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Beetroot Powder Capsules: A Novel Formulation for Natural Antioxidant Delivery

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Abstract: *Beetroot (Beta vulgaris) is a root vegetable recognized for its rich nutritional profile and health-promoting properties. This project explores the development and evaluation of beetroot powdered capsules as a natural dietary supplement. The primary objective is to harness the high nitrate, antioxidant, and micronutrient content of beetroot in a convenient capsule form, making it accessible for individuals seeking to enhance cardiovascular health, stamina, and overall well-being. The process includes selection, cleaning, slicing, drying, and grinding of fresh beetroots into a fine powder, followed by encapsulation using vegetarian- grade capsules. The study also assesses the stability, bioavailability, and potential health benefits of the capsules, comparing them with raw beetroot and commercial alternatives. The findings support the feasibility of beetroot powder capsules as an effective nutraceutical product, offering a shelf-stable, easy-to-consume alternative to raw beetroot with retained nutritional value.*

Keywords: Beetroot, Betalains, Nitrate Antioxidants; Inflammation; Oxidative stress

I. INTRODUCTION

Beetroot powdered capsules are a convenient dietary supplement derived from dehydrated and finely ground beets (*Beta vulgaris*). Known for their deep red color and rich nutrient profile, these capsules are packed with essential vitamins, minerals, and naturally occurring nitrates that support cardiovascular health, stamina, and overall wellness .Used traditionally for their detoxifying and energizing properties, beetroot capsules offer an easy and mess-free alternative to consuming raw or juiced beets. They are particularly popular among athletes and health-conscious individuals for promoting nitric oxide production, which helps improve blood flow, lower blood pressure, and enhance exercise performance. Formulated to retain the maximum potency of the root, beetroot powdered capsules are vegan-friendly, non-GMO, and often free of artificial additives, making them a clean and efficient way to reap the benefits of this super food. The health-promoting effects of beetroot, proven in clinical trials are related to the appropriate dose of bioactive substances delivered to the body, their release from the plant matrix, digestion, assimilation, and metabolism. Hence, it is related both to the quality of the product (including the substitute used in the supplement production) and its form. The individual formulation process factors exhibit a direct impact on the physical parameters of the final formation (hardness, abrasion, disintegration rate). They should also enable the effective release of the active substances from the dosage form. The uniformity of the weight of the dosage units is responsible for the reproducibility of the effect.

Historical Background

Zohary and Hope also suggested that beetroot cultivars were also cultivated at the time, and 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 some Roman recipes support this. Beets are native to the Mediterranean. Although the leaves as a colouring agent for many foods. Some frozen pizzas use beet powder for coloring in tomato sauce. The most common garden beet is deep red ruby in colour but yellow, white, and candle arrows are available in specialty markets. Outside the United States, beets are generally referred to as beetroot. It is estimated that about two-thirds of commercial beet crops end up canned. They state the earliest written mention of the beet comes from 8 th century Mesopotamia (Hope et al., 2000) [10] . The Greek Peripatetic Theophrastus later

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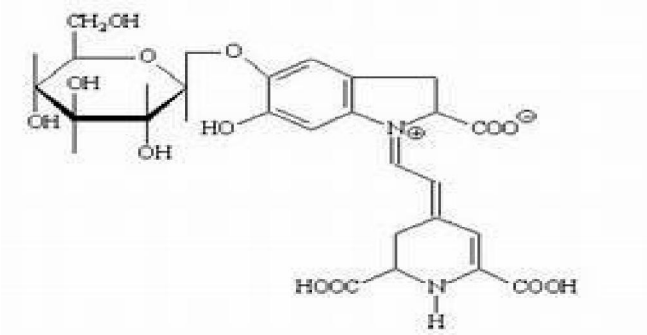
describes the beet as similar to the radish, while Aristotle also mentions the plant (Hill and Langer, 1991) [9] . Later English and German sources show that beetroots were commonly cultivated in Medieval Europe (Hope et al., 2000; Hill and Langer, 1991) [10, 9] .

