Original Research Article

EVALUATING THE NUTRITIONAL VALUE OF DEHYDRATED GREEN LEAFY VEGETABLES: BENGAL GRAM, FENUGREEK, AND SPINACH

Abstract

The present study aimed to investigate the nutritional composition of dehydrated spinach, fenugreek, and Bengal gram leaves. For the development of leaf powder, the green leafy vegetables (GLVs), were steam blanched for 2 min after pretreatment and dried in an oven at 80 °C for 8 h. The dehydrated samples were analyzed for selected proximate constituents, vitamins, minerals, antinutrients, and iron. Among all the dehydrated leaves powder BLP contains the highest (24.39 %) crude protein followed by SLP (24.79) and FLP (23.0 %). The β-carotene of BLP (Bengal gram leaves powder), FLP (Fenugreek leaves powder), and SLP (Spinach leaves powder) were found to be 48890, 22401, and 54911 µg/100g respectively. The total iron content in the dehydrated leaves i.e. BLP, FLP, and SLP was estimated as 111.33, 96.7, and 80.83 mg/100g. Dehydration is the simplest and most convenient technology for preserving GLVs, especially when they are abundantly available. Dehydrated GLVs are a concentrated natural source of micronutrients and can be used in product formulations. Adding traditional foods with dehydrated GLV can be a sustainable food-based approach to combating micronutrient malnutrition.

Keywords: β-carotene, Bengal gram leaves, dehydration, fenugreek, green leafy vegetables (GLVs), iron, micronutrient, and spinach.

Introduction

Since the Green Leafy Vegetables (GLVs) are the treasure house of micronutrients especially iron and calcium, owing to their high moisture content, it is perishable and unavailable during the entire season. Every day having animal food is not possible in our daily traditional custom, so we all rely on daily intake of micronutrients from green vegetables. In the present scenario, when the prevalence of malnutrition is increasing, there is a need to highlight the nutritional value of green leafy vegetables. Regular consumption of such vegetables can free from various consequences of malnutrition. It can improve the health condition. Our country, India has been blessed with a wide variety of inexpensive green leafy vegetables which are rich in various micronutrients such as carotenoids and iron. Navarrete *et al* (2021) studied eight traditional vegetables usually produced in southern Chile (pea, corn, carrot, leek, spinach, chard, coriander, and parsley) and were characterized in terms of their nutritional composition to evaluate their potential as lyophilized natural ingredients and reported that Green leafy vegetables were an excellent source of proteins and dietary fibers as well as vitamins (ascorbic acid, choline, alpha-tocopherol, and niacin), minerals (calcium, phosphorus, and iron), carotenoids and polyphenols. Among the eight vegetables assessed, spinach exhibited a more balanced nutritional profile.

The use of Bengal gram leaves, spinach, and fenugreek leaves can eradicate the micronutrient deficiencies. The nutritional composition of spinach leaves was estimated as moisture (92.1%), protein (2.0%), fat (0.7%), ash (1.7%), fiber (0.6%), carbohydrates (2.9%) and energy (26%) (Gopalan *et al* 2007). The nutrient content of Bengal gram leaves indicated that the protein, calcium, and iron content in Bengal gram leaves was 5.80g/100g, 337.56mg/100g, and 22.34mg/100g respectively (Bisla *et al* 2012). Among the leaves of amaranth, cauliflower, mint coriander, and carrot, the Bengal gram leaves have the highest content of ascorbic acid, β- carotene, and total iron (Singh *et al* 2001).
Green leafy vegetables are available at low cost or no cost during the season. Owing to high moisture content, green leafy vegetables are highly perishable and are sold at throwaway prices in the peak season resulting in heavy losses to the growers due to the non-availability of sufficient storage, transport, and proper processing facilities at the production point (Pande *et al* 2000). Arasaretnam (2018) investigated the Nutritional and mineral composition of selected green leafy vegetables and reported that the green leafy vegetables contain a considerable amount of essential micronutrients in addition to the presence of high amounts of vitamin C. The results also indicate that the high intake of GLVs could provide the nutritional requirements necessary for normal growth thus giving adequate protection against diseases arising from malnutrition.

