International Scholars Journals

African Journal of Wood Science and Forestry ISSN 2375-0979 Vol. 13 (3), pp. 001-006, March, 2025. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Unlocking the Potential of Underutilized Greens: Value-Added Products from Dehydrated Leaf Powders

Pallavi Joshi* and Beena Mathur

Department of Home Science, University of Rajasthan, Jaipur, India.

Accepted 20 January, 2025

In India various types of under utilized foods are available seasonally but are not utilized to the extent they should be in spite of their higher nutritive value. Looking into the prevalence of high level of micronutrient malnutrition among the vulnerable sections, utilization of under utilized foods can be explored to overcome nutritional disorders. Through this study an attempt was made to analyze the nutritional potential and acceptability of leaf mixtures (LM) prepared from the less utilized leaves of beet root (*Beta vulgaris*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*) and turnip (*Brassica rapa*) which are usually discarded or are used as animal fodder. The leaf mixture was prepared by mixing the powders of above mentioned greens in a definite ratio (1:2:1:1). The LM was analyzed for the proximate composition, mineral composition (Ca, P, Fe, Cu, Zn Mn and Mg) and antinutritional composition (oxalate and phenols). Twenty different recipes with different levels (0, 5, 10, 15 and 20%) of LM incorporation were prepared and were assessed for quality on the basis of sensory attributes. The products were well accepted to the level of 10%. Protein, iron and calcium content were significantly ($p < 0.05$) higher in the LM incorporated recipes and the increase was directly proportional to the level of leaf mixture incorporated.

Key words: Green leafy vegetables, underutilized, dehydrated.

INTRODUCTION

Green leafy vegetables occupy an important place among the food crops as these provide adequate amounts of many vitamins and minerals for humans. They are rich source of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous. In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever increasing human population. Many of them are resilient, adaptive and tolerant to adverse climatic conditions. Although, they can be raised comparatively at lower management costs even on poor marginal lands, they have remained underutilized due to lack of awareness and popularization of technologies for utilization. Nowadays, underutilized foods are gaining importance as a means to increase the per capita availability of foods. Since low consumption of green leafy vegetables in diet is one of the major factors, which leads to deficiency of vitamin A and iron.

Most developing countries depend on starch based foods as the main staple food for the supply of both energy and protein. This accounts in part for protein deficiency which prevails among the populace as recognized by Food and Agriculture Organization (Ladiji et al., 1995). In most of the tropical countries where the daily diet is dominated by starch staple foods, dehydrated vegetables are cheapest and most readily available source of important proteins, vitamins minerals and essential amino acids (Akubugwo et al., 2007).

Many of the local vegetable materials are under exploited because of inadequate scientific knowledge of their nutritional potentials. Many workers (Lockeett et al., 2000; Akindahunsi and Salawu, 2005; Edeoga et al., 2006; Hassan and Umar, 2006; EKkop, 2007) have reported the compositional evaluation and functional

*Corresponding author. E-mail:pulkitpal@rediffmail.com.

Table 1. Composition of 100 g leaf mixture.

Leaves	Amount (g)
B. Vulgaris (beet green)	20
D. Carota (carrot leaves)	40
B. Oleracea (cauliflower greens)	20
B. Rapa (turnip greens)	20
Total	100

properties of edible wild plants in use in the developing countries.

Green leafy vegetables are highly seasonal and are available in plenty at a particular season of the year. Abundant supply during the season results in spoilage of large quantities. Preservation of these green leafy vegetables can prevent huge wastage as well as making them available in the lean season.

Dehydration is one of the methods of preservation of green leafy vegetables. In addition to increasing variety in the menu and reducing wastage, dehydrated vegetables are simple to use and have a longer shelf life than fresh vegetables.

Dehydrated GLV are equal to legumes in their protein content. Dehydration also makes them a concentrated source of vitamins and minerals and thus they become a very suitable "natural fortificant".

Thus keeping in mind all these perspectives the present study was conducted for developing and quality evaluation of value added products made from the leaf mixture (LM) of dehydrated greens of beet root (*Beta vulgaris*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*) and turnip (*Brassica rapa*).

MATERIALS AND METHODS

The leaves of four selected vegetables, beet root (*B. vulgaris*), carrot (*D. carota*), cauliflower (*B. oleracea*) and turnip (*B. rapa*) were collected from the strategic market locations (farm stand) of Rajasthan.

