The Pharma Innovation Journal 2023; 12(6): 665-671

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 665-671

www.thepharmajournal.com
Received: 11-03-2023
Accepted: 15-04-2023

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A review on the analysis of nutritional composition of beetroot powder

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DOI: https://doi.org/10.22271/tpi.2023.v12.i6h.20567

Abstract
L. vulgaris, also known as *Beta vulgaris* beetroot, is a biennial (flowers in the second year of development) or, rarely, up to 120 cm (200 cm in the second year) depending on cultivation method. It is a growing perennial herb. Versions are mainly found every two years. The roots of cultivars are dark red, white or yellow, moderately to severely swollen and fleshy. On the other hand, the roots of the wild subspecies are brown, fibrous, and sometimes swollen and woody. Beetroot has been used in traditional medicine for hundreds of years to treat various ailments such as constipation, low libido, intestinal and joint pain, and dandruff. Beets are called Chukandar in Hindi, Kukadala in Punjabi, Bitrut in Telugu, Birut in Malayalam, Bitarta in Marathi, Bitano Kanda in Gujarati, and Pitrut in Tamil. Commercially available beetroot products include: beet energy booster drink, beet cucumber, beet cookie, beet cake.
Recent studies have convincingly suggested that beet consumption has beneficial physiological effects and may lead to improved clinical outcomes in various diseases such as dementia, type 2 diabetes, hypertension and atherosclerosis. Some evidence is shown.

Keywords: Beetroot, beets, betalains, pigments, compounds, essential nutrients, nutritional value

Introduction
The growing interest in so-called "functional foods" and their health and disease benefits is the result of the well-documented health benefits of a diet rich in fruits and vegetables. The root vegetable *Beta vulgaris* rubra, also known as beetroot (hence the name beetroot), has recently received a great deal of attention as a health-promoting food [1]. Reports of the use of beets as a natural remedy date back to Roman times, but scientific interest in the vegetable is only recent. Beetroot is now grown in many countries around the world, is consumed regularly as part of a healthy diet, and is commonly used in food production as food coloring E162 [2].
Beta vulgaris species L. vulgaris, also known as beetroot, is a biennial (flowers in the second year of development) or, rarely, a perennial that grows up to 120 cm (200 cm in the second year) depending on cultivation method. Versions are mostly found every two years of him. The roots of cultivars are dark red, white or yellow, moderately to severely swollen and fleshy, whereas the roots of wild subspecies are brown, fibrous, and sometimes swollen and woody [3].
Beta vulgaris (beet) is his Betoideae subfamily of the Amaranthidae. Beets are called Chukandar in Hindi, Kukadala in Punjabi, Bitrut in Telugu, Birrut in Malayalam, Bitarta in Marathi, Bitano Kanda in Gujrat, and Pitrut in Tamil. Beets are a low-fat vegetable, yet high in carbohydrates, starch, soluble fiber, protein, and low in calories. A, C, E, and K vitamins are abundant in beet roots [4]. They contain significant amounts of folic acid and potent antioxidants like triterpenes, sesquiterpenoids, carotenoids, coumarins, flavonoids (such as tiliroside, astragalin, rhamnocitrin, rhamnetin, and kaempferol), betalains, and phenolic compounds. They also contain important amounts of B-vitamins (B1 thiamine, B2 riboflavin, Saponins, alkaloids, amino acids (threonine, valine, cystine, methionine, isoleucine, leucine, lysine, phenylalanine, histidine, arginine, glutamic acid, proline, alanine, and tyrosine- in leaves), and tannins are some additional bioactive substances that are present bone health), magnesium, potassium, sodium, phosphorus, iron, zinc, copper, boron, silica, and selenium are abundant in beet roots [5]. Recent research has shown convincing evidence that eating beets delivers positive physiological effects that may translate to better clinical results for a number of illnesses, including dementia, type 2 diabetes, hypertension, and atherosclerosis [6, 7]. Numerous studies demonstrate that beetroot, when administered acutely as a juice supplement or in bread, dramatically lowers both systolic and diastolic blood pressure.

