1, Crimson Globe, Red Ball, Crosby Egyptian are the popular varieties.

9. Seed rate

About 6 kg seeds are required for a hectare.

10. Preparation of field

The land is ploughed to a fine tilth and ridges and furrows are formed at 30 cm apart.

11. Spacing

30 x30 x10 cm as four rows in each paired row / raised bed system. (Anonymous) ^[13].

Table 1: Names of Beetroot in different languages

Name	Language
Bitá gacha	Bengali
Cuqandar	Hindi
Salada	Gujarati
Bit	Malay
Beet	Punjabi
Carckarai vali kilanku ceti	Tamil
Dumpamokka	Telegu
Gajarugadde	Kannada
Bitá	Marathi

(Anonymous 2014) ^[14]

Chemical properties of beetroot

Beetroots are composed of 87.57g water, 1.61g protein, 0.17g lipids, and 9.56g carbohydrates per 100g. Of the carbohydrates, beets are composed of 29.3% fiber (2.8 g total dietary fiber/ 100 g beet) and 70.7% sugar (6.76 g sugar/ 100 g beets).

Table 2: Nutritional value of 100gm red Beetroot

Water	87.5gm
Energy	43kcal
Fat	0.17gm
Protein	1.61gm
Carbohydrates	9.56gm
Fibre	2.8gm
Potassium	325mg
Sodium	78mg
Phosphate	40mg
Calcium	16mg
Magnesium	23mg
Iron	0.80mg
Zink	0.35mg
Vitamin C	4.9mg`
Vitamin B2	0.040mg
Vitamin B6	0.067mg
Vitamin A	36IU
Vitamin E	0.300mg
Niacin	0.334mg

(USDA, 2011)^[15]**Health Benefits**

Betalains have antiviral effects (Strack *et al.*, 2003) ^[16] and also can inhibit the cell proliferation of human tumour cells (Reddy *et al.* 2005) ^[17]. Consumption of red beet which are rich source of antioxidants can contribute to protection from age related diseases. According to Vinson (1998) ^[18], Zitnanova *et al.* (2006) ^[19] red beet is one of the most potent vegetable with respect to antioxidant activity. Significant amount of vitamin C, Vitamin B1, B2, niacin, B6, B12 are found in beetroot, while the leaves are an excellent source of vitamin A consuming beetroot helps in curing many diseases such as anemia, blood pressure, cancer, dandruff, gastric ulcers, kidney ailments, liver toxicity or bile ailments like jaundice, hepatitis, food poisoning, diarrhoea or vomiting.

In addition to their usefulness as colorants, betalains play an important role in human health because of their pharmacological activities such as antioxidant, anti-cancer, anti-lipidemic and antimicrobial. In addition to the health beneficial compounds, however, beetroots also contain significant quantities of oxalic acid. Oxalic acid is a strong metal ion chelator interfering with iron and calcium metabolism and can lead to the formation of nephritis (Holmes and Assimos, 2004) ^[20].

Medicinal Benefits**1. Beetroot detoxifies the liver**

The Researchers claims that compounds found in beetroot detoxify the liver and have the ability to cure diseases of the digestive system in human being. It encourages liver cleansing, improves liver functioning and protects it from excessive alcohol consumption. Beetroot juice has the ability to cure liver and kidney diseases, particularly the buildup of fatty deposits in the liver caused by alcohol abuse, protein deficiency or diabetes. Beetroot juice can also dissolve kidney stones and prevent its pain.

2. Beetroot combats high blood pressure

People who used to drink two cups of beetroot juice can lower blood pressure within about 60 minutes of drinking the juice with a peak drop occurring 3-4 hours after ingestion. The reduction in blood pressure continued to be observed until up to 24 hours after the juice was ingested.

3. Beetroot boosts Glutathione levels in the body.

It has been found that beetroot increase the body's production of glutathione. This substance, which is naturally produced by the human body, is known as the body's master antioxidant and detoxifier. Virtually every cell of the body uses it to neutralize the toxins.

4. Beetroot juice can provide protection against birth defects.

It is a very good source of folic acid (also called folate). To prevent the possibility of birth defects, doctors recommend the B vitamin folate in a pregnant woman's diet. Folic Acid is a key vitamin for proper fetus development as it helps in the proper development of the infant's spinal column and optimal brain development. Folate is very involved in the production of new cells and the maintenance of existing cells.

5. Lower the cholesterol level

One of the important health benefits of beet juice is its ability to lower bad cholesterol levels and raise healthy LDL cholesterol levels in the body.

6. Anemia

Beets are rich in iron, which is easily assimilated by the body. They build up the hemoglobin and cleanse the blood.