Sample preparation

The leaves were thoroughly washed in water 2 - 3 times to remove the adhering dust and impurities and were dried in sun for 6 - 7 days till they turned crisp and brittle to touch and their moisture level reached 6 - 7%. The leaves were then turned to homogeneous powders in pastel and mortar and were passed through a fine mesh. The powders were then mixed together in a definite proportion of 1:2:1:1. The composition of 100 g LM is given in Table 1. The samples were then subjected to biochemical analysis. The water used in the analysis was glass distilled.

Sample analysis

The nutrient compositions (moisture, dry matter, ash, acid insoluble ash, ether extract and crude fibre) of the dehydrated vegetable mixtures were determined using the recommended methods of the Association of Official Analytical Chemists (AOAC) (1999). Nitrogen free extract was determined by difference. Protein was determined using the micro Kjeldhal method (Nx6.25). The Fe, Cu Zn, Mn, Mg and Ca were determined by established flame atomic absorption spectrophotometry procedures using a Shimadzu Atomic Absorption Spectrophotometer (Shimadzu AA6300). Oxalate were determined titremetrically using the standard AOAC (1999) procedures and Phosphorous was determined colorimetrically using Fiske and Subba row method (1952). The total phenol content was determined by mixing 0.5 ml aliquot (0.25 g of the sample extracted by 20 ml 80% ethanol) with equal volume of water, 0.5 ml Folin-Cioalteu's reagent and 2 ml of sodium carbonate were subsequently added, and the absorbance was measured at 650 nm (Singleton et al., 1999).

Preparation of value added products

Twenty different recipes which are commonly used in Western and Central India were selected Table 2. These were prepared by different methods of cooking. Most of the recipes were basically carbohydrate base, commonly used by low and middle income groups. The objective in selecting different methods of cooking of these recipes was to find if they made any difference in the preparation and acceptability.

Each recipe was standardized with total 100 g of weight of the ingredients. This was designated as the "basic recipe" and served as 'control' for the purpose of comparison. LM was then incorporated in this basic recipe at different concentrations of 5, 10, 15 and 20%. The amount of LM containing 6% moisture required to get these concentrations was 5.3, 10.6, 15.9 and 21.2% respectively. Organoleptic evaluation of all the recipes containing different levels of LM was done by a panel consisting of 8 judges on the basis of their appearance, aroma, texture and mouth feel. The judges were requested to fill up the score card sheet giving a maximum of 5 mark for each of the five factors listed above, thus making a total score of 25.

RESULTS AND DISCUSSION

Nutritive value of the LM is depicted in Table 3. The LM was a rich source of micronutrients and provided good amounts of energy and protein too and thus became a concentrated source of almost all the nutrients. The nutritive value of the LM is presented in Table 3.

The leaf mixture was a dark green coarse powder of the leaves with a dark green colour and a bland flavour. The physical properties of the LM affected the sensory attributes of the various food products developed by its incorporation. Sensory attributes of various products formed by incorporating varied levels of the LM (0, 5, 10, 15 and 20%) was assessed by a panel of eight judges. The elaborate findings of the organoleptic evaluations are covered under the following headings.

Effect of different levels of LM on the sensory attributes

Appearance

As the LM was a dark green coloured powder it gave a

Table 2. Details of selected food preparation.

S.No.	Food preparation	Method of cooking used	Consumed as
1.	Mathri	Deep frying	Snack
2.	Coconut balls	Sautéing	Snack
3.	Kothimbir Vadi	Steaming	Snack
4.	Laddoo	Roasting	Sweet
5.	Alu Pitika (Boiled mashed potatoes)	Sautéing	Side dish
6.	Alu Bonda	Deep frying	Snack
7.	Dal Kachori	Deep frying	Snack
8.	Amchoor chutney	No cooking required	Side dish/Relish
9.	Missi Roti	Roasting	Used for breakfast/lunch
10.	Rava Idli	Steaming	Snack
11.	Tikia	Shallow frying	Snack
12.	Bati	Shallow frying	Main dish
13.	Bottle gourd Halwa	Sautéing	Sweet
14.	Gatta Curry	Boiling	Main dish
15.	Coconut chutney	No cooking required	Side dish/Relish
16.	Pakora	Deep frying	Snack
17.	Upma	Sautéing	Side dish
18.	Dosa	Shallow frying	Main dish for breakfast/lunch
19.	Stuffed Paratha	Shallow frying	Used for breakfast/lunch
20.	Raita	No cooking required	Side dish

Table 3. Nutritional and antinutritional composition of the leaf mixture.

