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Jadhav DG
M.Tech Student, Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Sadawarte SK
Assistant Professor, Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Katakhade RP
M.Tech Student, Department of Food Microbiology and safety, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Pawar VS
Associate Professor, Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Jadhav DG
M.Tech Student, Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Effects of cabinet drying on nutritional and bioactive profiles of beetroot powder

Jadhav DG, Sadawarte SK, Katakhade RP and Pawar VS

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Abstract
The study explores cabinet drying affect the nutritional, antioxidant, and color characteristics of beetroot (*Beta vulgaris* L.). Fresh beetroot underwent drying processes to produce beetroot powder. Assessments were made on the composition, minerals, betalain compounds, phenolics, flavonoids, antioxidant activity (DPPH assay), and color changes in both fresh beetroot and the resulting powder. Drying concentrated the nutrients by reducing moisture and increasing protein, carbohydrates, fiber, and ash in the beetroot powder. Minerals like potassium, calcium, phosphorus, magnesium, iron, and zinc significantly increased in the powder. Betalain compounds were sensitive to drying, showing reductions in total betalains and betacyanins but an increase in betaxanthins due to heat exposure. Post-drying, there was an increase in total phenolics, but a decrease in total flavonoids. Antioxidant activity notably increased, indicating higher antioxidant potential in the beetroot powder. Color characteristics also changed during drying. This study underscores the transformation of fresh beetroot into a more concentrated, nutritionally dense powdered form through drying. However, it suggests a need for optimizing drying methods to retain essential nutritional elements. The findings highlight the potential benefits of beetroot powder as a functional food and a natural coloring agent.

Keywords: Beetroot, drying, antioxidants, minerals, betalains, phenolics, flavonoids, color

Introduction

The plant known as beetroot, which belongs to the *Beta vulgaris* subsp. Vulgaris conditiva family, is biennial or annual in nature and originated in the Middle East before migrating to North America, Europe, and Asia. Beetroot, also referred to as chakundar in Hindi, Remolachas in Spanish, and Hong cai tou in Chinese, is a superfood rich in minerals. It has significant concentrations of vital minerals, including manganese, iron, copper, potassium, sodium, and magnesium. It also has high levels of natural coloring agents, dietary fiber, and antioxidants, as well as vitamins A, B, and C. Moreover, it has phenolic chemicals, which are well known for their anti-oxidant qualities. Beetroot has been more and more known as an essential functional food in recent years because of all of its health advantages. Moreover, it has phenolic chemicals, which are well known for their anti-oxidant qualities. Beetroot has been more and more known as an essential functional food in recent years because of all of its health advantages. It is used as a food item, but it also functions as a natural food coloring and medicinal herb. (Tadimalla, 2017) [19].

Scientifically referred to as *Beta vulgaris* rubra, beetroot is a noteworthy plant-based food that has been shown to have positive effects on human health. It may be eaten raw, cooked, steamed, or roasted, among other ways. Essential minerals such as manganese, sodium, potassium, magnesium, iron, and copper are rich in red beetroot. Fresh beetroots must be preserved due to their high moisture content, which makes them susceptible to spoiling. Among the preservation methods that ensure the microbiological safety of biological products, drying and dehydration are particularly noteworthy. (Mathlouthi, 2001) [12]. Beetroot dehydration may be eaten straight as chips, which is a substitute for traditional snacks. (Aro *et al*. 1998) [1], or after easy preparation as a component of instant food (Krejcova *et al*. 2007) [10]. One simple way to extend the life of fresh food and keep it from spoiling is to lower its moisture level.