Dehydration is one of the traditional methods of preservation, which converts the food into a lightweight, easily transportable, and storable product. The advantage of this method is that it can be easily converted into fresh-like form by rehydrating and can be used throughout the year. It facilitates the utilization of dried leaves in other parts of the country or world where this vegetable is unavailable in plenty. In addition to increasing variety in the menu, and reducing wastage, labor and storage space, dehydrated vegetables are simple to use and have longer shelf life than fresh vegetables (Chauhan and Sharma 1993). Dehydration influences the nutrient composition of green leafy vegetables. On dehydration of *Amaranthus gangeticus, Chenopodium album, Centellaasiatica*, *Amaranthus tricolor* and *Trigonellafoenumgraecum* little effect on the proximate, mineral, and antinutrient content of the GLV were estimated. Among the vitamins, retention of ascorbic acid was 1-14 percent, thiamine 22-71 percent, total carotene 49-73 percent, and β-carotene 20-69 percent respectively, of their initial content. Dialyzable iron and calcium in the fresh vegetables ranged between 0.21-3.5 mg and 15.36-81.33 mg/100 g respectively, which reduced to 0.05-0.53 mg and 6.94–58.15 mg/100 g on dehydration (Gupta *et al* 2013). Special emphasis should be placed on the consumption of locally available green leafy vegetables during the season and on ensuring their preservation at the household level as they are affected by the ecological setting. The present study evaluated the nutritional value of dehydrated commonly consumed leafy vegetables i.e., spinach, fenugreek, and Bengal gram.

Methodology: Development of green leaves powder

Dehydration of green leafy vegetables (GLVs)

- **Selection and procurement of green leafy vegetables**

Three green leafy vegetables (GLVs) i.e. Bengal gram leaves (*Cicer arietinum*), Fenugreek leaves (*Trigonella corniculata*) and Spinach leaves (*Spinacia oleracea*) were selected for dehydration and procured from the local market.

- **Sorting and washing of green leafy vegetables**

The green leafy vegetables were sorted with tender stems and healthy leaves. Selected GLVs were washed thoroughly by dipping them in water for one minute. The procedure was repeated till the vegetables are devoid of dirt and soil.

- **Blanching and dehydration of fresh leaves**

Leaves were blanched (enclosed in muslin cloth) in a stainless steel pan for 2 minutes at 80°C and dried in a cabinet (tray) dryer at 50±5°C for 8 hours.

- **Storage of dehydrated green leaves**

The dehydrated green leafy vegetable was packed in low-density polythene bags and stored in an airtight container for further use.

Nutritional analysis:

The fresh green leafy vegetables (GLVs) and dehydrated GLVs were analyzed for the following components to study the effect of dehydration. Moisture, ether extractives, and ash (minerals) were estimated by standard methods (AOAC 2000). Total iron was analyzed by colorimetric method using α – α bipyridyl (AOAC 1985) and calcium by the method of AOAC (2000). Insoluble and soluble dietary fiber was analyzed by the separation of non-starch polysaccharides by the enzymatic gravimetric method. Ascorbic acid was estimated by the visual titration method of reduction of 2, 6—di chlorophenol-indophenol dye. Total carotene was extracted in acetone; β-carotene was separated by column chromatography and estimated colorimetrically (Ranganna 1986).

Double glass-distilled water was used to prepare the analysis's reagents. All chemicals used for the study were of analytical grade.

Statistical analysis: The data presented represents the mean of quadruplicate analysis, standard deviation was computed to assess the variation between the replicate values.

Result and Discussion

Proximate composition

The proximate composition of dehydrated GLVs is presented in Table 1. The moisture content of Bengal gram and fenugreek leaves powder was found to be 7.87 and 9.16 per cent. This is in good agreement with Kaur (2011) who reported the moisture content of Bengal gram leaves to be 6.87 per cent. Bedi (2004) reported the 5.9 per cent moisture content in spinach on DM basis. Among all the dehydrated leaves powder BLP contain highest (24.39 %) crude protein followed by SLP (24.79) and FLP (23.0 %). Kaur (2011) reported 21.4 per cent crude protein in BLP. Bedi (2002) also reported higher protein content in spinach as 26.2 per cent, whereas Punia *et al* (2004) found protein content in amaranthus and Khondhara leaves as 20.3 and 22.6 per cent respectively.

Table 1: Proximate composition of dehydrated GLVs (g/100g, DM basis)

Ingredients	**Moisture**	**Protein**	**Fat**	**Ash**	**Fiber**	**CHOs**	**Energy (kcal)**
Bengal gram leaves powder (BLP)	7.87±0.25	24.39±1.3	3.27±0.78	11.83±1.53	11.89±0.93	48.71	321.11
Fenugreek leaves powder (FLP)	9.16±0.66	23.0±1.31	3.07±0.04	11.89±0.39	14.22±0.72	47.82	317.23

Spinach leaves powder (SLP)	6.21±0.5	24.79±0.94	3.28±0.63	12.39±0.56	9.4±0.54	50.14	301.08

The fat content was found to be highest in SLP (3.28 %) followed by BLP (3.27 %) and FLP (3.07 %). Punia *et al* (2004) reported 4.55 per cent fat in Khondhara leaves on dry weight basis, whereas Reema *et al* (2004) reported higher content in dried cauliflower leaves as 7.7 per cent. Kaur (2011) reported the highest fat content in BLP (5.9 %).