Moisture (%)	6.37 ± 0.10
DM (%)	93.63 ± 0.10
Ash (%)	17.17 ± 0.23
Acid incoluble ash (AIA) (%)	2.09 ± 0.35
Ether extract (%)	4.38 ± 0.02
Crude protein (%)	25.77 ± 0.10
Crude fibre (%)	8.49 ± 1.20
Nitrogen free extract (%)	44.16 ± 1.36
Calorie (Kcal/100g)	319.23 ± 5.20
Ca (%)	3.77 ± 0.15
P (%)	0.50 ± 0.01
Mg (%)	0.49 ± 0.00
Fe (mg %)	77.10 ± 0.00
Zn (mg %)	2.52 ± 0.00
Cu (mg %)	0.89 ± 0.00
Mn (mg %)	0.49 ± 0.00
Oxalate (%)	0.39 ± 0.13
Polyphenol (%)	0.66 ± 0.03

The data are mean value ± standard deviation (SD) of four replicates. Values expressed as percent dry weight.

green colour to the food which was light in colour at the lower levels (5 and 10%), which increased to darker shades of green in most of the products at 15 g per level serving. Green colour was not a hindrance to acceptance

Table 4. Effect of level of leaf mixture on sensory attributes.

Sensory attributes	0%	5%	10%	15%	20%	SEM	P value
Appearance	4.96 [e]	4.61 [d]	4.04 [c]	3.64 [b]	3.23 [a]	0.03	0.00
Aroma	4.93 [e]	4.40 [d]	3.93 [c]	3.37 [b]	2.97 [a]	0.03	0.00
Texture	4.91 [e]	4.44 [d]	3.87 [c]	3.38 [b]	2.98 [a]	0.03	0.00
Mouth feel	4.94 [e]	4.28 [d]	3.61 [c]	3.11 [b]	2.62 [a]	0.03	0.00
Taste	4.97 [e]	4.34 [d]	3.62 [c]	3.00 [b]	2.41 [a]	0.02	0.00
Total	24.7 [e]	22.08 [d]	19.08 [c]	16.52 [b]	14.23 [a]	0.08	0.00

Values with different superscripts letters within a row differ significantly ($p < 0.05$) by Duncans multiple range test.

as was clear from the acceptability score of quality factor 'appearance'. In all the products up to 10 g LM per serving also, the product was well accepted in terms of appearance, while gradual decrease in acceptability scores could be seen as the level of leaf mixture incorporation increased (Table 4). The average scores for appearance at 15 and 20% were also 'good' to 'fair'.

Aroma and mouth feel

At the time of sun drying, the leaves had a strong aroma, however, once the leaves were fully dried, they had a very mild odour, but as the LM was rehydrated it regained the strong aroma and flavour. Therefore, aroma and mouth feel of the products secured higher scores at the level of 5% but the scores gradually decreased at higher level of incorporation, yet, none of the recipes scored poor scores in terms of aroma and mouth feel (Table 4). In most of the recipes beyond the level of 10%, the judges were able to identify the taste and odour of cauliflower leaves. Cauliflower and turnip both belong to the Brassica family which is known for their pungent taste and odour.

Texture

All the products had good texture at 5 to 15 g level of LM incorporation; but average acceptability scores for texture decreased markedly at 10 g level for all products (Table 4). At 10 g level it also became difficult to prepare the dough or the filling. *Idli* too acquired a rough texture beyond 10% level of LM incorporation.

Taste

The LM had quite a bland taste, therefore, addition of 5 or 10 g of LM did not alter the taste to a great extent. Thus, all the products were well accepted in terms of taste up to the level of 10%. However, an inverse relationship was observed between the level of LM and the taste (Table 4). The average acceptance scores for taste decreased markedly at 15 to 20% of LM incorporation.

The results are in line with the study done by Kaur and Kochar (2005) on organoleptic evaluation of the greens of carrot, turnip and radish. They reported the acceptability to the level of 20%. Spice mixture containing 10% curry leaf powder was found to be acceptable and the recipes incorporated with curry leaf powders showed higher levels of iron calcium and other micronutrients (Shenoy et al., 2000).

Effect of product on sensory attributes

The detailed observations noted during the trial are discussed under the following headings.

Steamed and fermented products

The overall acceptability of the steamed products was better as compared to the other products. Kothimbir vadi and idli scored high values in taste was also a steamed product and the pungency and after taste of the leaves was subdued by steaming the products. Another reason for kothimbir vadi to score high values was the presence of green coriander as the major ingredient. LM flavour and colour was masked by the use of green coriander and the standard recipe was also not standing out because of the presence of green colour from the green coriander. Besides steaming, one of the reasons for the high scores of idli, was the fermentation of the product. Fermentation had actually masked the leaf mixture flavour considerably. Similarly dosa which is not a steamed but a fermented product also scored high values while, the other recipes prepared by shallow frying scored comparatively lower values, the reason for which has been discussed earlier.