This is especially true for hypertension, which has been the focus of many treatment strategies [8, 9]. Several review articles have summarized additional discussion regarding the antihypertensive effects of beetroot. Beets are high in inorganic nitrates (250 mg/kg of live weight), which negatively affect the vascular system. Rather, nitrate's beneficial benefits are thought to result from its biotransformation to nitric oxide (NO), a versatile messenger molecule with important vascular and metabolic functions. Nitrate itself is not thought to mediate specific physiological functions [3, 7]. The nitrate-mediated formation of NO requires several sequential steps, which are well documented in the literature. Nitrate absorption first enters the systemic circulation through the upper small intestine. Next, 25% of the circulating nitrate is thought to reach the intestinal-salivary circuit, where microbes on the underside of the tongue either bioactivate salivary nitrate or convert it to nitrite [10].

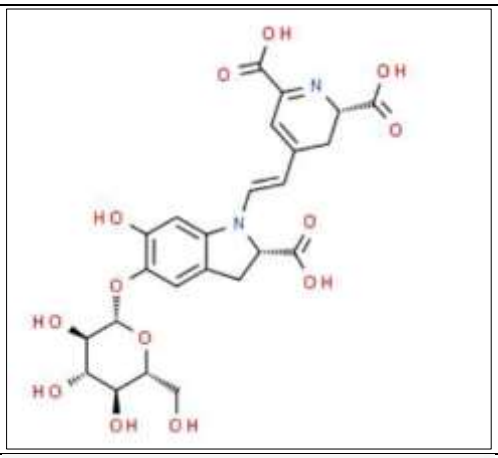
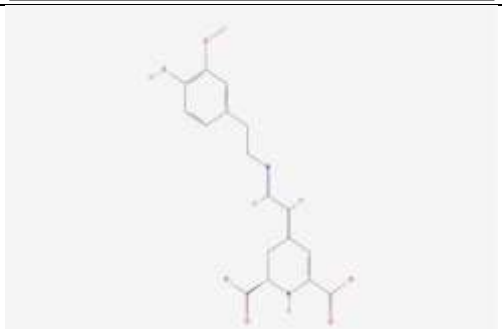
Functional and chemical properties

Beets are high in betalains. Betacyanins (red-violet pigments) and betaxanthins (yellow-orange pigments) are the two sub-classes of betalains, according to [16]. They have antibacterial and antiviral activities, as well as the ability to inhibit the proliferation of human cancer cells [17]. Consuming red beets, which are abundant in antioxidants, can help prevent age-related diseases. According to [18], red beetroot is one of the vegetables with the highest antioxidant activity.

Betacyanins, according to [19] and [20], are a class of compounds with antioxidant and radical-scavenging characteristics. Furthermore, in culture, they inhibit the proliferation of bladder and cervical cancer cells [21]. Red beetroot also serves as an antioxidant [22]. According to (23), drinking one dose of red beetroot juice increased urine excretion of antioxidant compounds such as betalains. Betalains and other phenolic chemicals present in red beets improve human antioxidant status and prevent lipid oxidative damage.

The antioxidant activity of red beetroot is linked to antioxidants' involvement in scavenging free radicals and, as a result, in the prevention of diseases such as cancer and cardiovascular problems [24]. Furthermore, betalains, which increase oxidative resistance, have been demonstrated to enrich human low density lipoproteins with antioxidant activity [25].

