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A DETAILED REVIEW OF BEETROOT (BETA VULGARIS L.) BIOACTIVE COMPONENTS AND USED IN THE FOOD AND PHARMACEUTICAL INDUSTRIES

Netra Pal[1], Dr. Sanjeev Kumar[2], Km. Kajal Rani[3], Lalita Tyagi[4], Ranveer Singh[5] and Km. Shiva*

[1]Principal, Mit Institute of Technology, Meerut Uttar Pradesh.
[2]Professor, Bareilly International University, Department BIU College of Pharmacy, Bareilly Uttar Pradesh.
[3]Research Scholar, Meerut Institute of Engineering and Technology, Meerut Uttar Pradesh.
[4]Assistant Professor, Kalka Group of Institutions Partapur by Pass, Meerut Uttar Pradesh.
[5]Principal, Shree Ram College of Pharmacy, Meerut Uttar Pradesh.
*NGI College of Pharmacy, Near SVBP University, Modipuram, Meerut Uttar Pradesh.

***Corresponding Author: Km. Shiva**
NGI College of Pharmacy, Near SVBP University, Modipuram, Meerut Uttar Pradesh.

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ABSTRACT

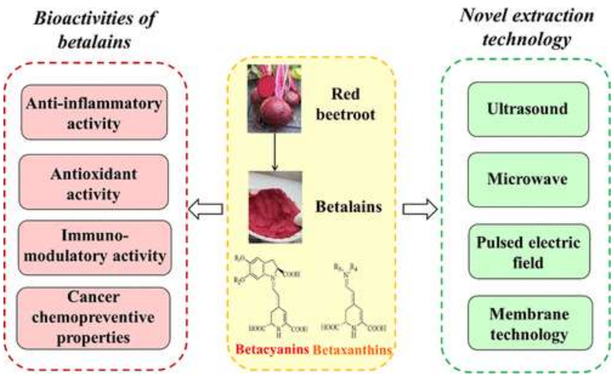
Beetroot, a nutritious root vegetable, is commonly consumed as a food additive due to its rich source of essential nutrients such as potassium, iron, magnesium, and vitamin B-6. These nutrients play a vital role in maintaining our overall health. Moreover, beetroot possesses remarkable properties including high antioxidants, anti-inflammatory, antimicrobial, antiviral, hepatoprotective, antidiabetic, and anticancer properties. The vibrant red color of beetroot can be attributed to the presence of water-soluble pigments called betalains, which are nitrogen-containing compounds derived from indole. These betalains have been scientifically proven to combat oxidative and nitrative stress by scavenging DPPH, protecting DNA from damage, and reducing LDL cholesterol levels. Recent research has extracted a peptide, a small protein molecule, from beetroot. This peptide demonstrates the ability to inhibit a specific enzyme responsible for breaking down messenger molecules in the body. Due to its highly stable molecular structure and pharmacological characteristics, the beetroot peptide shows promising potential for the development of medications targeting inflammatory disorders, including autoimmune and neurological diseases. The objective of this review is to gain a deeper understanding of the beneficial properties of beetroot ingredients, both for their utilization in food preparation and their potential in medicine development.

KEYWORDS: Beetroot, betalains, nitrate, antioxidants, inflammation, oxidative stress.

INTRODUCTION

These days, a significant portion of customers strongly favour "functional foods" to enhance their diets and maintain their health.[1] The beetroot (Beta vulgaris) has gained popularity recently as a potential "functional food" in this regard. Preclinical trials have advanced, giving customers more information about the biological effects of beetroot. To fulfil the growing demand, beetroot is now widely grown.[2] The EU produces the most sugar beets in the world, with 1.74 million hectares under cultivation as of 2018—roughly 50% of the total production. Since joining the EU, the Czech Republic, which has a long history of farming sugar beets, has contributed 4.4% of the EU's total production. With a yield of 71.2 t/ha, the cultivation area increased from 157 thousand hectares in 1980 to 50 thousand hectares in 2008 to 65 thousand hectares today.[3]