Deep fried and shallow fried products

Deep fried and shallow fried products though acceptable in taste did not score high values in appearance as frying

Table 5. Effect of level of leaf mixture on nutrient composition.

Nutrient composition	0%	5%	10%	15%	20%	SEM	P value
Carbohydrate	38.43 [a]	37.94 [bc]	37.44 [abc]	36.94 [ab]	36.43 [a]	0.45	0.02
Fat	20.4 [a]	20.26 [a]	20.13 [a]	20.00 [a]	19.87 [a]	0.29	0.73
Energy	333.23 [d]	327.16 [cd]	321.09 [bc]	315.04 [ab]	308.99 [a]	3.15	0.00
Protein	7.08 [a]	7.94 [b]	8.80 [c]	9.66 [d]	10.52 [e]	0.14	0.00
Iron (mg)	3.95 [a]	7.53 [b]	11.14 [c]	14.73 [d]	18.30 [e]	0.17	0.00
Calcium (g)	89.61 [a]	294.04 [b]	498.39 [c]	702.99 [d]	907.59 [e]	18.7	0.00

Values with different superscripts letters within a row differ significantly ($p < 0.05$) by Duncan's multiple range test.

imparts an unacceptable dark green colour to the food products. Shallow frying gave better results than the deep fried products especially in colour and appearance. The green colour was intensified in the deep fried products because of the solubility of chlorophyll, the leaf pigment, in fat.

Encased and non encased products

The preparations which were encased with a better or some other covering like dal kachori, stuffed paratha in which the green colour of LM was not visible scored consistently better scores in appearance, colour and taste than the non encased preparations.

Sweet preparations

Savory preparations were better liked and accepted than the sweet preparations like laddu, halwa and coconut balls especially at the higher concentration of the LM. It could probably because salt and spices mask the flavour more than sugar and jaggery. Secondly, because the leaves had high sodium content and the concentration of the salt in the leaves further increased due to dehydration. The high salt content gave a typical taste to the sweet preparations turning them unacceptable and thus all the sweet preparations were rejected and scored lowest values.

Familiarity with the products

One more reason for the less or high acceptability of some of the recipes in terms of appearance was the common or uncommon colour imparted to them by the incorporation of the LM. *Idli* though liked in taste scored low values in appearance as green *idlis* was an uncommon product for the judges. Whereas *bati* scored high in appearance as the colour imparted to the *batis* was similar to the palak, *bathua or methi* stuffed *batis* and hence green *batis* was a common product to the eyes of the judges. Similarly coconut balls scored lowest in all the sensory attributes except for appearance as green colour imparted to the balls was similar to *moong* and *pista laddoos*.

OTHER FINDINGS

The most interesting results were observed with amchoor chutney. High percentage of LM in chutney did not make any change in the taste. The green colour resembling the coriander chutney and the darker shade of the amchoor chutney due to the incorporation of the LM did not pose any problem in its acceptability. The sour taste of amchoor reduced the pungency and flavour of the LM and it was well accepted at 20% level and beyond it too.

Effect of various levels of leaf mixture on the nutrient composition of the recipes

Iron and calcium content of the recipes was directly proportional to the level of LM incorporated Table 5. As the level of the LM increased the iron and calcium content of the recipes also showed a significant ($p < 0.05$) improvement which shows that these leaves are rich in iron and calcium.

Thus, these leaves can be used for the preparation of value added products rich in micronutrients. LM incorporation did not show any change in the proximate composition except for protein. This could be because of two reasons: Firstly, in general green leafy vegetables are considered to be rich source of minerals and vitamins only and not of protein, fat and carbohydrate. Secondly, while making the recipes LM replaced the main ingredient of the recipe in equal amounts. The main ingredient of the recipe was mostly cereals which are carbohydrate rich providing the maximum share of energy and protein. Thus the displacement affected the carbohydrate composition of the recipes inversely that is with the increase in the level of LM the carbohydrate and fat content decreased where as protein content showed a directly proportional relation with the level of LM. As the level increased the protein composition of the recipe also increased and the difference was also significant ($p < 0.01$).