Table 1: Chemical structure in beetroot

Pigments	Chemical formula	Reference
Betacyanin C24H26N2O13		National Center for Biotechnology Information (2023).
Betaxanthin C18H18N2O6-2		

As a rich and nutritional source, beetroot is recognised to have health-promoting benefits, anti-oxidant and anti-inflammatory effects, anti-carcinogenic and anti-diabetic activity, addition to protective, hypotensive, and wound healing properties. It is worth noting that the bulk of current studies on beetroot supplements, notably those focusing on its hypotensive and ergogenic properties, have highlighted the critical role of inorganic NO3 in the therapeutic impact of this crop and its byproducts. Beetroot contains a variety of biologically active phytochemicals, including betalains (Such as betacyanins and betaxanthins), flavonoids, polyphenols, saponins, and inorganic nitrate (NO3). It is also rich in minerals such as potassium, sodium, phosphorus, calcium, magnesium, copper, iron, zinc, and manganese (1). Betalains come in two forms i.e. betacyanin (red-violet pigment) and betaxanthin (yellow-orange pigment) and are recognisable commercially as a food dye due to non-precarious, non-toxic, non-carcinogenic and non-poisonous nature. (26). Alphalipoic acid, an antioxidant found in beets, may help diabetes patients' blood sugar levels drop, their insulin sensitivity rise,

and their bodies resist changes brought on by oxidative stress. Beetroot helps to avoid constipation and encourage regularity for a healthy digestive tract because of its high fibre content. Beetroot contains choline, a crucial and multifunctional vitamin that supports learning, memory, muscle action, and sleep. In addition, choline aids in the maintenance of cellular membrane structure, the transmission of nerve impulses, the absorption of fat, and the reduction of chronic inflammation. [27].

500 ml of beetroot juice was consumed by healthy volunteers as part of a 2008 study on hypertension by [29] who discovered that the participants' blood pressure was dramatically decreased after consumption. Researchers postulated that this was probably caused by the high nitrate levels in beet juice and that vegetables high in nitrate could prove to be a cheap and efficient strategy to treat blood pressure and cardiovascular diseases [28].

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

Nutritional properties

Table 2: Nutritional value of 100 gm red beetroot

Moisture	87.4 ±0.3%
Energy	43 kcal
Ash content	1.4 ±0.2%
Marco nutrients	
Carbohydrates	9.56 gm
Fat	0.17 gm
Protein	1.61 gm
Fibre	2.8 gm
Micro nutrients	
Potassium	325 mg
Sodium	78 mg
Phosphorus	40 mg
Calcium	16 mg
Magnesium	23 mg
Iron	0.80 mg
Zinc	0.35 mg
Vitamins	
Vitamin A	361 U
Vitamin B1	0.042 mg
Vitamin B2	0.040 mg
Vitamin B3	0.334 mg
Vitamin B5	0.155 mg.
Vitamin B6	0.067 mg
Vitamin B7	ND
Vitamin B9	109 mg
Vitamin B12	ND
Vitamin C	4.9 mg
Vitamin D	ND
Vitamin E	0.300 mg
Vitamin K	0.3 mg
Pigments	
Betacyanin	75–95%

(30) (31)

Beetroot is Packed with essential nutrients, beetroots are a great source of fib er, folate (vitamin B9), manganese, potassium, iron, and vitamin C. Beets mainly consist of water (87%), carbs (8%), and fiber (2–3%).

Harvesting and handling

Beetroot farming is done through seed, which is take about 2 – 3 months to grow (32). Beetroot grows well in deep and well-drained, loose, loamy, sandy soils with a temperature ranging from 4.5 to 30 °C for seed germination. Beetroot needs a pH of 5.8 to 7.0 and it can tolerate a pH of up to 7.6 [33]. The advantage of fertilizers based on soil testing is an vital tool to prescribe nutrient doses for beetroot. The quantity of fertilizers that could be contributed to beetroot is 40 kg nitrogen (N), 21 kg phosphorus pentoxide, and 30 kg potassium oxide [33]. Beetroot can be harvested from early summer through to mid-autumn, which is normally ready for harvest between 75 and 90 days in summer and 100 and 120 days in winter [34]. In India beetroot is grown mainly in Haryana, Uttar Pradesh Himachal Pradesh, West Bengal, and Maharashtra [35]. Beetroot stored in the ground (field) or mechanically cooled rooms. Cold storage is a common method for prolonging the shelf life of red beetroot [36]. In further case, storage is limited to low temperatures for around 7-10 days. The optimal conditions are achieved by storing them in the fridge at 0 ºC and 95% of relative moisture [33]. Beetroot is grown and consumed in both raw and cooked form all over the world owing to its high nutritive and medicinal value [27]. Beetroot consists of various bioactive compounds that can exhibit health-promoting effects, including betalains, ascorbic acid, flavonoids, carotenoids, polyphenols, saponins, and high levels of nitrate [39].

