

Nutritional, Functional, and Sensory Aspects of Beetroot (*Beta Vulgaris* L.) and Its By-Products Enriched Bakery Products: A Comprehensive Review

Simmi Jain^{1,*}, Yamini Kesavan²

Abstract

*Beetroot (*Beta vulgaris* L.) is a biennial herbaceous plant rich in essential nutrients, including dietary fiber, vitamins, minerals, and antioxidants. Its high sugar content relative to calories and presence of phenolic compounds contribute to its health benefits, such as managing hypertension and exhibiting anticancer properties. Proper storage conditions are crucial for maintaining beetroot's quality. Recent studies have explored the incorporation of beetroot in various baked goods to enhance their nutritional and sensory profiles. Research includes the use of beetroot powder and pomace in muffins, cupcakes, cookies, and sponge cakes, revealing its impact on color, texture, flavor, and overall acceptability. Results indicate that beetroot enriches products with beneficial nutrients and antioxidants, though its incorporation affects physical characteristics like weight, volume, and texture. The studies also highlight changes in physicochemical properties, such as hardness and moisture content, as well as the presence of betalains, which are responsible for the pigment and antioxidant activity of beetroot. This review synthesizes findings from multiple studies to underscore beetroot's potential in bakery products demonstrating its value in both nutrition and product quality enhancement.*

Keywords: Beta vulgaris, baked products, enrichment, betalains, potential, beneficial

INTRODUCTION

Beetroot (*Beta vulgaris* L.) is a biennial herbaceous plant that produces beneficial nutrients such as dietary fiber, antioxidants, minerals, and vitamins. As beetroot is a popular food source for people, it should be kept in a dark, well-ventilated space with a relative humidity of 96%–100%, and at a temperature of 0–5 °C to maintain its quality. Despite having the fewest calories, *Beta vulgaris* L. has the highest sugar content. Red beetroot is rich in minerals, including manganese, sodium, potassium, magnesium, iron, and copper. Beetroot is high in fiber, natural colors, vitamins A, C, and B, and antioxidants. Additionally abundant in phenolic chemicals, which have anti-oxidant characteristics, is red beetroot. Apart from serving as a dietary component for the management and prevention of hypertension and cardiovascular disorders, betalains found in beetroot can halt the division of malignant cells.

*Author for Correspondence

Simmi Jain
E-mail: yaminikesavan | 10@gmail.com

¹Head of Food Technology and Management, Department of Food Science, M.O.P Vaishnav College, Chennai

²Postgraduate student, Department of Food Technology and Management, M.O.P Vaishnav College, Chennai.

Received Date: August 29, 2024

Accepted Date: August 30, 2024

Published Date: August 30, 2024

Citation: Simmi Jain, Yamini Kesavan. Nutritional, Functional, and Sensory Aspects of Beetroot (*Beta vulgaris* L.) and its By-products Enriched Bakery Products: A Comprehensive Review. *Research & Reviews: A Journal of Crop Science and Technology*. 2024; 13(2): 8–13p.

Data on macronutrients have been made available by the United States Department of Agriculture (USDA). For example, 100 g of raw beetroot has 43 kcal of energy, 9.56 g of carbohydrates, 1.61 g of proteins, 0.17 g of total fats, 2.8 g of total dietary fiber, and 6.76 g of total sugars. Food is prepared by baking, which is a dry heat technique that is often done in an oven but can also be done on hot stones or in hot ashes. Although bread is made the most frequently, numerous other dishes are also baked.

Foskett et al. (1995) claim that heat-induced chemical reactions in components like baking powder and yeast transform many meals from their raw state into a texture that can be eaten (pastry, cakes). However, there will be a wide range of differences due to varied ingredients, mixing techniques, and product types needed. Muffins are a popular tiny, delectable snack cake because of their portion control and mobility. It is affordable to produce and looks good. According to Oxford Dictionaries (2019), these are batter cakes baked in cup-shaped foil or temperature-resistant paper. Similar to bigger cakes, customers may apply frosting and additional cake embellishments including fruit, cashew nuts, resins, and candies.

Among the world's most organized food industries is the bakery business. Because of their convenient use, long shelf life, and readiness for consumption, cakes and biscuits are among the most popular products. Beetroot was also used to make pastry products like ice cream and candy.