Crude fiber of raw ingredients was found to be in range of 0.66 to 14.22 per cent, being lowest in tomato and highest in FLP, followed by BLP (11.89 %) and SLP (9.4 %). The results were supported by Kaur (2011) who found the fiber content of BLP as 14.5 per cent. Lakshmi and Vimla (2000) observed that the fiber content of green leafy vegetables varied from 6.8 to 13.97 per cent on a dry matter basis. The fiber content of Bengal gram was observed as 4.07g fiber/100g on a dry matter basis by Bhamma (1999). Waseem (2021) studied dehydrated spinach powder's nutritional characterization and food value-addition properties. The results suggested that spinach powder holds 8.2% crude fiber, 19.2% protein, 1,304 mg/100g calcium, and 40.4 mg/100g iron. The carbohydrate content of dehydrated leaves powder was estimated to be highest in spinach leaves (50.14 g) followed by Bengal gram (48.71 g) and fenugreek leaves powder (47.82 g). The energy content is estimated to be highest in Bengal gram leaves (321.11 kcal) among all the three leaves powder.

Vitamin content

The β- Carotene content is given in Table 2. The β-carotene of BLP, FLP and SLP was found to be 48890, 22401 and 54911 µg/100g respectively. Yadav and Sehgal (1995) observed the β- carotene content of spinach and amaranthus leaves was 2263 and 5900 µg/100g respectively. Lakshmi and Vimla (2000) estimated the β- carotene content of amaranthus, curry leaves, gogu and mint and reported as 1328, 5005, 1994 and 1565 µg/100g on fresh weight basis respectively.

Table 2: Vitamin content of dehydrated leaves (dry matter basis)

Dehydrated leaves	β-carotene (µg/100g)	Vitamin C (mg/100g)
Bengal gram leaves powder (BLP)	48890	155.7

Fenugreek leaves powder (FLP)	22401	55.9
Spinach leaves powder (SLP)	54911	35.7

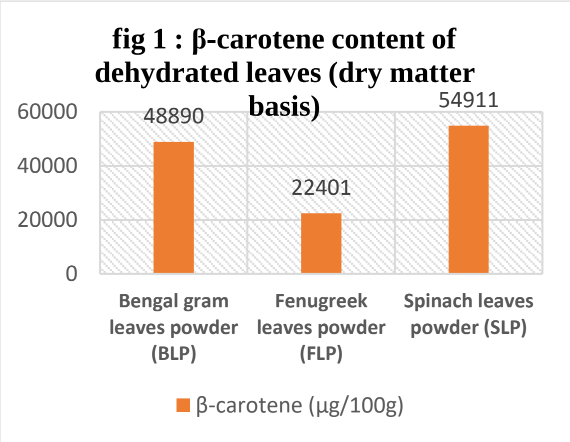

fig 1 : β-carotene content of dehydrated leaves (dry matter basis)

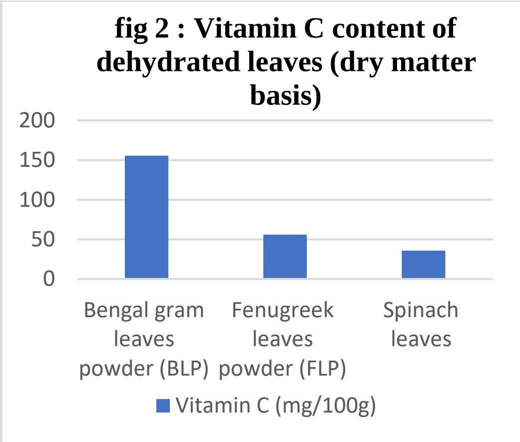

fig 2 : Vitamin C content of dehydrated leaves (dry matter basis)

The ascorbic acid content of various raw food ingredients is given Table 2. The ascorbic acid content of raw food ingredients ranged from 0.45 to 155.7 mg/100g, being maximum in BLP followed by FLP (55.9 mg/100g) and SLP (35.7 mg/100g). Kaur (2011) reported that 196 mg/100g vitamin C content in BLP. Kaur and Kochar (2005) reported that vitamin C content of leaves of cauliflower, radish, turnip and carrot was 97, 84, 143 and 67 mg/100g respectively.

Anti-nutritional factors

The data on phytates, polyphenols, and oxalates is given in Table 2. The inhibitory effect of phytate on iron absorption shows that phytate is the main cause of iron inhibition. The phytate content in the three samples of the dehydrated leaves was in the range of 110-128 mg/100g. Maximum phytate content (128 mg/100g) was found in SLP and the minimum in FLP. 116mg/100g of phytate was found to be in BLP. A finding was similarly Kaur (2011) reported phytate content in BLP as 109 mg/100g.