Beetroot contains inorganic nitrate, which lowers blood pressure and lowers the risk of cardiovascular disease. The nitrate concentration of beetroot helps prevent myocardial infarction, which is the blocking of blood supply to heart tissue, and also lowers the risk of heart disease and strokes. Beetroot also improves the oxygen flow to working skeletal muscles. These muscles' ability to operate is compromised when there is insufficient oxygen available, which may limit movement and raise the risk of heart disease. Making use of beetroot's health benefits, a study was recently carried out to evaluate the quality of beetroot powder and make it. Beetroot is a widely favored vegetable among athletes due to its rich content of antioxidants and micronutrients such as potassium, betaine, vitamins, and nitrates. The distinctive color of beetroot is attributed to pigments called betalains, which are purple and yellow in hue. These betalains possess significant antioxidant potential. (Ormsbee *et al*., 2013) [16].

2. Materials and Methods
2.1 Proximate content
Protein, fat, crude fiber and ash of the beetroot and beetroot powder were evaluated as suggested by AOAC (2000) [24]. Difference method is used for carbohydrate calculation.

2.2 Minerals
After dry washing of the sample an Atomic Absorption Spectrophotometer (Analyst 300 Perkin Elmer) was used to determine the mineral content of the beetroot sample.

2.3 Determination of betalains compounds
After dissolving around 0.1 g of the materials in 10 ml of 50% ethanol and stirring for 10 seconds, the homogenate was centrifuged for 10 minutes at 6000 rpm. To guarantee that the most betalains could be extracted, the supernatant was collected exactly as it was after centrifugation and the process was performed twice more. The amount of betalains was also determined using the supernatant. Using a UV-Vis spectrometer, the betaxanthin and betacyanin contents in the extracts were measured spectrophotometrically at 538 nm and 480 nm, respectively, in accordance with Stintzing and Carle's (2004) [7] methodology. The betalain concentration for each sample was determined using the acquired absorbance value. Betacyanins with betaxhantins added up to total betalains. In milligrams of total betalains per gram of dry weight, the findings were reported.

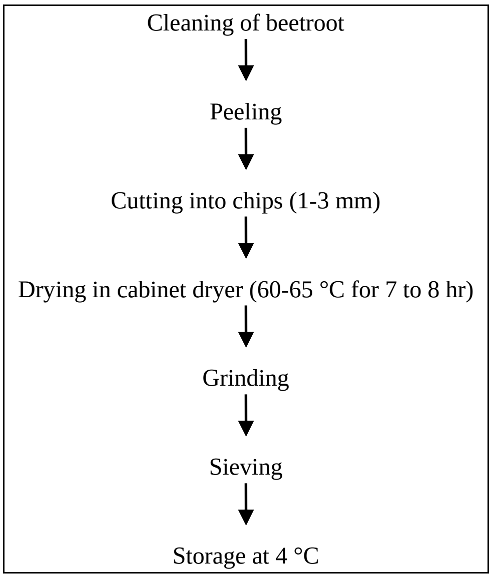
2.4 Total phenolic content
Folin-ciocalaetu method was used for the determination of phenolic compound (Singleton, Orthofer & Lamuela-Raventos, 1999) [21]. Phenol react with phosphomolybdic acid in folin-ciocalaetu reagent in alkaline medium and produce blue colored complex. TPC expressed in gallic acid equivalents.

2.5 Total flavonoids determination
A modified colorimetric approach, as reported by Zhishen *et al*. (1999) [20], was used to measure the total flavonoid content of tomato extracts. Following a 6-minute incubation period, 1.25 ml of distilled water and 75 µL of 5% $NaNO_2$ solution were combined with the methanolic extract (250 µL) and (+) −catechin standard solutions, respectively. After that, 150 µL of a 10% $AlCl_3$ solution was added, and everything was stirred for five minutes. The volume was then increased to 2.5 ml with distilled water after adding 0.5 ml of 1.0 M NaOH. Using a UV/Vis spectrophotometer Model 4050 (LKB Biochrom, Cambridge, England), the absorbance was measured at 510 nm in comparison to a produced blank.