MATERIALS AND METHODS

- In a study by [3], Muffins were enriched with beetroot and carrot pomace. Five types of muffins were formulated substituting 10 % and 20% wheat flour with carrot and beetroot pomace.
- In their work [1], they substituted soft wheat flour with beetroot powder in cupcakes at 2.5, 5.0, 7.5, 10 % compared with the control which was made from wheat flour with 72% extraction. The study's objective was also to utilize beetroot's natural antioxidant, antimicrobial, and natural pigment-imparting properties in cupcakes.
- In the work done by [6], cookies were prepared with refined wheat flour and further substituted with beetroot powder at 5, 7, 10, 15, and 20 % concentrations and were examined for their physical and chemical composition.
- The developed sponge cake was enriched with beetroot powder and puree and was assessed for their nutritional and sensory properties. Weak flour was substituted with beetroot powder and eggs were substituted with beetroot chard puree at 5, 10, 15, 20, and 10, 15, 20, and 25 concentrations respectively [5].
- In their study [2] they incorporated beetroot leaf powder into cookies. Refined wheat flour was substituted with dried beetroot leaves powder at 4.5, 7, 9, 5, and 12 % concentrations in cookies. The dried beetroot leaves incorporated cookies we analyzed for their nutritional, sensorial, textural, and antioxidant properties.
- Fortification of steamed bread with red beetroot powder and their changes during the bread-making process were recorded. Chinese steamed bread was made into four formulations of 10, 30, 50, and 70 % red beetroot powder was added in the place of wheat flour and compared with control for its physiochemical, structural, and nutritional properties [4].

RESULTS AND DISCUSSION

Organoleptic Properties of Baked Products

color

- In their study [3], the first two samples prepared by incorporating carrot pomace had a yellow-orange color due to the presence of β -carotene, while the other two samples which were integrated with beetroot pomace had a red-violet color due to betacyanins. Muffins incorporated with 10% beetroot pomace flour received the highest average color rating (8.20 points out of a possible 9.00).
- An increasing quantity of red beetroot powder in Chinese steamed bread showed a decrease in whiteness in the crumb and crust of the bread [4].
- The color of 10% beetroot powder added cupcake was marked for crust and crumb color, which had become semi-hard when compared to control cupcakes which scored 14.65 on 15 while 10% addition scored 13.50 on 15, respectively. The 2.5, 5.0, and 7.5 % addition scored 14.60, 14.15, and 14.00 on 15 respectively as shown in Figure 1 [1].
- The 10% cookie sample scored the highest in terms of appearance and color (8.20) while the lowest score was the 20% cookie sample (6.40) [6].

- Sponge cake sample 3 made with the addition of 15% beetroot powder and 20% chard puree had high color scores among other proportions of beetroot powder compared to the control [5].
- The results discovered that there were not many significant differences between the control cookie and the cookie containing 4.5% DBLP concerning texture, taste, aroma as well as overall acceptability [2].



Figure 1. Cupcake substituted with beetroot powder at 2.5, 5.0, 7.5, and 10.0% levels (Source: Alshehry., 2019).

Texture

- Of all the muffins made, the ones made with 20% beetroot pomace flour had the highest average texture score (8.20 out of 9.00), whereas the control and 10% beetroot pomace received 8.00 and 7.97 points, respectively [3].
- In the study by [1], the texture of the cupcake with 2.5%, and the control was marked with the same score which is 14.35 on 15.
- The 10% beetroot cookies scored the highest (7.85) compared to the control cookies prepared from maida flour [6].
- From the study of [5], the texture of sample 3 sponge cake prepared by the addition of 15% beetroot powder and 20% chard puree scored the highest than the control and other samples.
- The results discovered that there were not many significant differences between the control cookie and the cookie containing 4.5% DBLP concerning texture, taste, aroma as well as overall acceptability [2].

Odor and taste

- A study by [3], concludes that both 10 % and 20 % carrot and beetroot pomace incorporated muffins were rated low when compared to control muffins prepared from wheat flour can be due to several reasons for new taste profile deviating from the standard, less acceptance to product modifications from consumers.
- A study on cupcakes enriched with beetroot powder concluded that 10% addition scored 19.40 on 20 while others were consecutively ranked [1].
- The 10% beetroot cookies scored the highest (7.77) and (8.29) respectively for flavor and taste as compared to the control cookies which were prepared from maida flour [6].
- Sponge cake sample 3 made with the addition of 15% beetroot powder and 20% chard puree had high scores for taste in comparison with the control and beetroot incorporated samples [5].

Overall Acceptability

- The muffins with 10% beetroot flour received the highest rating (8.30 points out of a possible 9,00) for overall acceptability. The muffins that had 20% beetroot flour substituted were assessed with 8.10 points, compared to 8.27 points for the control group [3].
- From [1]. study cupcakes with 2.5% addition were ranked higher in overall acceptability when compared to the control which scored 96.65 and 96.75 on 100 respectively.
- Sample 3 sponge cake which was made by addition of 15% beetroot powder and 20% chard puree was accepted overall [5].

