POST-HARVEST PROCESSING AND STANDARDIZATION OF VALUE ADDED CEREAL BASED TRADITIONAL RECIPES FOR IRON SECURITY

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ABSTRACT
Bengal gram leaves (Cicer arietinum) were selected for the study which aimed to standardize iron rich cereal based traditional recipes with dried Bengal gram leaves for iron security. Blanched Bengal gram leaves were dried in cabinet dryer and its rehydration ratio (4.07), chlorophyll content (16.0±0.42 mg/g) and total iron content (93.61±0.08 mg/100g) were recorded. Dehydrated Bengal gram leaves powder was incorporated into 'Chapati', 'Poori' - wheat flour based deep fried product and 'Paratha' - a cereal based shallow fried product at 5, 7.5 and 10% levels. All the acceptable products incorporated with 7.5% dehydrated Bengal gram leaves received higher scores of 8.34 (extremely good) to 8.44 (excellent) on nine point hedonic scale, indicating the acceptable utilization of dehydrated Bengal gram leaves in traditional products. However, acceptability scores reduced with increasing concentration of dehydrated Bengal gram leaves. Total iron content was estimated higher in chapati (14.787mg/100g) supplemented with dehydrated Bengal gram leaves than Poori (12.87mg/100g) and Paratha (13.33mg/100g). Addition of dehydrated Bengal gram leaves increased iron density of all products. Development of value added cereal based recipe using dehydrated Bengal gram leaves extend the utility of supplementation of dehydrated vegetables in traditional recipes for iron security.

Key words: Bengal gram leaves, Chlorophyll, Dehydrated greens, Iron security, Rehydration ratio, Traditional products.

INTRODUCTION
Anaemia is a global public health problem affecting both developing and developed countries with major consequences for human health as well as social and economic development. Two billion people over 30 per cent of the world’s population are anaemic (WHO 2013). Iron deficiency continues to be the leading single nutritional deficiency in the world, despite considerable efforts over the past three decades to decrease its prevalence. Iron deficiency also compromises the immune system and is associated with limited cognitive development in children. Among preschool aged children worldwide, 23% suffer from iron deficiency anemia (Gegios et al., 2010). In India, 79% of children between 6 to 35 months and women between 15 to 49 years of age are anemic (Krishnaswamy, 2009). The most sustainable approaches to increasing the micronutrient status of populations are food-based strategies, which include food production, dietary diversification and food fortification. The food based approach for combating micronutrient malnutrition, is difficult and of a long duration, although its effect is predicted to be long lasting. Green leafy vegetables (GLV) are micronutrient dense nature’s gift to mankind.

Green Leafy Vegetables (GLV), a treasure trove of nutrients in general and micronutrients in particular, are available at low cost or no cost throughout the year. Apart from ten conventional GLVs, more than 40 types find usage in limited area and quantity. Owing to high moisture content, green leafy vegetables are seasonal and highly perishable and are sold at throwaway prices in the peak season resulting in heavy losses to the growers due to non-availability of sufficient storage, transport and proper

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processing facilities at the production point (Pande et al., 2000). Augmenting utilization and avoiding wastage calls for employing suitable preservation techniques that are user friendly and sustainable at the household level. Dehydration is one of the traditional methods of preservation, which converts the food into light weight, easily transportable and storable product. Advantage of this method, if employed for vegetables, 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 the dried leaves in other parts of the country or world where this vegetable is unavailable in plenty. Dehydration removes enough moisture to prevent microbial growth whereas Sun drying may be too slow and organisms may cause spoilage. In addition to increasing variety in the menu, reducing wastage, labour and storage space, dehydrated vegetables are simple to use and have longer shelf life than fresh vegetables (Chauhan and Sharma, 1993). Since the consumption of green leafy vegetables in Indian population is limited to 5 - 10 g per day (NNMB, 1997) as against the recommendation of 100 g by Indian Council of Medical Research (ICMR, 1998). So the present investigation is an attempt to dehydrate the commonly consumed GLVs to prevent the post-harvest losses and to extend the utility of dehydrated vegetables in traditional recipes for iron security.

**MATERIALS AND METHOD**

**Procurement of sample:** Bengal gram leaves (Cicer arietinum) required for the study, were procured from local market which was the cheapest (Rs.2.50 per 100g of edible portion) available in the winter season (January to February) and rich in iron content (23.8 mg/100g on fresh basis).

