



Utilization of *Beta vulgaris* Leaves for Fortification of Gujarati Traditional Snacks

Shikha Singh¹, Sana Afreen¹, Pallavi Singh², Simran Kumari¹

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ABSTRACT

Background: Beetroot greens (*Beta vulgaris* L.), a lesser-known leafy vegetable from the Chenopodiaceae family, are often overlooked despite their high nutritional value. This study aimed to enhance traditional Gujarati recipes by incorporating beetroot greens and evaluating their sensory and nutritional properties.

Methods: The sensory acceptability and nutritive score of dried beetroot leaves powder (DBLP) incorporated *Khaakra* and *Murukku* at different per centages (0, 5, 10, 15) of added dried beetroot leaves powder (DBLP) were evaluated.

Result: There was a direct correlation between increasing levels of DBLP and improved nutrient content. DBLP-enriched products had mostly enhanced parameters, such as moisture content, protein, fiber, iron and calcium, while carbohydrate content was decreased. Among all products, the highest sensory acceptability was that of the product containing 10% DBLP.

Key words: *Beta vulgaris*, Fortification, Product development, Snacks.

INTRODUCTION

Agricultural and industrial food by-products like peels, leaves and seeds constitute significant waste. Despite being reaped for its benefits, they are disposed leading to environmental pollution. With the surge in awareness, there has been an expansion in the utilization of the same in food products (Anal, 2017). Mango peel is incorporated into bakery products and is served as a functional ingredient (Jahurul *et al.*, 2015). However, strategies have not been formulated to partially or fully utilize most by-products (Lai *et al.*, 2017).

Beetroot (*Beta vulgaris* L.), a commonly consumed vegetable worldwide, belongs to the Chenopodiaceae family. Its leafy greens, known as beetroot greens, are often discarded due to limited dietary awareness (Amnah, 2013; Biondo *et al.*, 2014). These leaves contain anti-nutrients like oxalate, tannins and phytate at levels comparable to or lower than those found in spinach (*Spinacia oleracea* L.). Both the leaves and the root of beetroot are nutrient-dense, offering minerals, protein, fiber and essential vitamins such as cyanocobalamin, pyridoxine, calcium and folic acid (Fernandez *et al.*, 2017). Furthermore, beetroot leaves are abundant in plant pigments like carotenoids, chlorophylls and betalains, as well as bioactive compounds such as kaempferol, quercetin and rutin, which contribute to their antioxidant properties. Additionally, they serve as a good source of omega-3 fatty acids, particularly linolenic acid (Elaby and Ali, 2018).

Incorporation of underutilized low-cost traditional ingredients in value-added products can spur interest in the market, especially among the malnourished population (Ebert, 2014). The current consumer demand is convenient but nutritious ready-to-eat foods (Ali *et al.*, 2015). Consumers are approaching food to fulfill nutritional requirements, not just satiate hunger. There is an increased understanding

¹Department of Food and Nutrition, Era University, Lucknow-226 003, Uttar Pradesh, India.

²Faculty of Public Health, Poornima University, Jaipur-303 905, Rajasthan, India.

Corresponding Author: Shikha Singh, Department of Food and Nutrition, Era University, Lucknow-226 003, Uttar Pradesh, India. Email: drshikha489@gmail.com
ORCIDs: 0009-0008-0649-6998; 0000-0002-1091-6421; 0000-0002-6404-2782.

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of its role in preventing nutritional deficiency disorders (Betoret *et al.*, 2011; O'Shea *et al.*, 2012). This has created a demand for nutritious snacks (Yangilar, 2013).

Murukku is a widely consumed ready-to-eat snack, particularly in Gujarat and among Indian communities in Fiji and Sri Lanka. Crunchy Murukku, shaped like tiny coils, is the most popular in southern India. It is typically savored for its flavor and crisp texture. It is a mixture of black gram, rice flour, salt, spices and flavorings like cumin, carom seed, chili and asafoetida. When combined into a batter, shaped into a coil or spiral shape, it is mechanically extruded before being deep-fried until crisp (Ramasamy *et al.*, 2011).