Table 3: Health benefits

Health Benefits	Key findings	References
Antimicrobial	• Beetroot effectively reduces the infection of *Salmonella typhimurium*, *Bacillus cereus*, and *Staphylococcus*. • Beetroot's main compound is Betalains, which could suppress Gram- negative bacteria infection e.g.,	[36, 40]
Anti-Cancerous	• Beetroot contains the compound betacyanin which can detoxify the body of hazardous chemicals and prevent the formation of tumours in the body. • Betacyanin protects cells against peroxidation and DNA damage, has a hepatic protective effect, and exhibits anticancer properties. • This particular compound betacyanin is also known to have a marked effect on cancers including lung, skin, leukaemia, breast, testicular, and especially stomach cancer.	[40]
Hyperlipidaemia	• Betanins in beetroot can regulate blood lipids by scavenging lipid free radicals to inhibit peroxidase, nitrite oxidoreductase, and LDL. • Betalain can inhibit the rise of short-chain fatty acids and total serum cholesterol by enhancing the excretion of bile acids. • Betalain contributes to the effective suppression of neutrophil oxidative metabolism and could reduce body fat content. Overall, betalains have great potential for the treatment of hyperlipidaemia.	[39]
Anti-inflammatory	• Inflammation is an adaptive response and a complex physiological process caused by detrimental stimuli and conditions related to pathogen-associated molecular patterns and antigens. • The most abundant betalain in beetroot was found to possess anti- inflammatory activity through inhibition of cyclooxygenase, hypochlorous acid scavenging, and oxidants produced by neutrophils during the inflammation reaction. • Betalains along with other phenolic compounds decrease the oxidative damage of lipids and can also reduce inflammation in joints, bones, and blood vessels.	[37, 40]
Antioxidant	• The major betalains in beetroot, the antioxidant capacity of betanin, is gradually receiving greater attention in response to health benefits. • It can scavenge DPPH (2,2diphenyl-1-picrylhydrazyl), hydroxyl- radicals, superoxide, and galvinoxyl in a concentration-dependent manner and prevent DNA damage induced by hydrogen peroxide. • Beetroot also contains a considerable amount of polyphenols and phenolics, and a small quantity of vitamin C and vitamin E, which have been proven to the great antioxidant ability by protecting cells from oxidative stress.	[41, 39]
Improve Cognitive Function	• Beetroot is a rich source of nitrate, which is converted to nitric oxide • (NO). • NO has pleiotropic effects on the brain and improves cognitive function. • Nitric oxide plays an important role in the regulation of cerebral blood flow (CBF), neurotransmission, and neurovascular coupling. • Nitric oxide works as a retrograde neurotransmitter in synapses, allows the brain blood flow, and also has important roles in intracellular signaling in neurons from the regulation of the neuronal metabolic status to the dendritic spine growth. • The compound betanin in red beetroot helps to reduce the accumulation of inappropriate proteins in the brain (a process that is associated with Alzheimer's disease).	[37]
Vasodilation	• Nitric oxide, which is present in beetroot causes vasodilation of blood vessels and increases blood flow. • Nitric oxide regulates vascular tone by diffusing across endothelial cells, reaching vascular smooth muscle cells, and, through soluble guanylate cyclase, activates the sarcoplasmic Ca2+ pump, decreasing intracellular Ca2+ and promoting vasodilation.	[42]
Hyperglycaemia	• Dietary nitrate is a key bioactive within beetroot, as nitrate can be broken down into nitric oxide (NO), which plays a pivotal role in regulating glucose metabolism. It acts as anti-hyperglycaemia • Nitric oxide inhibits the breakdown of glucose in the saliva, leading to overall improvements in glucose control. • It mediates glucose uptake from the intestines and skeletal muscle and could play an important role in the regulation of blood glucose levels.	[36, 39]
Dementia	• Beetroots are rich in vitamins. They have an important content of B-vitamins (B1 - thiamine, B2 - riboflavin, B3 -niacin, B5 -pantothenic acid, B6 -pyridoxine, B9 -folates and B12-cyancobalamin. • These B vitamins help to reduce the effect of dementia and the loss of memory by increasing the blood flow to the brain.	[43]
Anti-osteoporosis	• The high level of vitamins A, K, and C is important for the production of a protein essential for bone health. • Beetroot contains the minerals potassium, calcium, and magnesium, which help prevent the loss of bone density over time and lower the risk for osteoporosis.	[41]
Anaemia	• Beetroot excellent source of vitamin, C as well as iron and folic acid, which helps cure many conditions and illnesses such as anaemia. • This content is useful for people with anaemia or low haemoglobin; it facilitates the absorption of iron into the bloodstream, as a result of which there is an increase in blood count and oxygen-carrying capacity in the red blood cells.	[43, 33]
Constipation	• Beetroots are high in fiber, which helps to move waste through the intestines and prevent constipation. • The cellulose content of the beetroot acts as a bulk residue. It increases peristalsis and eases the	[36]