2.6 Antioxidant activity
Using antioxidant assays like DPPH free radical scavenging, the hydrogen-donating or radical-scavenging capacity of popped sorghum was tested to determine its antioxidant activity. 1,1 - According to Eklund *et al*. (2005), diphenyl 2-picrylhydrazyl (DPPH) is a stable free radical with a nitrogen linkage. It is a typical colorimetric reagent that neither dimerizes nor interacts with oxygen, and it may be stored for an extended period of time with little degradation. Owing to its distinct color shift from deep violet to yellow upon reduction, with a measurement at 517 nm, it is frequently employed in the assessment of antioxidant characteristics in various substances.

2.7 Color measurement
The color (L, a and b) of treated and untreated samples was measured with a Hunter Lab colourimeter. The instrument was calibrated with black and white reference tiles through the tri-stimulus values X, Y and Z, taking as standard values those of the white background tile. Beetroot powder was scanned at three different locations to determine the average L, a and b values during the measurements.

2.8 Methodology
2.8.1 Preparation of beetroot Powder
Red beetroot (*Beta vulgaris* L) was obtained from the local market, Parbhani. Fresh beetroots were washed, blanched, peeled and reduced to size (1-3 mm) using a sharp knife. These slices were dried in cabinet dryer at 60-65 °C for about 7-8 hr. The dried beetroot slices were subjected to grinding in a grinder. Then ground material was passed through 60 mesh sieve and packed in plastic bags and stored a refrigerator at 4 °C for further use.



Flow sheet 1: Preparation of beetroot powder

3. Results and Discussion

3.1 Effect of drying on chemical composition of beetroot

Table 1: Effect of drying on chemical composition of beetroot

Parameter (%)	Beetroot	Beetroot Powder
Moisture	87.3±0.04	2.64±0.55
Protein	1.45±0.12	13.15±0.49
Fat	0.15±0.07	0.53±0.60
Carbohydrate	6.8±0.01	82.89±1.60
Crude Fiber	1.9±0.12	16.39±0.31
Ash	1.4±0.14	7.07±0.72

The table illustrates the percentage composition of various nutritional components in both fresh beetroot and beetroot powder. In fresh beetroot, the moisture content is notably high at 87.3%, while protein, fat, carbohydrate, crude fiber, and ash constitute 1.45%, 0.15%, 6.8%, 1.9%, and 1.4% respectively. On the other hand, beetroot powder shows significantly reduced moisture content at 2.64%, while the levels of protein, fat, carbohydrate, crude fiber, and ash remarkably increase to 13.15%, 0.53%, 82.89%, 16.39%, and 7.07% respectively. The transition from fresh beetroot to beetroot powder results in a concentrated form with notably higher protein, carbohydrate, crude fiber, and ash content, along with reduced moisture. Proximate composition findings of beetroot powder are similar with result given by Dhawan and Sharma (2019) [5].