**Sorting and washing:** Bengal gram leaves were sorted with tender stem and healthy leaves and washed thoroughly by dipping in water for one minute. The procedure was repeated till the leaves are devoid of dirt and soil.

** Blanching:** Sorted and cleaned Bengal gram leaves were subjected to Blanching prior to the dehydration. For blanching, the GLVs were tied in destarched muslin cloth and kept immersed in boiling water for two minutes at 80°C and drained in colander to remove excess water.

** Dehydration:** Blanching leaves were dried in a cabinet (tray) dryer at 60°C for 5 hour. The percent yield was recorded.

**Storage:** The dehydrated leaves were packed in low-density polyethylene pouches and stored in air tight aluminum containers for future use.

**Determination of rehydration ratio:** The rehydration ratio of dehydrated Bengal gram leaves powder was estimated using the method suggested by Patil et al. (1978). Distilled water (100 ml) was brought to boil and two grams of the dehydrated GLV was added. The beaker was covered with a watch glass and kept for five minutes. The contents of the beakers were then transferred to a Buchner funnel and filtered over a Whatman No.1 filter paper by applying gentle section for 2-3 min. The drained rehydrated material was weighed and the rehydration ratio calculated as follows:

\[
\text{Rehydration Ratio} = \frac{\text{Weight of rehydrated material}}{\text{Weight of dehydrated material}}
\]

**Chemical analysis of dehydrated leaves**

**The proximate composition:** The proximate composition of the dehydrated leaves was determined by AOAC (1985) method.

**Moisture:** Weigh 5g of fresh sample was taken in triplicate and dried to a constant weight in a hot air oven for 8 hours at 105°C. China with dried material was transferred immediately to a desicator, cooled and weighed. Moisture was calculated according to the following formula

\[
\% \text{ Moisture} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100
\]

**Crude protein:** The macrokjeldahl method was used for determination of nitrogen. The factor 4.25 was used to convert nitrogen to crude protein.

**Chemicals:** Concentrated sulphuric acid, digestion mixture: 1 part Copper sulphate and 9 parts of potassium sulphate, 4% boric acid, 40% sodium hydroxide, mixed indicator: 0.1g methyl red and 0.5g bromocresol green were dissolved in 100ml of 95% ethanol and 0.1N sulphuric acid.

**Procedure:** Weighted 0.5g of test sample and transferred to a kjeldhal digestion flask. It was digested with 25ml concentrated sulphuric acid and digestion mixture (3-5g). The digestion was carried out until the solution was clear. Digested solution
was taken in the distillation flask, added 50ml of 40% NaOH, (an excess amount to neutralize the acid and create strong alkaline pH) and 100 ml of water. After addition of sodium hydroxide, immediately the flask was fixed to a condenser having a 250ml flask containing 25ml of boric acid with mixed indicator. The distillation was carried out till the distillate became almost double. Distillate was titrated with 0.1NH$_2$SO$_4$ to a pink red end point.

A blank was also run with the sample.

\[
\% \text{ Nitrogen} = \frac{\text{Vol. of } 0.1\text{NH}_2\text{SO}_4 \text{ used} \times 0.0014 \times 100}{\text{Weight of sample (g)}}
\]

Per cent crude protein = Per cent nitrogen × 6.25

**Note:** volume of 0.1NH$_2$SO$_4$ used was taken after subtraction of blank sample.

**Crude fat**

**Chemical:** Petroleum ether

**Procedure:** Thimbles were prepared from whatman No.1 filter paper sheet with the help of 2 cm diameter testtube and thread. Five gram of moisture free sample was transferred to the thimble and was plugged with cotton. The thimble was placed in the soxlet assembly and petroleum ether (40-40 C) was put in the flask to 1.5 times capacity of soxlet assembly and the apparatus was fitted with condenser to a water tap for cold water circulation. The apparatus was started by fixing at 40 C. and was run for 18 hours taking care of the tap water and ether in the flask. All the fatty constituents were dissolved in the ether.