	passage of stool, hence its regularly prevents habitual constipation	
Cardiovascular Disease	• Beetroot good source of Phytosterols and nitrate. Which can dramatically bring down high blood pressure. High blood pressure or hypertension is one of the main causes of diseases like strokes and heart attacks. • Phytosterols lower the body's cholesterol levels by promoting cholesterol excretion and also the decreasing risk of cardiovascular disease.	[44]
Improve athletic performance	• The nitrate in beetroot decomposes into nitrite and subsequently converts to nitric oxide (NO) and other nitrogen-active intermediates that affect the physical performance of athletic Population.	[39]
	• Beetroot capacity to increase muscle blood flow, improve oxygen utilization, reduce exercise energy consumption, and thus improve exercise performance. • Beetroot also attenuates muscle soreness in certain types of exercise.	

Value added products

Table 4: Being high in antioxidants, vitamins and minerals, Beetroots are also useful in making commercial products too, such as

S. No.	Product name	Composition	Significant findings	Reference
1.	Beetroot energy booster drink	Beetroot crude juice (350 ml), carrot crude juice(350 ml), cucumber crude juice (87.5 ml), lemon crude juice (87.5 ml), water for dilution (125 ml), sugar (30 gm), and salt (1 tbsp)	• Cardiac glycosides were found to be in good amount, phytosterol in strong amount, phenolic compounds in good amount and terpenoids in moderate amount • The antioxidant activity increases along with the increase in beetroot juice concentration. • The acidity of energy drink (PH – 3-4) was attributed to the content of vitamin C, therefore, becoming more resistant to bacterial decomposition.	[12]
2.	Beetroot flavoured milk	The standardized and preheated milk (5 part), pure beetroot juice (1 part) and sugar (30 g)	• Cardiac glycosides were found to be in moderate amount, phytosterol in moderate amount, terpenoids in good amount and phenolic compounds were absent. • Nutraceutical products containing beetroot are enriched with optimum quantities of proteins and fats and low carbohydrates at a stable pH with adequate total energy content.	[12]
			• Higher water, protein, lactose, and solid non-fat are present in flavoured milk compared with unflavoured milk	
3.	Fresh beetroot incorporated in potato-based snack pellets	Potato flakes (25 gm), potato grits (25 gm), potato starch (20-50 gm) and fresh beetroot pulp (2.5- 30 gm)	• With an increase in beetroot pulp concentration, an increase in the total protein, ash content, fibre, TPC and antioxidant activity was observed. • However, the hardness of the final product and bulk density was found to be decreased.	[45]