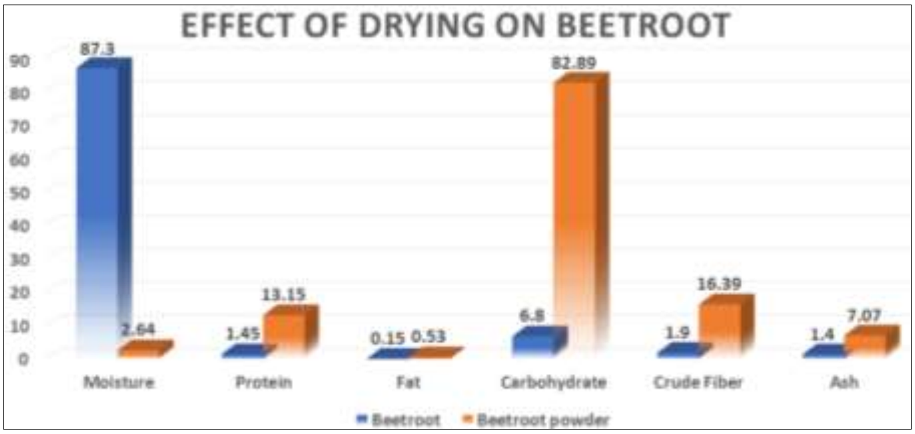


Fig 1: Effect of drying on chemical composition of beetroot

3.2 Effect of drying on minerals composition of beetroot

Table 2: Effect of drying on minerals and nitrate composition of beetroot

Minerals (mg/100 g)	Beetroot	Beetroot powder
Calcium	18.06±0.15	240±0.58
Magnesium	23±0.10	33.4±0.02
Iron	2.02±0.21	7.2±2.3
Zinc	8.1±0.12	0.50±0.04
Phosphorous	50±0.05	219±0.03
Potassium	63±0.1	830±1.25

Minerals content as potassium, phosphorus, calcium, magnesium, iron and zinc were determined in beetroot and beetroot powder and the results are recorded in Table 6. The results showed that the potassium is the major compound in beetroot powder was 830.0 mg/100 g. The potassium content of fresh beetroot significantly increased after drying. The calcium content also increased significantly from 18.06 mg/100 gm to 240 mg/100 g after drying and phosphorous content from 50 to 219 mg/100 g. Similarly, Negi and Roys (2001) [14] reported that the calcium and phosphorous content of dried vegetables is higher than that of fresh vegetables. Beetroot powder has high magnesium content 33.4 mg/100 g than beetroot which was 23 mg/100 g. David and Whitefield (2000) [4] also reported that the dried vegetables had higher magnesium. Improved iron content from 2.02 to 7.2 mg/100 g. Similar result of increment in Fe as a result of drying was reported by Joshi & Mehta (2010) [8].

3.4 Effect of drying on bioactive compounds of beetroot

Table 3: Effect of drying on bioactive compounds of beetroot

Sample	Total betalain	β-cyanin	β-xanthin	Total phenolics	Total flavonoids	DPPH (%)
Beetroot	110.34±2.09	79.67±0.24	30.67±0.78	25.36±0.13	30.07±0.65	11.86±0.27
Beetroot powder	106.1±0.03	62.67±0.46	61.7±0.61	33.17±0.3	26.58±0.97	22.58±0.65

3.5 Effect of different drying methods on betalains contents

Table 3 depicts how drying affects the bioactive substances found in beetroot. The beetroot slices underwent cabinet drying, which resulted in a notable drop in the overall amount of betalain and betacyanin, but a notable increase in betaxanthin levels. These water-soluble pigments that include nitrogen are called betalains, and they are divided into two groups: yellow-orange betaxanthins and reddish-violet betacyanins (Ravichandran *et al*., 2013) [17].

As observed in Table 3, The drying-induced decrease in betalains is consistent with other research showing these compounds' susceptibility to high temperatures (Herbach *et al*., 2006 and Ravichandran *et al*., 2013) [22, 17]. According to these investigations, heating is the most important physicochemical condition that affects betalains' thermal resistance (Herbach *et al*., 2006) [22]. It was highlighted by Kowalski and Szadzinska (2014) [9] that betalains are extremely sensitive to heat, light, and oxygen. Gokhale and Lele (2014) [6] have pointed out that changes in drying temperature might affect the amount of betalain and the antioxidant activity of whole beet powder. According to their findings, as the drying temperature increased from 50 to 120 °C, betacyanin decreased and betaxanthin increased (Gokhale and Lele, 2014) [6]. As a result, it was shown that betacyanin was more sensitive to temperature variations than betaxanthin. Furthermore, greater drying temperatures were shown to result in lower betacyanin (red pigment) and higher betaxanthin (yellow pigment) (Ravichandan *et al*., 2013) [17], indicating that betacyanin converts to betaxanthin at higher temperatures.