The results clearly indicate improvement in iron and calcium content thus, the leaves could be used as an iron supplement since the protein was also high and high protein diets help in better absorption of iron. Similar results were found by Singh et al. (2007) in dehydrated *bathua* (*chenopodium album linn*). *Bathua* (*Chenopodium album* Linn*.*) leaves, were tray dried at 50 - 60°C for three to four hours till the moisture reached to 6 – 7%. These dehydrated leaves were incorporated at 3 – 15% levels in two conventional foods namely green gram *dal* and *paratha.* Organoleptic properties of products were judged by nine point hedonic scale. Proximate composition, iron content and carotene content of leaves and products were analyzed. Results showed that dehydrated leaves were rich sources of protein, carbohydrate and ash. Iron and carotene contents of dehydrated *bathua* leaves (27.48 mg/100 g and 14826 µg/100 g, respectively) were 6 - 8 times higher than fresh leaves. Green gram *dal* and *paratha* incorporated with 7 and 5% dehydrated *bathua* leaves were liked most. Iron content of green gram *dal* (8.8 mg/100 g) and *paratha* incorporated with dehydrated *bathua* leaves was higher than their respective control. In comparison to control enriched *paratha* (4255.66±0.6 µg/100 g) and green gram *dal* (984 ±1.8 µg/100 g) had many fold greater carotene content. Begum et al. (2000) also reported cauliflower leaf powders to be a good source of protein and micronutrients. Motey and Lee (2003) also reported the similar results on a study done on dehydrated leaves.

Conclusion

Results of the present study clearly revealed high potential of the mixture prepared by dehydrating the less utilized greens of beet root (*B. vulgaris*), carrot (*D. carota*), cauliflower (*B. oleracea*) and turnip (*B. rapa*). Development of products based on these vegetables will increase the nutritional value of the regular Indian diet as well as this can contribute to the food security among the people of the region.

REFERENCES

Akindahunsi AA, Salawu SO (2005). Photochemical screening and nutrient and anti-nutrient composition of selected tropical green vegetables. Afr. J. Biotechnol., 4(1): 497-501.

Akubugwo IE, Obsai NA, Chinyere GC, Ugbogu AE (2007). Nutritional and chemical value of *Amaranthus hybridus* L. leaves from Afikpo, Nigeria. Afr. J. Biotechnol., 6(24): 2833-2839.

AOAC (1999). Methods Anal. Assoc. Anal. Chem. (16th ed). Washington D.C., 1: 600-792.

Begum MJ, Deshpande B, Farzana C (2000). Sensory attributes and nutrient composition of iron and beta-carotene enriched products. Sci. Prog. Abs., NSI. Ab PSEN6.51.

Edeoga HO, Omosun G, Uche LC (2006). Chemical composition of *Hyptis sauveolens* and *Ocimum gratissium* hybrids from Nigeria. Afr J. Biotechnol., 5(10): 892-895.

Ekop AS (2007). Determination of chemical composition of *Gnetum africana* (AFANG) seeds. Pak. J. Nutr., 6(1): 40-43.

Hassan LG, Umar KJ (2006). Nutritional value of Balsam apple (*Momordica balsamina* L.) leaves. Pak. J. Nutr., 5(6): 522-529.

Kaur TJ, Kochar GK (2005). Organoleptic evaluation and retention of vitamin C in commonly consumed food preparations using under exploited greens. Ind. J. Nutr. Dietet., pp. 42, 425.

Ladeji O, Okoye ZS, Ojobe T (1995). Chemical evaluation of the nutritive value of leaf of fluted pumpkin (*Telferia occidentalis*). Food Chem., 53: 353-355.

Lockeett CT, Calvert CC, Grivetti LE (2000). Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought: Study of rural Fulani, Northeastern Nigeria. Int. J. Food Sci. Nutr., 51: 195-208.

Motey R, Lele S (2003). Fresh cauliflower preservation technology. J. Food Sci., Technol., 40(4): 419-422.

Shenoy AH, Shantala M, Prakash J (2000). Utilizing dried curry leaf for value addition in selected products. Sci. Prog. Abs., NSI. Ab-Open 3: 37.

Singh L, Yadav N, Kumar AR, Gupta AK, Chacko J, Pravin K, Tripathi U (2007). Preparation of value added products from dehydrated *bathua* leaves (*Chenopodium album* Linn.). Nat. Prod. Radiance., 6: 6-10.

Singleton VL, Orthofer R, Lamuela-Raventos RM (1999). Analysis of total phenols and other oxidation sustrates and antioxidants by means of Folin-Ciocalteu Reagents. Methods Enzymol., 299: 152-178.