Beetroot Profile
Synonym: Beta vulgaris
Family: Amaranthaceae
Active Ingredient : Betanin, Betalains, Betacyanins, Betaxanthins, Nitrate, Acsorbic acid

Fig No.1

Chemical formula: Betanine: C24H26N2O13
Structural formula :-



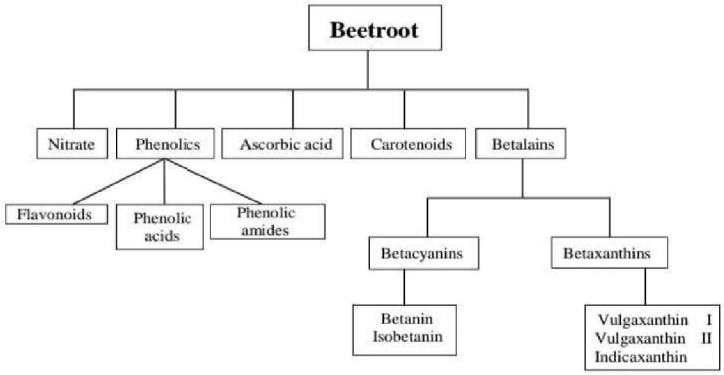


Fig No.2 Bioactive Compounds in beetroot

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Moisture	87.4 ±0.3%
Energy	43 kcal
Ash content	1.4 ±0.2%
Carbohydrate	9.56 gm
Fat	0.17 gm
Protein	1.61 gm
Fibre	2.8 gm
Potassium	325 mg
Sodium	78 mg
Phosphorus	40 mg
Calcium	16 mg
Magnesium	23 mg
Iron	0.80 mg
Zinc	0.35 mg
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
Betacyanin	75-95%

Table No.1 Nutritional value of 100gm Red Beetroot

Formulation Table:

Component	**Specification**	**Amount of per capsule**
Active ingredient		
Beetroot Powder	Freeze-dried or sun –dired ;may be standardized	500mg
Excipients	Used for flow, stability and encapsulation	
Microcrystaline Cellulose	Filler	Up to 100mg
Magnesium stearate	Lubricant	1-3mg
Slicon Dioxide	Anti-caking agent	1-5 mg
Capsule shell	HPMC(vegetarian) or gelatine	Size 0 - 00

Manufacturing process overview:

Weighing and Sieving: All ingredients are weighed and sieved to remove lumps.

Blending: Beetroot powder is mixed with excipients to ensure uniform distribution.

Encapsulation: The blend is filled into empty capsules using a capsule filling machine.

Quality Control: Check weight uniformity, disintegration time, and assay of active ingredient.

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Packaging: Pack in moisture-resistant containers, preferably with a desiccant

Procedure:

Beetroot Cleaning
↓
Sorting Peeling
↓
Cutting into slices
↓
Sun Drying
↓
Lyophilizer drying
↓
Dried beetroot grind to powder by grinding machine
↓
Powder packed in polyethylene bags separately
↓
Sealing
↓
Storage at room temperature Mix the other ingredients
↓
Capsule Filling

Fig No.2 Beetroot capsules

Health Benefits of Beetroot Powdered capsules

- **Exercise Performance**: The nitrates in beetroot powder can enhance stamina and endurance, making it popular among athletes.
- **Heart Health**: Rich in nitrates, beetroot powder can help lower blood pressure and improve circulation.
- **Athletic Performance**: It enhances endurance and stamina by increasing oxygen delivery to muscles.
- **Blood Pressure Regulation**: Beetroot is high in nitrates, which help produce nitric oxide, a compound that relaxes blood vessels and lowers blood pressure.
- **Improved Circulation & Exercise Performance**: The nitrates in beetroot enhance oxygen delivery to muscles, potentially boosting endurance and workout recovery.

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- **Antioxidant & Anti-Inflammatory Properties**: Beetroot contains betalains, which help fight oxidative stress and inflammation, protecting cells from damage.
- **Heart Health Support**: Some studies suggest beetroot may help lower LDL cholesterol and triglycerides, contributing to better cardiovascular health
- **Brain Function & Memory**: Improved blood flow from beetroot consumption may enhance cognitive function and memory.

Ideal Properties of beetroot powdered capsule:

- **High Nutrient Retention**: They should preserve the beneficial compounds found in fresh beetroot, such as nitrates, betalains, and antioxidants, which support heart health, muscle recovery, and overall wellness2.
- **Purity & Quality**: The capsules should be free from artificial additives, preservatives, and fillers to ensure maximum health benefits.
- **Easy Absorption**: The formulation should allow for efficient absorption of nutrients, particularly nitric oxide, which enhances blood flow and oxygen delivery.
- **Convenient Dosage**: The capsules should provide an optimal concentration of beetroot powder to deliver its benefits without excessive intake.
- **Minimal Side Effects**: They should be well-tolerated, with low risk of digestive discomfort or excessive nitrate accumulation.