Table 3: Antinutritional factors of dehydrated leaves (mg/100g, DM basis)

Dehydrated leaves	**Phytate (mg/100g)**	**Polyphenol (mg/100g)**	**Oxalates (mg/100g)**
Bengal gram leaves powder (BLP)	116±0.12	330.77±0.04	257.5±0.02
Fenugreek leaves powder (FLP)	110±0.14	326.92±0.34	270±0.62

Spinach leaves powder (SLP)	128±0.15	323.08±0.64	805±0.52

The polyphenol content in the three samples of the dehydrated leaves was estimated as 330.77, 326.92, and 323.08 mg/100g in BLP, FLP, and SLP respectively. Similarly, Kaur (2011) found polyphenol content in BLP as 326mg/100g. The polyphenol content of wheat flour was found to be 248.46mg/100g. Maushumi (1997) and Kaur (1997) reported polyphenol in wheat flour as 345 and 199mg/100g. Polyphenol content in tomato and potato was reported as 403.85 and 350 mg/100g respectively.

The oxalate content is maximum in SLP followed by FLP (270 mg/100g) and BLP (257.5 mg/100g). A similar result was reported by Kaur (2011) that oxalates content in BLP was found 263 mg/100g. Oxalates content of wheat flour was 8.7 mg/100g. Gopalan *et al* (2012) reported 8.16 mg/100g oxalates in whole wheat on dry matter basis.

Iron content

The total and iron content in dehydrated green leafy vegetables (GLVs) is presented in Table 4. The total iron content in the three samples of the dehydrated leaves i.e. BLP, FLP, and SLP was estimated as 111.33, 96.7, and 80.83 mg/100g.

Soluble iron was found to be in the range of 1.09mg/100g in potato to 41.6 mg/100g in BLP followed by FLP (36.25mg/100g) and SLP (31.5mg/100g). Kaur (2011) obtained soluble iron in BLP to be 36.57mg/100g respectively.

Table 4: Total, soluble, and ionizable iron content and % bioavailability of iron of dehydrated leaves (mg/100g DM basis)

Dehydrated leaves	**Total iron**	**Soluble iron**	**Ionizable iron**	**% Bio-availability**
Bengal gram leaves powder (BLP)	111.83	41.6	14.93	7.51
Fenugreek leaves powder (FLP)	96.7	36.25	16.34	8.17
Spinach leaves powder (SLP)	80.83	31.5	17.94	8.93

It may be attributed to the high quantity of iron in dehydrated leaves powder of Bengal gram, fenugreek, and spinach. Among these three dehydrated samples, BLP contains the highest amount of iron. Goyle and Gujral (1992a) also reported an increase in the total iron content of raw mix *biscuits* of wheat and Bengal gram from 4.36 to 5.39 mg/100g after 7.5 percent supplementation with colocasia leaves. Punia *et al* (2004) found 3.23 and 4.03 mg/100g of iron in khondhra leaves supplemented Bengal gram *dal* and green gram *dal*, whereas 6.32 mg/100g of iron in amaranthus leaves supplemented *parantha*, at different levels of supplementation. Khatonia (2018) studied the formulation and evaluation of dehydrated greens incorporated value-added products aimed to increase the consumption of green leafy vegetables in the daily diet for this a series of laboratory experiments were carried out to find the nutritional constituents of some selected green leafy vegetables and after comparing the iron and calcium content of the dehydrated green leafy vegetables, Amaranthus spinosus, Talinum triangulare, and Chenopodium album were found to be higher in both iron and calcium content.

Ionizable iron and *in vitro* iron availability

The ionizable iron and *in vitro* iron availability content is presented in Table 4. Maximum ionizable iron content (17.94 mg/100g) was estimated in SLP followed by FLP (16.34 mg/100g) and BLP (14.93 mg/100g). Kaur (2011) reported that BLP and germinated wheat contain ionizable iron at 15.45 and 0.83 mg/100g respectively. *In vitro* iron availability was reported maximum in SLP (8.93) followed by FLP (8.17) and BLP (7.51).

CONCLUSION

Dehydrating GLVs concentrates nutrients that provide adequate nutrition for optimal human well-being and productivity. The dehydrated GLVs are a rich source of dietary fiber which can be applied in the development of high-fiber and micronutrient-rich foods. Easy to preserve, feasible, convenient, and off-season availability are advantages of incorporating dehydrated GLVs in products. Dehydrated GLVs can be incorporated into traditional products at the household level or utilized in the formulation of processed foods at the industrial level. Value addition of food products with dehydrated GLVs can be advocated as a feasible food-based approach to combat micronutrient malnutrition. Green leaf powder has a longer shelf life and is easy to use in daily meals which enhances the value addition of food by adding culinary diversity. This study reported that the dried leaf powder is an excellent source of nutrients required for human well-being in combating iron deficiency anemia and other micronutrient deficiencies. The leaf powder can be a cost-effective, suitable ingredient for improving the nutritional quality of food by value addition. Its use in diets should be encouraged and sustained.

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