- The results discovered that there were not many significant differences between the control cookie and the cookie containing 4.5% DBLP concerning texture, taste, aroma as well as overall acceptability [2].

PHYSICAL CHARACTERISTICS OF BAKED PRODUCTS

Weight

- The cupcakes' weight increased when the beetroot powder was added, going from 51.0 g at 2.5% beetroot to 53.0 g at 10.0% beetroot, in comparison to the control's 50.0 g of wheat flour [1].
- The weight of the cookies increased with incremental order of cookie concentrations as the beetroot powder incorporated ratios increased [6].

Volume

- Compared to the control's 50.0 g of wheat flour, the weight of the cupcakes increased as the beetroot powder was added, going from 51.0 g at 2.5% beetroot to 53.0 g at 10.0% beetroot [1].

Diameter

- While variations were observed with greater levels of beetroot powder that are 10, 15, and 20% concentrations, there were no notable differences in the diameter and thickness of the cookies between those containing up to 7.0% beetroot powder and the control [6].

Form

- The muffins' volume is mostly determined by their form, and the gluten in the wheat flour that is used to make them gives them their volume. [3], in their trial, they replaced wheat with 10% and 20% of beetroot and carrot pomace flour—both of which are gluten-free—and the mixture still had a decent form. The shape-averaging muffins with 20% beetroot pomace flour received the highest rating (8.53 points out of a possible 9.00).

Thickness

- As the amount of beetroot powder substitution rose, larger diameter and lower thickness values were noted [6].

Spreadratio

- The addition of beetroot powder reduced the gas-holding capabilities of the cookies in comparison to the control. Cookies with beetroot powder had a much smaller spread ratio than the control group [6].

Physicochemical Characteristics of Baked Products

Hardness

- Cookies increased in hardness from 57.88 N to 73.44 N with the addition of beetroot powder which could be due to the dilution of gluten proteins with beetroot proteins and fiber [6].
- Dried beetroot leaf powder cookies increased in hardness with increasing substitution of DBLP, while the control cookie was recorded with low value [2].

Proximate Analysis

- [1], his study carried out a proximate analysis for the beetroot powder that is going to be used in the cupcakes, and the results showed that the total carbs, ash content, protein, ether extract, and crude fiber were 54.06%, 12.8, 1.36, 20.40, and 11.30, respectively. In [6], the researchers conducted a proximate analysis of cookies incorporating beetroot powder. The findings indicated that the moisture content of the beetroot powder-containing cookies rose from 2.88 to 5.26%, whereas the control cookies had a moisture content of 2.57%. Protein content increased from 7.39 to 9.12%, with the control group having a protein content of 10.19%. In contrast to the control, the ash content rose from 0.84 to 1.89 percent. Beetroot powder was added up to 20% of the total, increasing the crude fiber content from 0.95 to 1.90%.

- Crude fat and carbohydrate contents were decreased from 23.42 to 21.08 % and 62.9to62.65 respectively with the addition of beetroot powder [10].
- With the inclusion of DBLP, the created cookie samples' crude protein and fat content increased, which may have been caused by DBLP's higher protein and fat content than wheat flour [2].

Phytochemical aspects of used ingredients

- 255.0 mg of gallic acid equivalent (GAE)/100 g sample was detected in the beetroot powder, which was rich in total phenolic components [1].
- The beetroot powder contained rich amounts of flavonoid compounds in which 260 mg rutin equivalent (RE)/100 g sample was identified [1].
- The dried beetroot leaves powder has total phenolic compounds of 5.14 mg gallic acid equivalent (GAE)/100 g sample [2].

Antioxidant Activity of Ingredients Used

- A study by [1] used tests like DPPH, ABTS, and FRAP, which were 137, 190, and 181 mg trolox equivalent antioxidant activity (TEAA)/100 g samples, respectively, to determine the antioxidant activity of beetroot powder to be added to cupcakes.
- The total antioxidant activity of dried beetroot leaves powder was found to be 43.84% while the control was 0.09% [2].

Mineral contents

- From [1], he analyzed the mineral content of beetroot powder which had been used to prepare cupcakes and the results are shown in Table (1).
- The calcium, phosphorous, and iron content were found to be increased whereas zinc and calorific value decreased with increased levels of beetroot powder in cookies [6].

Table 1. Mineral content of beetroot powder mg/g (source: Alshehry., 2019).