Khakhra, a widely enjoyed Gujarati snack, is a thin, crispy flatbread commonly paired with tea, coffee, butter, yogurt, cheese, chutney, or pickles. Available in flavors such as cumin, fenugreek, mint leaves and various spice blends, it is traditionally made from wheat flour and oil. This homemade, roasted snack is a convenient and flavorful

option for breakfast or light meals. Its minimal packaging requirements, lack of additional processing and extended shelf life contribute to its popularity (Vijayarani *et al.*, 2021). There are some studies done on Khakhra fortified with whole unripe pumpkin (Patel *et al.*, 2023), millets (Vijayarani *et al.*, 2021), Multiple grains, spirulina powder, flax seeds (Bansal *et al.*, 2023), red rice, buckwheat and flaxseed (Bartwal *et al.*, 2020), apricots (Hirdyani and Mundeja, 2015) have been done. Similarly, limited studies replaced refined flour with rajma flour in the preparation of Murukku (Vijayarani *et al.*, 2021) or preparation of low-fat Multigrain Murukku (Sarangam *et al.*, 2015). Although reports of Dried Beetroot Leaf Powder (DBLP) incorporated Khaakra and Murukku are unprecedented.

When cooking oils are heated to standard frying temperatures, they produce high levels of certain toxins that can get into the food. Regular consumption of these toxins, especially the α, β -unsaturated types, can be very harmful to human health in the long term. It's crucial to develop strategies to address this serious issue (Grootveld *et al.*, 2020). From this perspective, our study aims to prepare and standardise DBLP-incorporated value-added products, namely, Khaakra and Murukku, by baking.

MATERIALS AND METHODS

Fresh beetroot (*Beta vulgaris* L.) leaves were sourced from local vegetable markets, while other ingredients for product development were procured from nearby grocery stores. The experiment was conducted at the Food Processing Laboratory and Food analysis Laboratory of Department of Food and Nutrition, Era University, Lucknow, UP in 2022.

Preparation of DBLP

First, the fresh beetroot leaves were cleaned. Asadi and Khan's (2019) specifications were followed in the preparation of the DBLP. A tray dryer (Biogen Scientific C.A.T.

No. BGS-123 Sr. No. 101742, U.P. India) was used to dry the beetroot leaves for seven hours at $60 \pm 2^\circ\text{C}$, followed by blanching in a microwave system (Kenstar KE20CBGJ MGA, India) at 560 W for 50 seconds. The DBLP was ground into powder using an automatic blender (Tandem brand, India) and then sieved through a sieve (SETHI firm, India, mesh size of 180 μm). The leaves were then placed in low-density polyethylene (LDPE) bags, sealed with a heat sealer (Golden Eagle, India) and kept for later use at -18°C (Fig 1).

Preparation of value-added products

Value-added products were prepared using the method recommended by Giridhar (2019). The basic recipe (control M_0, K_0) had three basic variations namely $M_1, M_2, M_3, K_1, K_2, K_3$ respectively as seen in Fig 2a and 2b. The 100:0 ratio was the control product. The different products, such as *Khakhra* and *Murukku*, were prepared by using different ratios of DBLP on a trial basis as follows:

Product composition

The DBLP was incorporated into the value-added products (*Murukku* and *Khakhra*) at 5, 10 and 15 per cent.

M_0, K_0 - Control (No incorporation of DBLP), 100% Bengal gram flour.

M_1, K_1 - Bengal gram flour 95 g and DBLP 5 g.

M_2, K_2 - Bengal gram flour 90 g and DBLP 10 g.

M_3, K_3 - Bengal gram flour 85 g and DBLP 15 g.

Nutritional analysis

The Association of Official Analytical Chemists (AOAC, 2000) guidelines were followed to determine the percentage of ash, moisture, crude fiber and crude protein in the samples for proximate analysis. Energy was calculated using the energy conversion factor and the carbohydrate content of value-added products was determined using the difference approach. Fat content analysis was conducted using the Soxhlet extraction method (LTSW-4). For ashing, the samples were digested in a muffle (Model No- HT-MF800-2.3S/G) at 600°C for 6 to 8 hours, or until complete organic matter breakdown and then recovered with acid for mineral identification. An atomic absorption spectrophotometer (HV-AAS02-2100) was used to quantify iron in the samples. Calcium was estimated by the titration method.

Sensory analysis

The Nine Point Hedonic Scale (Srilakshmi, 2011) was used to assess different sensory parameters *viz.* color, appearance, body and texture, taste and flavor and overall acceptability of the prepared value-added products. A panel of fifteen trained judges evaluated the prepared value-added products for their various sensory attributes and the analysis was replicated three times. The panelists underwent semi-training to get acquainted themselves with the product's sensory attributes and the previously indicated nine-score ranges for the sensory analysis (Baljeet *et al.*, 2014; Ranganna, 1986).



Fig 1: Method of preparation of DBLP.

Statistical analysis

The results were presented as triplicates $\pm$ standard deviation for each sensory attribute. The significant differences between the properties of *Murukku* and *Khakhra* were



Fig 2a: Method of preparation of *Murukku*.