PHARMACOLOGICAL ACTIVITIES:

Anti-inflammatory effect: The protective effect of (Beta vulgaris L.) beet root ethanolic extract (BVEE) on gentamicin-induced nephrotoxicity and to elucidate the potential mechanism was investigated. BVEE treatment significantly reduced the amount of cleaved caspase 3 and Bax, protein expression and increased the Bcl-2 protein expression. BVEE treatment also be ameliorated the extent of histologic injury and reduced inflammatory infiltration in renal tubules. These findings suggest that BVEE treatment attenuates renal dysfunction and structural damage through the reduction of oxidative stress, inflammation, and apoptosis in the kidney

Antioxidant Properties: The effects of home processing on the antioxidant properties and in vitro bioaccessibility of red beetroot bioactives were investigated. This study provides comparative data to evaluate the effects of various home-processing techniques antioxidant potential of red beetroot products.

Anti-stress effect : Anti-Anxiety and anti Depressive effect :The protective effect of Beta vulgaris Linn. Ethanolic extract [BVEE] of leaves against acute restraint stress [ARS]induced anxiety- and depressive-like behavior and oxidative stress in mice was investigated.

Anti-cancer: Table beet affects numerous biochemical reactions, enzymes and metabolic synthesis.According to results, it seems that moderate and permanent consumption of table beet product affects the life expectancy of patients favorably; however, due to the increasing values of EGF, medical control is necessary for patients with prostate cancer treated by chemotherapy.8

Antihypertensive effect: Beta vulgaris cicla and Beta vulgaris rubra shows that BVc extracts possess antihypertensive and hypoglycaemic activity as well as excellent antioxidant activity. BVc contains apigenin flavonoids, namely vitexin, vitexin-2-Orhamnoside and vitexin-2-O xyloside, which show antiproliferative activity on cancer cell lines. BVr contains secondary metabolites, called betalains, which are used as natural dyes in food industry and show anticancer activity. In this light, BVc and BVr can be considered functional foods.9

Evaluation Test of Beetroot capsule:

Analysis of size and shape:

Beetroot powdered capsules come in various sizes and shapes depending on the brand and formulation. Typically, they are available in quick-release or vegetarian capsule forms, with sizes ranging from small (500 mg) to larger doses (1500 mg or more)**.** The shape is usually oblong or cylindrical, making them easy to swallow.

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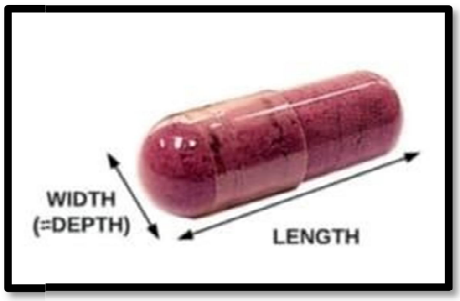

Fig No.3 Indicates formulation size and shape

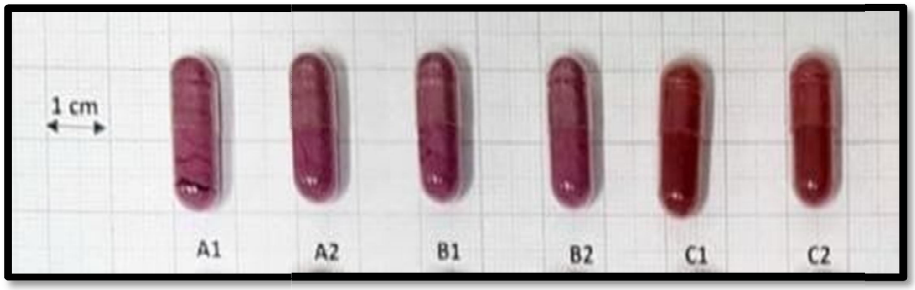

Fig No. 4 Variation of sizes and shapes of capsules

Table No .3.Analysis of shape and dimensions of formulations.