3.6 Effect of drying on total phenolics and flavonoids.

Table 3. Displays a significant rise in the fresh beetroot's total phenolic content after drying. The results of the study indicate that beetroot's total phenolic content was greatly increased when heat was applied during the drying process, which is consistent with what Oboh and Akindahunsi (2004) [15] found. Their study found that when green leafy vegetables were sun-dried, the overall phenolic contents significantly increased. Air drying was shown to significantly enhance the total phenolic content of peppermint and oregano leaves in a different study conducted by Capecka *et al*. (2005) [2]; however, no discernible difference was found for lemon balm. Food processing operations may contribute to the release of additional bound phenolic compounds as a result of the disintegration of cell components.

However, once the slices were dried, the amount of flavonoids in fresh beetroot significantly dropped. The study supports the findings of Mohd-Zainol *et al*. (2009) [13] by showing that heat has a negative effect on the flavonoids in beetroot. Their investigation into the effects of various drying techniques on Centella asiatica revealed that the degree of flavonoid degradation differed depending on the drying treatments: it was lowest in freeze-dried samples, highest in vacuum-dried samples, and highest in oven-dried data. This result is explained by the temperature and duration used in the various drying techniques. Flavonoids and other macromolecules are likely lost during heat treatment because of the strict drying conditions—temperature and time in particular.

According to Davey *et al*. (2000) [3], wet thermal processing may also have an effect on phytochemicals by causing thermal breakdown, altering the integrity of the cell structure, and causing component migration. These effects may result in losses from leakage or breakdown through a variety of chemical reactions involving enzymes, light, and oxygen.

3.7 Effect of drying on DPPH during drying.

As shown in Table 3, Fresh beetroot's DPPH (2, 2-diphenyl-1-picrylhydrazyl) value considerably rose after drying. Consistent with the findings of Oboh and Akindahunsi (2004) [15], the results showed that the heat treatment given to the beetroot significantly increased its antioxidant activity due to enhanced levels of total phenolics and betaxanthin. Through sun drying, they found that green leafy vegetables' antioxidant qualities were significantly increased. Furthermore, Kavitha *et al*. (2013) [23] noted that betalains and polyphenols, which are enhanced after heat treatment, have an impact on the antioxidant capacity. Although betalains and anthocyanins are usually mutually exclusive in nature, Kujala *et al*. (2000) [11] have shown that phenolics and flavonoids are also present in some beetroot materials, which add to the strong antioxidant activity of beetroot extract.

Furthermore, it was shown that higher drying temperatures were associated with higher antioxidant activity and total phenolic content. According to Kujala *et al*. (2000) [11], this finding implies that betaxanthin has more antioxidant activity than betacyanin.

3.8 Effect of different drying on color characteristics of dried beetroot

Table 4 shows the effect of different drying methods on color characteristics of dried powder of beetroot. The measurement of color of beetroot powder on Hunter Lab scale showed.

Table 4: Effect of different drying on color characteristics of dried beetroot

Colour Characteristics	Beetroot	Beetroot powder
L*	24.74±0.69	23.55±1.02
a*	22.19±0.38	16.70±0.93
b*	1.01±0.78	2.09 ±0.19

Table 4 shows the impact of various drying techniques on the color properties of beetroot powder that has been dried. The color of the beetroot powder was measured using the Hunter Lab scale, which revealed a considerable rise in yellowness (b) and a decrease in redness (L).

Conclusion

The drying process significantly affected various aspects of beetroot, resulting in concentrated nutrients, altered bioactive compounds, enhanced antioxidant activity, increased mineral content, and modified color characteristics. These changes are crucial in transforming the fresh vegetable into a powdered form that exhibits increased nutritional density, longer shelf life, and altered physical attributes. However, the alterations in bioactive compounds, especially the reduction in certain flavonoids, may indicate a loss of some nutritional elements during the drying process. Therefore, while drying improves shelf life and concentrates nutrients, the impact on certain bioactive compounds suggests a need for further exploration into optimizing drying methods to retain these beneficial components.

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