Fig 2b: Method of preparation of *Khakhra*.

statistically tested for significant differences using the ANOVA (Analysis of Variance). The nutritional content of the control recipe and the best acceptable product were statistically analyzed by t-test.

RESULTS AND DISCUSSION

This study was carried out in the Food Processing Laboratory at the Department of Food and Nutrition, Era University, Lucknow. Good raw materials were procured from Lucknow's local market to prepare value-added products. The per centage of DBLP in treatments of *Murukku* and *Khakhra* was 0% in M_0 , K_0 , 5% in M_1 , K_1 , 10% in M_2 , K_2 and 15% in M_3 , K_3 . The mean sensory scores for evaluating value-added products are presented in Table 1. The final products underwent 9- point Hedonic scale assessment as shown in Fig 3 and 4.

M_0 was the most acceptable color and appearance as the *Murukku* turned dark green from cream as the level of DBLP incorporation increased. Being dense and crunchy, *Murukku* showed the highest acceptability of M_1 regarding Body and Texture. While the taste, flavor and overall acceptability of M_2 were most liked, with the increase in DBLP beyond 10%, the product turned dark, bitter and hard, hence reducing the overall acceptability of M_3 . DBLP incorporated *Murukku* had a significant effect on color, appearance, body and texture, taste and flavour and overall acceptability ($p \leq 0.05$). *Khakhra* showed a slight tinge of green color and hardness in value-added products, making the Color and Appearance, Body and texture of K_0 most acceptable. Value-added K_1 *Khakhra* had an enhanced Taste and Flavour and Overall acceptability, but the acceptability decreased beyond 5% incorporation of DBLP. The inclusion of DBLP in *Khakhra* significantly influenced its color, appearance, texture, taste, flavor and overall acceptability ($p \leq 0.05$). According to the Ingle *et al.*, (2017) the incorporation of beetroot powder in cookies lowered the lightness (L^*) and yellowness (b^*) but increased redness (a^*) of cookies. The hardness of the cookies was increased with increasing the level of beetroot powder. Sensory evaluation of cookies concluded that the cookies prepared with addition of 10% beetroot powder were more acceptable as compared to others.

Research on DBLP incorporated *Khakhra* and *Murukku* is lacking. Although various research reports similar sensory attributes of DBLP incorporated snacks. In a study reported by Giridhar 2019, the color of T1 was more acceptable than the different treatment combinations of GLV-based *Khakhra*. It has been noted that a small drop in the amount of GLV in *khakhra* results in a slight drop in the color and appearance score. Similarly, in our study, as DBLP levels increase, the mean score for color and appearance decreases slightly. As per the research findings revealed by Aulia and Sunarharum 2020, there was a notable effect on the cookies' colour and crispiness' when the amount of beetroot powder was increased along with the oven's temperature. Similar to our study, was reported by

Evstigneeva *et al.*, 2020, where a higher per centage of beetroot powder was characterized by a more pronounced color, taste and aroma. Kakade *et al.*, 2015 reported an increase in the hardness of extruded snacks with an increase in beetroot leaves powder per centage, whereas

the lateral expansion was decreased. Another study by Singh and Sharma in 2021 reported that up to 15% of incorporation was accepted, contrary to our study. This may be attributed to the powder mixing cauliflower and DBLP. Incorporating this mix resulted in dark color and

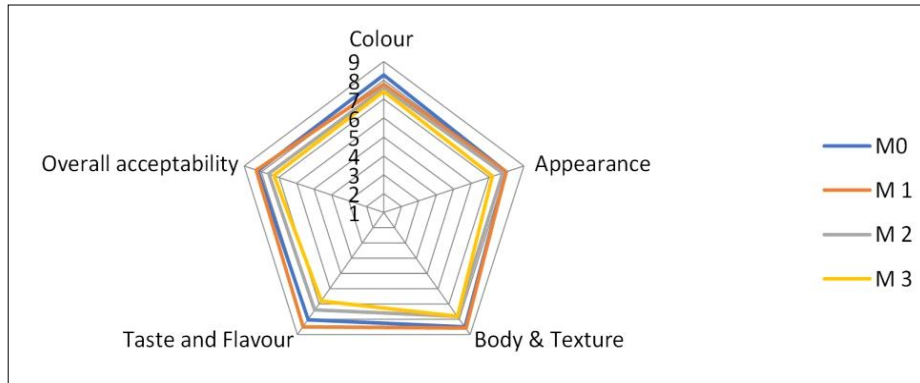


Fig 3: Sensory scores of Murukku.