Form Product	Shape Shield/ Coating	Width SD	Length SD	Depth SD	W+L+D(mm)
CAPSULES A1	cylindricalcapsule gelatine	7.44±0.06	21.49± 0.16	7.44± 0.06	36.36
A2 B1 B2 C1 C2	cylindricalcapsule gelatine	7.40± 0.06	21.46 ± 0.18	7.40± 0.06	36.26
	cylindricalcapsule gelatine	7.45 ± 0.05	21.40± 0.26	7.48 ±0.05	36.35
	cylindricalcapsule gelatine	7.48 ± 0.05	21.3± 0.22	7.48± 0.05	36.34
	cylindricalcapsule gelatine	7.57 ± 0.02	21.6± 0.27	7.57± 0.02	36.75
	cylindricalcapsule gelatine	7.56 ± 0.02	21.6± 0.22	7.56± 0.02	36.81

Weight Variation:

The weight variation test for capsules, including beetroot powdered capsules, ensures uniformity in dosage units. According to USP guidelines, the test involves weighing 20 intact capsules individually and determining the average weight. The capsules must fall within 90**%** to 110**%** of the average weight to meet the requirements. If some capsules fall outside this range, further testing is conducted by weighing the empty shells and calculating the net weight of the contents.(13) For soft-shell capsules, the process includes cutting open the capsules, removing the contents with a solvent, and weighing the dried shells to determine the net weight. The test ensures that no more than 2 capsules deviate by more than 10**%**, and none exceed 25**%** deviation. If more than 2 but fewer than 6 capsules deviate, an additional 40 capsules are tested.

Disintegration Test:

The disintegration test for capsules, including beetroot powdered capsules, evaluates whether they break down within a prescribed time when placed in a liquid medium. The test is conducted using a basket-rack assembly, which repeatedly immerses the capsules in a thermostatically controlled fluid at 37°C. The capsules must fully disintegrate into a soft mass with no firm core, leaving only fragments of the gelatin shell. This test ensures that the capsule dissolves properly, allowing the active ingredients to be released effectively.

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Generally, for hard capsules, the British Pharmacopoeia (BP) sets a limit of not more than 30 minutes, while the United States Pharmacopoeia (USP) specifies disintegration times based on individual monographs. the supplements of beetroot in the form of capsule disintegrated in (4-30 min).

Dissolution Test: The dissolution test for beetroot powdered capsules follows standard procedures used for solid oral dosage forms. It helps determine how quickly and efficiently the active ingredients are released into the body. It helps determine the rate at which the active ingredients are released into the systemic circulation.

Dissolution test overview:

Apparatus: Either a rotating basket or paddle dissolution apparatus.

Dissolution Medium: A suitable liquid medium, often maintained at 37 ± 0.5°C**.**

Rotation Speed: Usually between 25-150 rpm, depending on the formulation

Sampling & Analysis: The dissolved drug is sampled at specific time intervals and analyzed to measure the concentration of dissolved active ingredients.

The dissolution time of a beetroot powdered capsule depends on various factors, including its formulation, coating, and the dissolution medium used in testing. The beetroot capsules dissolved in 30 min.

TableNo.2 Physical parameters of supplements in capsule form

Code	Weight Uniformity				DisintegrationTime
	DeclaredWt. Of dosage unit	AverageGross wt. in mg	AverageNet wt.in mgto decleared wt(%).	RatioofAv.wt.	DisintegrationTime(min) pharmacopeia criteria
A1	500	496.75 ± 15.25	397.15 ± 13.81	99.35	5:00 passed
A2	500	486.15 ± 22.5	392.95 ± 25.75	97.23	4.30 passed
B1	500	490.05 ± 14.59	403.45 ± 15.32	98.01	5:00 passed
B2	500	492.55 ±11.88	399.75 ± 10.93	98.51	4:00 passed
C1	596	608.05 ± 12.48	512.9 ± 12.37	102.02	5:30 passed
C2	596	599.7± 18.17	502.95 ± 18.18	100.62	6:00 passed

Analysis of betaxanthins and betalains by UV spectroscopy:

A UV test of beetroot powder capsules, or UV-Vis spectrophotometry, can be used to analyze the betalain pigments (betacyanins and betaxanthins) present in the beetroot powder. This method helps determine the pigment content, which can be useful for quality control and ensuring the product meets specific standards.

UV Test is typically performed:

Sample Preparation:

The beetroot powder capsules are ground and extracted using a suitable solvent (like water, methanol, or ethanol).

Spectrophotometry:

The extracted solution is then analyzed using a UV-Vis spectrophotometer. wavelength Scan:The spectrophotometer scans the sample's absorbance across a specific wavelength range, typically 250-600 nm.

Peak Identification:

Distinct absorption peaks are observed in the spectrum, corresponding to the presence of betalain compounds. Betacyanins typically exhibit peaks around 530 nm, while betaxanthins show peaks around 480 nm.

Concentration Determination:

The absorbance values at the characteristic wavelengths are used to calculate the concentration of betacyanins and betaxanthins in the sample.

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