Beetroot is 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 fibres (2 g) per 100 g of wet weight, according to the database displays in the US Department of Agriculture Agricultural Research Service. Beetroot also contains a lot of biologically active phytonutrients. Vitamin and nitrate contents are 4.805 mg and 25 mg per 100 g of wet weight, respectively. The dry extract of beetroot contains 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. These bioactive phytonutrients have been demonstrated to be essential components in the treatment of a number of chronic illnesses, including cancer, diabetes, cardiovascular and cerebrovascular diseases, and chronic respiratory illnesses. As an illustration, betalains, primarily betanin, are a powerful antioxidant that may be obtained from beetroot. Beta-lains may lower the risk of some malignancies, cardiovascular and cerebrovascular illnesses, liver and kidney damage, and other conditions.[4] Many consumers use fresh beetroot juice orally to supplement nitrate, which improves physiological response and lowers the risk of cerebrovascular and cardiovascular disorders. Currently, beetroot is a common vegetable consumed by athletes as a source of energy.[5]



Due to the high levels of fibre and saponin in the gut, it has a detoxifying effect, aids in the body's natural detoxification procedures, and purifies the blood and intestines. It facilitates optimal nutrient absorption by enhancing digestion and the regular, thorough evacuation of built-up waste. Beets aid in preventing the onset of deficiency disorders in this way. It improves the way the liver works and is excellent for treating a number of liver conditions like cirrhosis and hepatitis. Reduced digestive tract inflammation, unpleasant sensations, and accelerated healing are all achieved very well with beetroot.[6]

Extraction Process of Beetroot

Different extraction techniques, including ultrasound, Soxhlet, cold, and supercritical fluid, were used to extract beetroot samples. Every experiment has used components from the same batch. Additionally, a variety of solvents and co-solvents were used. The resulting extracts were then evaporated, and the solvent was removed so that the drying could take place under reduced pressure. Until further tests, all obtained extracts were kept at 20°C.

Chemical uses for extraction: Methanol and ethanol with purity ≥ 99.9%, used as solvents for conventional extractions, Carbon dioxide with a purity of 99.99% liquefied gas.

1. **Ultrasonic Extraction (UE):** Ultrasonic extraction includes water, 30% aqueous methanol, 50% aqueous methanol, and 50% aqueous ethanol, The Erlenmeyer flask is placed in an ultrasonic bath with a fixed power of 40 kHz while maintaining the liquid level at the bottom of the bath. For 1.5 h, the extraction is carried out at a constant temperature of 40°C.
2. **Soxhlet Extraction (SE):** Soxhlet apparatus is used to perform Soxhlet extraction. The solvents used are water, 50% aqueous ethanol, 30% aqueous methanol, and 50% aqueous methanol. Fill the tubes with the dry and ground material, and fill the flask with 150 mL of solvent. During three cycles, approximately two hours later in the extraction process. The heating temperature is changed to suit the boiling point of the solvent being used. carried out for 1.5 h at a constant temperature of 40 °C.
3. **Cold Extraction (CE)**: A 250 mL solvent and the dry and powdered material are poured into an Erlenmeyer flask and various mixtures including water, 50% aqueous methanol, 50% aqueous ethanol and so on are used as the solvent. The extraction process is carried out for approximately two hours at room temperature by placing the mixture on a magnetic stirrer after the introduction of the magnetic granules to reduce the need for constant stirring.
4. **Supercritical Fluid Extraction (SFE):** In this extraction process, supercritical carbon dioxide and two different co-solvents (ethanol and propanol) are used for sugar beet extraction. A quasi-continuous high-pressure flow apparatus that can withstand temperatures of 100 C and pressures of up to 500 bar was used for the experiments. The cycles of extraction were at pressures of 100 bar and 300 bar and temperatures of 40 °C and 60 °C. Charge the extractor with approximately 15 grams of dry, powdered material. The temperature of the water bath was managed and maintained at +/- 0.5 °C. Nitrogen is used to clean the equipment before it is used in the extraction process. After that, liquefied gas (CO_2) is slowly introduced using a high-pressure pump onto the sample bed and into the extractor through the preheating coil. The solvent flow is determined using a flow meter. The product is separated in a separator (glass trap), where precipitation is carried out under air conditions.