7. Antioxidant

The deep, red pigment betacyanin is a powerful antioxidant and protects against several types of cancer.

8. Cancer

Dr. Alexander Ferenczi successfully treated cancer patients with either raw beet roots or juiced.

9. Colon Health

Beets are full of fiber, which helps to move wastes through the intestines and helps to prevent constipation. Also, the antioxidants found in beets protect against colon cancer.

10. Constipation

The high fiber content of beets makes them excellent to relieve constipation.

11. Eye Health

Traditionally, beetroot juice has been use to improved eye health and fatigue.

12. Heart Disease

The abundance of vitamins and minerals in beetroot helps to protect against heart disease.

13. Inflammation Reduction

The compound called betaline found in red beets can reduce inflammation in joints, bones and blood vessels. This reconstruction in inflammation helps those suffering from asthma and osteoporosis.

14. Menstrual Problems

Beetroot juice has been shows to help correct menstrual problems in women.

15. Pregnant Women

Beets are high in folic acid which helps to prevent birth defects in your unborn baby. Folic acid is important whenever

your body is actively making new cells when healing after physical trauma or when children are growing.

16. Stamina Increase

Drinking beetroot juice boosts stamina and can increase workout time by causing a reduction in the uptake of your oxygen, thus increasing stamina. The natural and unprocessed abundance of carbohydrates found in beets are an excellent source of energy for body. When the Betalaine pigment is absorbed into the blood it can reportedly increase the oxygen-carrying ability of the blood by up to 400 per cent. (Anonymous 2011) ^[21]

Beetroot processing

The beetroot apart from consumption in its fresh form, is also a valuable vegetable used in the food industry to produce dried and frozen food, non-concentrated and concentrated juices as well as natural colorants (betalains) used as additives in food manufacturing. Beetroot peel contained higher antioxidant compounds thus promising a more intense utilization of the peels in food and nutraceutical. Beetroot pigment is used commercially as a food dye (Singh *et al.*, 2014) ^[22].

The aim in food processing of beetroot is to increase its shelf life, so that it is available in the off season also. Many processed value added products are prepared from beetroot vegetable are given in Fig.1.

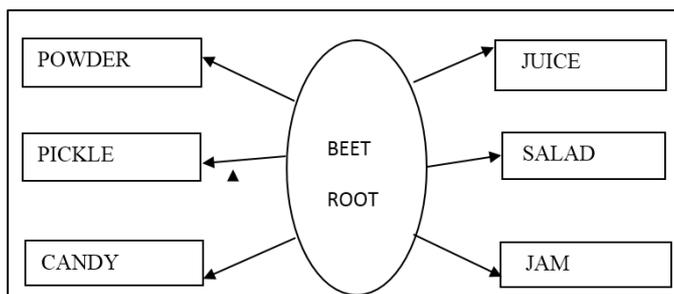


Fig 1: Food application of beetroot

Candy preparation

A whole fruit or its pieces impregnated with cane sugar or glucose syrup and subsequently drained free of syrup and dried, is known as candied fruit. This process is also known as osmotic dehydration. The process for making candied fruit is practically similar to that for preserves. The only difference is that the fruit is impregnated with syrup having a higher per cent of sugar or glucose. A certain amount (25-30 per cent) of invert sugar or glucose, viz., confectioner's glucose (corn syrup, crystal syrup or commercial glucose), dextrose or invert sugar is substituted for cane sugar. The total sugar content of the impregnated fruit is kept at about 75 per cent to prevent fermentation. The syrup left after the candying process can be used for candying of another batch of same kind of fruit after suitable dilution for sweetening product (Anonymous, 2013) ^[23].

In candy-making, controlling the rate and extent of sugar crystallization provides a vast array of different texture. These range from the soft textures of fondants and fudges, where crystallization is minimized, to hard candies where crystallization results in a desired grainy or crystalline structure. The sugar is an essential to perceive the texture of foods commonly referred to as 'mouthfeel'. Considering the importance of acceptability of osmotically dehydrated product in the process of candy making, it is necessary to fix the level

of sugar gain and moisture content in the final product, so that it is acceptable by the consumers.

Conclusion

It is quite evident from this review that the beetroot is an important vegetable and a very good source of vitamin and minerals. Beetroot are basically used for juice, vegetable, salad and powder purposes but it is also use as candy, jam etc. Beetroot peel contains higher antioxidant compounds thus promising a more intense utilization of the peels in food and nutraceuticals. The commercial utilisation of beetroot is as food dye. It changes colour when heated so can only be used in ice-cream, sweets and other confectionary, but it is both cheap and has no known allergic side-effects. Almost all parts of this plant such as leaf, fruit, seed, bark and root are used to cure a variety of diseases.

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