Mineral content	mg/g	Mineral content	mg/g
Potassium	26.0±1.25a	Magnesium	1.84±0.02d
Sodium	6.26±0.12b	Manganese	1.05±0.02d
Phosphorus	3.50±0.03c	Iron	0.06±0.001e
Calcium	2.28±0.01d	Zinc	0.03±0.00e

PIGMENT IDENTIFICATION AND SEPARATION

- Beetroot is rich in a water-soluble nitrogen-containing pigment called betalains, which was identified and separated in the study by [1], in which betalains can further be divided into betaxanthins (yellow-orange pigments) and betacyanins (reddish-violet pigments). Using HPLC, it was determined that betalain, which made up 62.6% of the root vegetable, was the main element of red beetroot. Isobetalain and 15-decarboxy-betainin were found to make up 25.3 and 17.1% of the root vegetable, respectively.

CONCLUSION

In conclusion, the organoleptic properties of baked products, such as color, texture, odor, taste, and overall acceptability, were significantly influenced by the incorporation of beetroot powder and products like pomace and leaves. The addition of beetroot powder not only affected the physical characteristics of the baked goods but also contributed to changes in physicochemical properties, proximate analysis, phytochemical properties, antioxidant activity, mineral contents, and pigment identification and separation.

Acknowledgement

I would like to express my sincere gratitude to Dr. Simmi Jain, Head of the Department of Food Technology and Management, M.O.P Vaishnav College for Women for her invaluable guidance and

support throughout the development of this review article. Her expertise and insightful feedback greatly contributed to the depth and quality of this work. I am deeply appreciative of her encouragement and the resources she provided, which were instrumental in shaping this review.

REFERENCES

1. Alshehry, N. G. A. (2019). Utilization of beetroot as a natural antioxidant, pigment, and antimicrobial in cupcake during the storage period. *International Journal of Engineering Research And*, V8(10). <https://doi.org/10.17577/ijertv8is100053>.
2. Asadi, S. Z., & Khan, M. A. (2020). The Effect of Beetroot (*Beta vulgaris* L.) Leaves Powder on Nutritional, Textural, Sensorial and Antioxidant Properties of Cookies. *Journal of Culinary Science & Technology*, 19(5), 424–438. <https://doi.org/10.1080/15428052.2020.1787285>.
3. Bajraktari, F., Stamatovska, V., Nakov, G., & Lukinac, J. (2024). SENSORY CHARACTERISTICS OF MUFFINS ENRICHED WITH CARROT AND BEETROOT BY-PRODUCTS. *Journal of Hygienic Engineering and Design*, 47. <https://keypublishing.org/jhed/wp-content/uploads/2024/07/01.-Abstract-Fatime-Bajraktari.pdf>.
4. Cui, R., Fei, Y., & Zhu, F. (2022). Physicochemical, structural and nutritional properties of steamed bread fortified with red beetroot powder and their changes during breadmaking process. *Food Chemistry*, 383, 132547. <https://doi.org/10.1016/j.foodchem.2022.132547>.
5. Holovko, T., Bordunova, O., Bolhova, N., Vasylenko, O., Nazarenko, Y., & Prymenko, V. (2023). SPONGE CAKE ENRICHED WITH BEETROOT POWDER AND CHARD PUREE: NUTRITIONAL AND SENSORY QUALITIES. *Food Science and Technology*, 17(1). <https://doi.org/10.15673/fst.v17i1.2558>.
6. Ingle, M., Thorat, S. S., Kotecha, P. M., & Nimbalkar, C. A. (2017). Nutritional assessment of beetroot (*Beta vulgaris* L.) powder cookies. *Asian Journal of Dairy and Food Research*, 36(03). <https://doi.org/10.18805/ajdfr.v36i03.8963>.
7. Kohajdová, Z., Karovičová, J., Kuchtová, V., & Lauková, M. (2018). Utilisation of beetroot powder for bakery applications. *Chemical Papers*, 72(6), 1507–1515. <https://doi.org/10.1007/s11696-018-0392-z>.
8. Mitrevski, J., Pantelić, N. Đ., Dodevska, M. S., Kojić, J. S., Vulić, J. J., Zlatanović, S., Gorjanović, S., Laličić-Petronijević, J., Marjanović, S., & Antić, V. V. (2023). Effect of beetroot powder incorporation on functional properties and shelf life of biscuits. *Foods*, 12(2), 322. <https://doi.org/10.3390/foods12020322>.
9. Bangar, S. P., Singh, A., Chaudhary, V., Sharma, N., & Lorenzo, J. M. (2022). Beetroot as a novel ingredient for its versatile food applications. *Critical Reviews in Food Science and Nutrition*, 63(26), 8403–8427. <https://doi.org/10.1080/10408398.2022.2055529>.
10. Ingle M, Thorat SS, Kotecha PM, Nimbalkar CA. Nutritional assessment of beetroot (*Beta vulgaris* L.) powder cookies. *Asian Journal of Dairy & Food Research*. 2017 Sep 1;36(3).