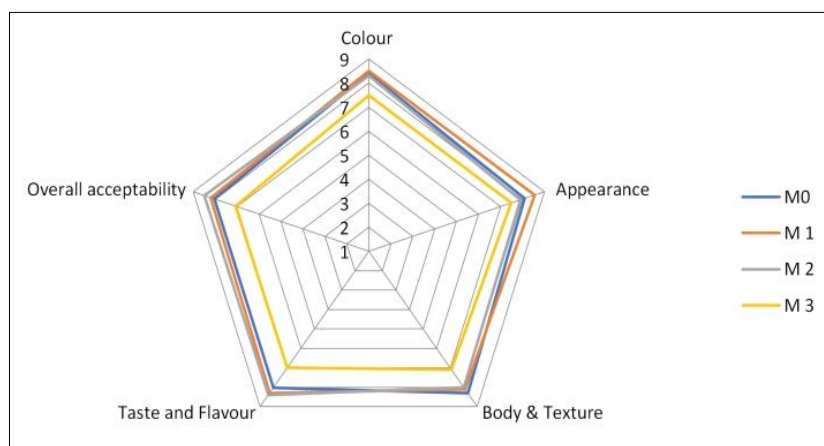


Fig 4: Sensory scores of Khakhra.

Table 1: Sensory evaluation of Murukku and Khakhra.

Sensory attribute	Colour (Mean±SD)	Appearance (Mean±SD)	Body and texture (Mean±SD)	Taste and flavour (Mean±SD)	Overall acceptability (Mean±SD)
Treatments					
Murukku					
M ₀	8.3±0.05	8.0±0.03	8.20±0.00	8.03±0.05	8.2±0.02
M ₁	7.8±0.04	7.5±0.10	8.4±0.03	8.19±0.00	8.1±0.0
M ₂	7.6±0.02	7.3±0.08	8.1±0.10	8.5±0.04	8.3±0.02
M ₃	7.4±0.02	7.0±0.05	7.8±0.08	7.9±0	7.5±0.04
F _{Cal}	19.52 ^S	29.12 ^S	20.615 ^S	91.86 ^S	266.98 ^S
Khakhra					
K ₀	8.5±0.02	8.21±0.04	8.3±0.00	8.01±0.04	8.03±0.03
K ₁	8.4±0.04	8.1±0.12	8.1±0.03	8.3±0.00	8.32±0.03
K ₂	8.3±0.00	7.6±0.15	8±0.10	7.8±0.11	8.14±0.02
K ₃	7.5±0.02	7.0±0.04	7.1±0.01	7.6±0	7.06±0.02
F _{Cal}	35.0265 ^S	43.05 ^S	107.860 ^S	96.242 ^S	68.7365 ^S

M±SD=Mean ± Standard deviation, F_{tab} = 4.76 at 5% level of significance S= Significant; NS= Non-significant.

appearance, both in cooked and raw form. The sensory scores of the treatments decreased as the incorporation level of DBLP increased. The taste scores across the treatments showed remarkably similar results. Upon the escalation of DBLP powder, an atypical mouthfeel was noted. However, the overall flavor and acceptability of the product were not significantly affected, as demonstrated by the nearly identical ratings for different treatments (Singh and Sharma, 2021). According to study reported by Tangariya *et al.*, (2023) BRP incorporated snack bars were evaluated for various sensory parameters viz; taste, after taste, color and appearance, texture and overall acceptability using nine- point Hedonic scale. In case of BRP incorporated snack bars sensory quality declined with increase in the level of BRP. Mean sensory scores for taste and after taste decreased significantly ($p<0.05$). In contrast to our study, Rachana *et al.*, (2025) reported the lowest organoleptic parameters for bar with highest amount of pineapple and equal amounts of beetroot and dates followed by highest amount of pineapple than beetroot and dates.

Values of ash, moisture and fiber were determined to understand the composition of developed value-added products as shown in Table 2 and 3. Results show that K_3 and M_3 had the highest per centage of proximate composition. This can be attributed to the fact that DBLP is rich in mineral content, which leads to high ash value. DBLP is also naturally high in fibre content. It has been proven that DBLP has a high moisture absorbing capacity; hence, the product with the highest concentration, *i.e.*, K_3 and M_3 , showed the highest per centage of the proximate composition. Ash and moisture content of dehydrated beetroot leaves are 156.09 g/Kg and 85.08 g/Kg, respectively (Biondo *et al.*, 2014). The nutritional composition of the prepared products was determined using the standard procedure described by AOAC (2000). M_0 and K_0 provided the highest value for energy and carbohydrate among all treatments, as shown in Table 4. This can be attributed to the decrease of high-energy base ingredients, *i.e.*, Bengal gram in *Murukku* and *Khakhra* and the increase in low-energy ingredients, *i.e.*, DBLP, by 5% in each treatment following the previous. Since the quantity of beetroot powder increased by 5% in each treatment of both *Murukku* and *Khakhra* following the

Table 2: Proximate composition of *Khaakhra*.