At the end ether was evaporated in the flask and the contents were transferred to a pre-weighted crucible using small quantities of the ether. It was evaporated in the crucibles on water bath and then fatty constituents left in the crucibles were weighted.

\[
\text{Crude fat(%) } = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100
\]

**Crude fiber**

**Chemicals:** 1.25 % sulphuric acid and 1.25% Sodium hydroxide

**Procedure:** Took 5 g of moisture and fat free sample in a 500 ml beaker and added 200 ml of 1.25 % sulphuric acid. It was refluzed for 30 moinhuts and filtered through muslin cloth using backner funnel. Washed the residue with hot water till it was acid free and transferred the residue to beaker. Added 200ml of 1.25% sodium hydroxide to beaker and again transferred the residue to a pre-weighted crucible and dried to a constant weight at 130 C for 2 hours in hot air oven. Residue was then ignited in muffle furnace and loss in the weight was recorded.

Crude fiber %=

\[
\frac{\text{Weight of residue }- \text{ weight of ash after ignition}}{\text{Weight of sample taken}} \times 100
\]

**Total Ash:** Took 5g of sample in previously weighted crucible. It was ignited and placed in a muffle furnace at 550 C for 4 hours. After cooling, the residue left in the crucible was weighted.

\[
\text{Ash (％) } = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100
\]

**Total carbohydrates or nitrogen free extract (NFE)**

The NFE was calculated by the formula:

NFE(％) = 100 - (CP % + CF% + EF% + Total ash %)

Where CP = crude protein, CF = crude fiber, EF = ether/crude fat

**Energy:** The energy content was calculated by factorial method i.e.

Energy (Kcal) = (4 × protein) + (9 × fat) + (4 × carbohydrate)

**Determination of total iron:** Total iron was estimated using atomic absorption spectrophotometer (Piper, 1950).

**Principle:** The sample is vaporized into its atomic state usually by a flame and irradiated by the light from a source whose emission lines are those of the element being sought. The absorption of the light by the vaporized sample is related to the concentration of the element in it.

**Chemicals:** Diacid mixture was used for digesting the food sample consisting of nitric acid and perchloric acid in the ratio 5:1 respectively. It was always used fresh.

**Procedure:** Weighed sample (0.5g) was digested with 25 ml of diacid mixture in a conical flask (100-250 ml) and were kept overnight and then heated at a low temperature on a hot plate till about 1 ml clear, colourless liquid was left. Then content were cooled and transferred with deionised water into 50 ml volumetric flask and volume was made to the mark. The digest was filtered stored in decontaminated
dried labeled and air tight polyethylene bottles for iron
determination by atomic absorption
spectrophotometer. For blank, 25 ml of diacid mixture
was digested as in case of sample and volume was
made to 50 ml with demineralized water.

**Estimation of soluble minerals:** To 1 g of sample,
added 50 ml of 0.03 N HCl, incubated the mixture
at 37°C in a shaker cum bath for three hours to
stimulate the conditions that occur in human
stomach. Filtered the mixture through ash less filter
paper (Whatman No. 42). The filtrate was oven
dried, digested in diacid mixture (nitric: perchloric
acid, 5:1 v/v) and processed for determination of
individual minerals by atomic absorption
spectrophotometer. The extractability was
determined as:

\[
\text{Extractability (\%)} = \left( \frac{\text{HCl extractable minerals (mg)}}{\text{Total minerals (mg)}} \right) \times 100
\]

**In vitro availability of iron (Rao and Prabhavati,
1978):** For mineral estimation, 2 g of sample was
mixed with 25 ml of pepsin HCl (5% pepsin in 0.1
N HCl) solution. The pH of mixture was adjusted to
1.35 with HCl and incubated in 100 ml conical flasks
at 37°C in metabolic shaker cum water bath for 90
minutes. After incubation, the contents of the flask
were filtered through Whatman No. 44 filter paper.
Than the pH of the solution was adjusted to 7.5
with NaOH and again centrifuged at 3000 rpm for
45 minutes and supernatant were filtered through incubated in metabolic shaker cum water bath for 90
minutes. The contents were than centrifuged at
3000 rpm for 45 minutes. The supernatant were
filtered again and used for determination of ionizable
ing iron.