4.	Beetroot lemon pickle	Fresh beetroot (600 gm), lemon (400 gm), salt (150 gm), oil (50-60 gm), turmeric powder (40 gm), soyabean oil (23–30 ml), chilli powder (20–25 gm), fenugreek (7– 10 gm), cumin seeds (20– 30 gm), black pepper (3-5 gm), clove (3-5 gm), asafoetida (1-2 gm).	• Research study suggested that optimal conditions(pH, acidity, humidity, temperature) must be maintained in order to extend the shelf-life of a pickle. • The temperature maintained should be between 15-20 degrees C to allow proper fermentation to occur.	[13]
5.	Beetroot biscuits	Beetroot powder (0 – 15 gm), wheat flour (85– 100 gm), sugar (50 gm), fat (15 ml), curd (25 ml), baking soda (2.5 gm), vanilla essence (1ml)	• Biscuits produced by incorporating 5gm beetroot powder is most acceptable among other samples • With an increase in beetroot concentration in biscuits, fibre, protein content, antioxidants, betanin, choline, and other micronutrients (calcium, iron, phosphorus, magnesium, folate, Vit-C) were found to be increased along with the increase in hardness and redness of biscuits.	[14]
6.	Beetroot cake	Beetroot powder (5 gm – 20 gm), wheat flour (80-100 gm), sugar (80 gm), oil (82 ml), milk powder (4.5 gm), egg (4), baking powder (1.8 gm), vanilla essence (1 ml)	• On the basis of sensory analysis, a sample containing 15 g beetroot powder was found to be the most acceptable. • With a decrease in beetroot powder concentration, fat and carbohydrate content were found to be increased from 21.59 g to 21.63 g and 34.28 g to 40.42 g respectively. • Similarly, the protein content, ash content, and dietary fibre were also increased with an increase in beetroot powder concentration.	[15]

Conclusion

Beetroot, is a biennial (flowers in the second year of development) that can grow up to 120 cm (200 cm in the second year) depending on growing method. It is a growing perennial herb. Versions are generally found every two years. Cultivar roots are dark red, white, or yellow, moderately to severely swollen, and meaty. The roots of the wild subspecies, on the other hand, are brown, fibrous, and often bloated and woody.

For hundreds of years, beetroot has been used in traditional medicine to cure a variety of diseases such as constipation, low libido, intestinal and joint discomfort, and dandruff. Beets are a low-fat vegetable that is also abundant in carbs, starch, soluble fibre, protein, and has a low calorie count. Vitamins A, C, E, and K are rich in beetroot roots. They are high in folic acid and antioxidants such as triterpenes, sesquiterpenoids, carotenoids, coumarins, flavonoids (such as tiliroside, astragalin, rhamnocitrin, rhamnetin, and kaempferol), betalains, and phenolic compounds.

Declarations

Author and contributions

AD and AM are the sole authors of the review article. PC supervised the work and edited the manuscript. DG have contributed equally for the literature collection, manuscript documentation and its revision.

Competing interest

There are no conflicts of interests to declare.