Beetroot's nutritional profile

Vegetables are rich in critical elements including vitamins, minerals, fibre, phytochemicals, and other compounds that are good for your health. One of the key vegetables with roots, beets are high in carbohydrates, lipids, and protein. micronutrients and a number of functional components with strong health-promoting qualities. Due to its growing popularity as a source of natural antioxidants, beetroot is increasingly being processed and used in products. Early research suggested that beetroot includes a variety of vitamins, including[9]:

S.No	Nutrients	Max. conc./100gm
1.	Vitamin A	2 µg
2.	Thiamine	0.31 mg
3.	Riboflavin	0.27 mg
4.	Niacin	0.331 mg
5.	Pantothenic Acid	0.145 mg
6.	Vitamin B6	0.067 mg
7.	Ascorbic Acid	3.6 mg
8.	Folate	80 µg
9.	Calcium	16 mg
10.	Iron	0.79 mg
11.	Phosphorus	38 mg
12.	Potassium	305 mg
13.	Magnesium	23 mg
14.	Zinc	0.35 mg

Betanin extraction

The beets were cleaned, disinfected with 200 ppm of active chlorine for 15 minutes, and then thinly sliced. Utilising a centrifugal, the juice was extracted and then filtered through paper.

Analysis of total phenolic compounds

Examination of all phenolic chemicals by using spectrophotometry and the Folin-Ciocalteu method, the total phenolic content was ascertained. A gallic acid curve was used as a standard for the measurements, which were carried out in triplicate. A spectrophotometer with a wavelength of 765 nm, model 700S of the FEM brand, was utilised. The results were given in milligrams of gallic acid equivalents (GAE) per kilogramme of powder.

A portable colorimeter with an integrating sphere and a 3° viewing angle was used to assess colour.

Processing beetroot for use in food

The beetroot-based functional foods and beverages market is experiencing rapid growth due to the increasing recognition of beets as a superfood and a versatile vegetable that offers not only vibrant color and flavour but also nutritional benefits. Researchers and the food industry have been drawn to exploring the potential of beets in culinary applications. Humans consume deep red beets both raw in salads and cooked in stews. However, beetroot can also be processed into various formulations to provide a convenient and alternative supply of its beneficial components, such as NO3 (nitrate).

In the oral cavity, commensal bacteria possessing the nitrate reductase enzyme can convert dietary nitrate (NO3) into nitrite (NO2). The NO3-NO2/NO pathway then carries NO2 to the stomach, where it is non-enzymatically broken down into nitric oxide (NO) and other bioactive nitrogen oxides upon contact with gastric acid. This process has led to the emergence of a novel physiological, therapeutic, and dietary strategy, as increasing evidence suggests that dietary NO3 and NO2 can enhance the endogenous synthesis of NO.

Beetroot has found applications in the food industry as a marketing tool and as a natural alternative to synthetic colorants. With the growing preference for green consumerism and reduced use of artificial additives, natural colorants are considered safer for human consumption than synthetic ones. Natural colorants, being water-soluble, can be easily incorporated into aqueous food systems. Furthermore, they possess strong antioxidant properties, making them visually appealing and potentially beneficial to health.

The food and beverage industries primarily produce beetroot as beet juices and ground dehydrated beets. However, excessive consumption of beet liquids in powder form or dehydrated beets can have negative effects on human health, including potential allergies and even cancer risks.

It is important to avoid consuming toxic colorants found in lipsticks. Lipstick, a widely used makeup item available in various colors and textures, typically consists of an oil-wax base that forms the stick, a staining dye dissolved or dispersed in oil, and pigments suspended within. Natural cosmetics are believed to offer better skin protection against ultraviolet rays and are considered safer than those containing chemicals. As such, researchers are aiming to develop and evaluate herbal lipsticks and lip balms derived from standardized carotenoid extracts of beetroot (Beta vulgaris) with a castor oil base, aiming to minimize the side effects associated with synthetic alternatives.