Characteristics	K_0	K_1	K_2	K_3
Moisture (%)	3.12	3.24	3.27	3.42
Fiber (%)	4.68	4.32	5.96	6.603
Ash (%)	1.3	2.41	3.52	4.64

Table 3: Proximate composition of *Murukku*.

Characteristics	M_0	M_1	M_2	M_3
Moisture (%)	4.13	4.21	4.29	4.62
Fiber (%)	5.01	5.75	6.29	6.93
Ash (%)	1.6	2.71	3.82	4.94

Table 4: Nutritional composition of *Murukku* and *Khaakhra*.

Nutrients	M_0	M_1	M_2	M_3	K_0	K_1	K_2	K_3
Energy (Kcal)	765.7±0.62	765.51±0.24	765.32±0.19	763.13±0.59	75.5±0.68	74.97±0.39	74.45±0.13	73.92±0.54
Protein (gm)	11±0.06	11.19±0.65	11.38±0.23	11.57±0.05	0.9±0.16	1.595±0.33	2.29±0.68	2.58±0.54
Carbohydrate (gm)	123.4±0.46	119.95±0.53	116.23±0.20	112.79±0.31	8.15±0.44	8.22±0.19	8.29±0.59	8.36±0.62
Fat (gm)	25.2±0.10	23.075 ±0.21	22.95±0.05	22.83±0.13	20.92±0.02	18.79±0.09	18.67±0.11	18.55±0.04
Calcium (mg)	2.778±0.39	19.7±0.23	36.7±0.10	53.70±0.33	1.5±0.16	18.57±0.68	35.53±0.25	52.69±0.048
Iron (mg)	29±0.05	96.26±0.09	168.91±0.07	241.56±0.11	27±0.07	68.4±0.19	133.9±0.12	217.35±0.21

M±SD=Mean ± Standard deviation, (n=3). Significant differences was observed between control and treatment at 5% level of significance.

previous, the protein content was highest in M₃ and K₃. There was an increase in calcium and iron content with each treatment, as the level of incorporation increased by 5% in each following the previous. In another study, based on nutrient content as per the increasing maturity level of DBLP, Dehydrated beetroot leaves' energy and carbohydrate levels range from 3,5843.56 to 3350.19 Kcal/kg and 307.21 to 410.19 g/Kg. The protein content ranges from 310.25 to 264.12 g/Kg. The Saturated fatty acid content ranged from 8.56 to 13.90 mg/g. The Calcium content ranged from 1476.35 to 1864.85 mg/kg. The iron content ranged from 187.30 to 342.75 mg/kg (Biondo *et al.*, 2014). DBLP incorporated *Khakhra* and *Murukku*, which are rich in iron and can be good for the anaemic community. Sobhy *et al.*, 2020 reported that DBLP contains 13.71 mg/100 g of iron, approximately half of the values reported by Biondo *et al.*, 2014 (25.63 mg/100 g). The variation in iron content may be attributed to the fact that the species or the soil quality may differ in both studies. nonetheless, it is an iron-rich source. The studies show that DBLP contains a good amount of ash, ranging from 145.06 g/kg to 184.33 g/kg (Biondo *et al.*, 2014). DBLP could be considered a viable source of protein for individuals with constrained options for animal protein, as its crude protein levels varied from 264.12 gm/kg to 310.25 gm/kg. The DBLP's ash and protein contents were greater in 52 varieties of vegetables and 36 hydroponic systems when compared to the findings of Kinupp and Barros (2008).

CONCLUSION

Regarding sensory attributes, the DBLP incorporated *Murukku* at 10% and the DBLP incorporated *Khakhra* at 5%, with the highest overall acceptability. Based on nutrition composition, it was found that the nutrient content (Protein, Calcium and Iron per 100gm) was highest in M₃ and K₃. While energy, carbohydrates and fat content were highest in the control treatment of both products. The products formulated by incorporation of DBLP at different per centages were acceptable and at the same time, nutritionally enhanced.

Consumption of iron and protein-rich foods has been proven to alleviate various nutritional deficiency disorders. Nutrition education programs that utilize and incorporate underutilized food items like beetroot leaves can be beneficial. Further, intervention with similar value-added products can be done to determine their therapeutic use.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the

information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

No animals and human intervention was done.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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