References

1. Mirmiran P, Houshialsadat Z, Gaeini Z, Bahadoran Z, Azizi F. Functional properties of beetroot (*Beta vulgaris*) in management of cardio-metabolic diseases. Nutrition & metabolism. 2020;17:1-15.
2. Elleuch JJM, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H. Dietary fibre and fibre- rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food chemistry. 2011;124(2):411-421.
3. Jastrebova J, Witthöft C, Grahn A, Svensson U, Jägerstad M. HPLC determination of folates in raw and processed beetroots. Food Chemistry. 2003;80(4):579-588.
4. Katiyar R, Chen CW, Singhania RR, Tsai ML, Saratale GD, Pandey A, *et al*. Efficient remediation of antibiotic pollutants from the environment by innovative biochar: current updates and prospects. Bioengineered. 2022;13(6):14730-14748.
5. Butt MS, Randhawa MA, Shahid M. Extraction, characterization and optimization of betalains from red beetroot using response surface methodology. Pakistan Journal of Agricultural Sciences. 2020, 57(2).
6. Silva DVTD, Baiao DDS, Ferreira VF, Paschoalin VMF. Betanin as a multipath oxidative stress and inflammation modulator: A beetroot pigment with protective effects on cardiovascular disease pathogenesis. Critical Reviews in Food Science and Nutrition. 2021;62(2):539-554.
7. Babarykin D, Smirnova G, Pundinsh I, Vasiljeva S, Krumina G, Agejchenko V. Red beet (*Beta vulgaris*) impact on human health. Journal of biosciences and medicines. 2019;7(3):61-79.
8. Ashraf S, Sayeed SA, Ali R, Vohra F, Ahmed N, Alam MK. Assessment of potential benefits of functional food characteristics of beetroot energy drink and flavored milk. BioMed Research International; c2022.
9. Khandekar SA, Kamble PS, Badarkhe VG. Production characterization and preservation of beetroot lemon by pickling. Journal of Pharmacognosy and Phytochemistry. 2020;9(4S):103-106.
10. Srivastava S, Singh K. Physical, Sensory and nutritional evaluation of biscuits prepared by using beetroot (*Beta vulgaris*) Powder. Int. J Innov. Res. Adv. Stud. 2016;3:281-283.
11. Lucky AR, Al-Mamun A, Hosen A, Toma MA, Mazumder MAR. Nutritional and sensory quality assessment of plain cake enriched with beetroot powder. Food Research. 2020;4(6):2049-2053.
12. Hájos MT, Varga IS, Lugasi A, Fehér M, Bányai ÉS. Correlation between pigment contents and FRAP values in beet root (*Beta vulgaris* ssp. esculents var. rubra). International Journal of Horticultural Science. 2004;10(4):85-89.
13. Al-aboud NM. Effect of red beetroot (*Beta vulgaris* L.) intake on the level of some hematological tests in a group of female volunteers. ISABB Journal of Food and Agricultural Sciences. 2018;8(2):10-17.
14. Kovačević SZ, Tepić AN, Jevrić LR, Podunavac-Kuzmanović SO, Vidović SS, Šumić ZM, *et al*. Chemometric guidelines for selection of cultivation conditions influencing the antioxidant potential of beetroot extracts. Computers and Electronics in Agriculture. 2015;118:332-339.
15. Gandía-Herrero F, Escribano J, García-Carmona F. Biological activities of plant pigments betalains. Critical reviews in food science and nutrition. 2016;56(6):937-945.
16. Pedreno MA, Escribano J. Studying the oxidation and the antiradical activity of betalain from beetroot. Journal of Biological Education. 2000;35(1):49-51.
17. Gengatharan A, Dykes GA, Choo WS. Betalains: Natural plant pigments with potential application in functional foods. LWT-Food Science and Technology. 2015;64(2):645-649.
18. Georgiev VG, Weber J, Kneschke EM, Denev PN, Bley T, Pavlov AI. Antioxidant activity and phenolic content of betalain extracts from intact plants and hairy root cultures of the red beetroot *Beta vulgaris* cv. Detroit dark red. Plant foods for human nutrition. 2010;65:105-111.
19. Gengatharan A, Dykes GA, Choo WS. Betalains: Natural plant pigments with potential application in functional foods. LWT-Food Science and Technology. 2015;64(2):645-649.
20. De Azeredo HMC, Pereira AC, De Souza ACR, Gouveia ST, Mendes KCB. Study on efficiency of betacyanin extraction from red beetroots. International journal of food science & technology. 2009;44(12):2464-2469.
21. Hadipour E, Taleghani A, Tayarani-Najaran N, Tayarani-Najaran Z. Biological effects of red beetroot and betalains: A review. Phytotherapy Research. 2020;34(8):1847-1867.
22. Arshad M, Ashfaq M, Tariq M, Parveen I, Khalid S, Faridi TA, *et al*. Bio-Active Potential of Naturally Coloured Foods and Their Nutraceutical Significance; c2019.
23. Shuaibu BS, Aremu MO, Kalifa UJ. Chemical composition and antioxidant activities of beetroot peel.