Processing beetroot for use in medicine

Processing beetroot for use in medicine formulation involves extracting and utilizing its beneficial compounds for therapeutic purposes. Beetroot is known for its rich content of bioactive compounds such as betalains, nitrates, antioxidants, and other phytochemicals, which have shown potential health benefits.

To harness these properties, the processing of beetroot begins with careful selection and cleaning of fresh beetroots. The beets are then typically subjected to various methods such as juicing, extraction, or drying to obtain concentrated forms of the desired compounds. One common extraction method involves obtaining beetroot juice, which is obtained by crushing or pressing the beets. This juice can be further processed using techniques like filtration, centrifugation, or evaporation to concentrate specific compounds or remove unwanted components. For medicinal formulations, beetroot extracts can be incorporated into different pharmaceutical forms, such as capsules, tablets, syrups, or topical preparations. The concentration and specific composition of the extract will depend on the intended therapeutic application.

The extracted compounds from beetroot, such as betalains, have shown antioxidant, anti-inflammatory, and potential anticancer properties. These properties make them valuable in the development of pharmaceutical formulations for various health conditions. For instance, beetroot extracts may be utilized in formulations targeting oxidative stress-related disorders, cardiovascular health, inflammation, and certain types of cancer. Furthermore, beetroot extracts rich in nitrates have been studied for their potential to enhance nitric oxide (NO) production in the body. Nitric oxide plays a crucial role in regulating blood flow, blood pressure, and vascular health. Therefore, beetroot-derived formulations with optimized nitrate content may be developed for conditions related to cardiovascular health, endothelial dysfunction, and exercise performance. Processing beetroot for use in medicine formulation requires adherence to strict quality control measures, ensuring the extraction process maintains the stability and potency of the desired compounds. Additionally, thorough research and clinical studies are necessary to determine the appropriate dosage, safety, and efficacy of beetroot-derived medicines.

Overall, the processing of beetroot for medicinal purposes involves extracting its bioactive compounds and incorporating them into various pharmaceutical formulations to harness their potential health benefits. Continued research and development in this area may lead to the discovery of new therapeutic applications and contribute to the advancement of natural-based medicine.

CONCLUSION

In conclusion, beetroot has gained popularity as a potential "functional food" due to its rich nutritional profile and the presence of bioactive compounds such as betalains, nitrates, and antioxidants. The growing demand for beetroot has led to increased cultivation and processing of this vegetable.

Studies have shown that beetroot and its extracts have various potential health benefits. The betalains found in beetroot act as powerful antioxidants, reducing the risk of certain cancers, cardiovascular diseases, and liver and kidney damage. Beetroot is also a natural source of nitrate, which can be converted into nitric oxide in the body, contributing to improved blood flow, cardiovascular health, and exercise performance. The extraction process of beetroot involves different techniques such as ultrasonic extraction, Soxhlet extraction, cold extraction, and supercritical fluid extraction. These methods allow for the concentration of desired compounds and the development of pharmaceutical formulations.

Beetroot's nutritional profile includes vitamins, minerals, fibre, and other functional components that are beneficial for health. Its high content of vitamins A, B, and C, as well as minerals like iron, calcium, and potassium, make it a valuable addition to a healthy diet. The processing of beetroot for use in the food industry involves incorporating it into functional foods and beverages, taking advantage of its vibrant color, flavour, and nutritional benefits. Beetroot is also used as a natural alternative to synthetic colorants in food products. In the cosmetics industry, researchers are exploring the use of beetroot extracts in natural lipsticks and lip balms, aiming to minimize the side effects associated with synthetic alternatives.

Overall, processing beetroot for medicinal purposes involves extracting its beneficial compounds and incorporating them into pharmaceutical formulations. The research and development in this field hold promise for the discovery of new therapeutic applications and the advancement of natural-based medicine. With the increasing interest in functional foods and natural remedies, beetroot has emerged as a versatile ingredient with potential health benefits. Further studies and ongoing research will continue to shed light on the efficacy, safety, and optimal utilization of beetroot in medicine and other industries.

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