Afr. J. Eng. Environ. Res. 2021;2:62-73.
24. Siervo M, Lara J, Ogbonmwan I, Mathers JC. Inorganic nitrate and beetroot juice supplementation reduces blood pressure in adults: a systematic review and meta-analysis. The Journal of nutrition. 2013;143(6):818-826.
25. Beetroot CPU. Standardization of innovative salubrious Indian; c2011.
26. Kale R, Sawate AR, Kshirsagar R, Patil B, Mane R. Studies on evaluation of physical and chemical composition of beetroot (*Beta vulgaris* L.). International journal of chemical studies. 2018;6(2):2977-2979.
27. Mampa SS, Maboko MM, Soundy P, Sivakumar D. Nitrogen application and leaf harvesting improves yield and nutritional quality of beetroot. HortTechnology. 2017;27(3):337-343.
28. Akan S, Horzum Ö. Preharvest Nitrogen and Boron Application Preserve Quality Characteristics of Red Beet Under Storage Conditions. Gesunde Pflanzen. 2023;75(1): 127-138.
29. Katharine SP, Santhi R, Chandrasekhar CN, Maragatham S, Sellamuthu KM. Evaluation of soil test crop response based integrated plant nutrition system (STCR-IPNS) recommendations for transgenic cotton on Inceptisol. Research on Crops. 2014;15(1):226-231.
30. Van Hooft JE, Van Halsema EE, Vanbiervliet G, Beets-Tan RGH, DeWitt JM, Donnellan F, *et al*. Leitlinie der Europäischen Gesellschaft für Gastrointestinale Endoskopie (ESGE) zum Einsatz von selbstexpandierenden Metallstents bei Obstruktionen durch Kolonkarzinome und extrakolische Karzinome. Endoskopie heute. 2014;27(04):246-255.
31. Dhiman A, Suhag R, Chauhan DS, Thakur D, Chhikara S, Prabhakar PK. Status of beetroot processing and processed products: Thermal and emerging technologies intervention. Trends in Food Science & Technology. 2021;114:443-458.
32. Clifford T, Bell O, West DJ, Howatson G, Stevenson EJ. Antioxidant-rich beetroot juice does not adversely affect acute neuromuscular adaptation following eccentric exercise. Journal of sports sciences. 2017;35(8):812-819.
33. Rojas-Méndez KJ, Sánchez Segura L, Chagolla A, Lino B, González de la Vara LE. Voltage-dependent anion-selective channels and other mitochondrial membrane proteins form diverse complexes in beetroots subjected to flood-induced programmed cell death. Frontiers in Plant Science. 2021;12:714847.
34. Guo Z, Ge X, Li W, Yang L, Han L, Yu QL. Active-intelligent film based on pectin from watermelon peel containing beetroot extract to monitor the freshness of packaged chilled beef. Food Hydrocolloids. 2021;119:106751.
35. Mudgal D. Nutritional composition and value added products of beetroot: A review. Journal of Current Research in Food Science. 2022;3(1):01-09.
36. Giampaoli O, Ieno C, Sciubba F, Spagnoli M, Miccheli A, Tomassini A, *et al*. Metabolic Biomarkers of Red Beetroot Juice Intake at Rest and after Physical Exercise. Nutrients. 2023;15(9):2026.
37. Chalabi M, Fanchi LF, Dijkstra KK, Van den Berg JG, Aalbers AG, Sikorska K, *et al*. Neoadjuvant immunotherapy leads to pathological responses in MMR-proficient and MMR-deficient early-stage colon cancers. Nature medicine. 2020;26(4):566-576.
38. Masih D, Singh N, Singh A. Red beetroot: A source of natural colourant and antioxidants: A review. Journal of Pharmacognosy and Phytochemistry. 2019;8(4):162-166.
39. Lisiecka K, Wójtowicz A. Effect of fresh beetroot application and processing conditions on some quality features of new type of potato-based snacks. LWT. 2021;141:110919.