**Ionizable iron:** Free form of iron in the filtrate, which
reacts with alpha- alpha- dipridyl to yield colour,
obtained after incubation of the samples with pepsin-
HCl at 1.35 and 7.5 as described by AOAC (1985).
This form of iron corresponds to the ionizable iron.
The percentage of iron absorption was determined by regression equation of Rao and Prabhavati
(1978) as given below:

\[
Y = 0.4827 + 0.4707X
\]

\[
X = (\text{Ionizable iron/ Total iron}) \times 100
\]

Where \( Y \) = \% Fe absorption in adult
\( X \) = ionizable Fe at pH 7.5

**Reagents**
1. Alpha- alpha- dipridyl solution: Dissolved 0.1 g
of alpha- alpha- dipridyl in distilled water and
incubate to 100 ml in volumetric flask.
2. Acetate buffer solution: Dissolved 8.3 g of
anhydrous sodium acetate (AR) in distilled water
followed by the addition of 12 ml of glacial acetic
acid (AR) and volume made to 100 ml. The contents
were filtered through what’sman No. 1 filter paper.
3. Hydroxylamine hydrochloride solution: Dissolved
10 g of Hydroxylamine hydrochloride in distilled
water and diluted to 100 ml.

**Procedure:** From the aliquot, pipette 1.0 ml into 10
ml volumetric flask and added 1 ml of hydroxylamine
hydrochloride solution. In few minutes, added 5 ml
of buffer solution and 1 ml of alpha, alpha- dipridyl
solution and volume was made up to 10 ml. Read
the intensity of colour against reagent blank, in
spectrophotometer at 510 nm.

**Determination of chlorophyll:** The chlorophyll
content of the dehydrated GLVs was measured using
the method of Mackinney (1941). The principle of estimation involves the absorption of light by aqueous acetone extracts of chlorophyll at a wavelength of 652 nm and setting up simultaneous equation using the specific absorption coefficient for chlorophyll.

**Development of product:** Three traditional products namely ‘chapati’, ‘poori’ and ‘paratha’ were selected for incorporating dehydrated Bengal gram leaves in rehydrated form (converted into fresh-like form). These products are wheat flour based, which are generally eaten as a routine diet. The ingredients used for preparing the three products were wheat flour (100 g), Bengal gram leaves powder (7.5 g) and water (150 ml). The dough made for Chapatti, Poori and Parathawas same.

Wheat flour, and Bengal gram leaves were mixed together. Flour was supplemented with dehydrated Bengalgram leaves at 5, 7.5 and 10% levels. Water (lukewarm- 150 ml) was added and kneaded well to make soft dough. The dough was kept aside for 10 min, kneaded again and divided into equal balls. The dough was rolled on rolling board into small circles and give shape of Chapatti, Poori and paratha. Chapatti was cooked on hot griddle. Poori was deep fried in oil for 5 min until they were golden brown in color and Parathawas semi
fried on a hot griddle with cooking oil. The thickness of the fried Poori was about 5 mm.

**Sensory analysis:** The sensory quality of the products was assessed using nine-point hedonic scale at laboratory level by trained panel of ten judges with the help of a score card. The score card was developed for appearance, color, texture, taste and overall quality. The product without green leafy vegetable served as control. The control was placed first followed by the samples with increasing amounts of dehydrated greens incorporated in the products. Dehydrated green leaves powder were supplemented to control at 5%, 7.5% and 10% level. The following treatments were given:

1: **Treatment (T\(_0\))** (*Control*): Cooked products with standardized method without supplementation of dehydrated leaves powder.

2: **Treatment (T\(_1\))**: Same as \(T_0\) + 5% dehydrated Bengal gram leaves powder.

3: **Treatment (T\(_2\))**: Same as \(T_0\) + 7.5% dehydrated Bengal gram leaves powder.

4: **Treatment (T\(_3\))**: Same as \(T_0\) + 10% dehydrated Bengal gram leaves powder.

**Statistical analysis:** The data were analyzed statistically by using appropriate statistical tools. The data of sensory analysis was subjected to one way ANOVA to determine the statistically significant differences among the products that were developed. The statistical packages used for the above analysis are SPSS 16.0 version.

**RESULTS AND DISCUSSION**

**Dehydration characteristics of Bengal gram leaves:** Table 1 present the dehydration parameters of Bengal gram leaves. After dehydration moisture content of Bengal gram leaves was brought down to 7.87 per cent. Before dehydration the leaves were blanched at 80°C for two minutes. They were dried at controlled temperature in cabinet tray dryer. Time and temperature required for drying were reported as 5 hour at 60°C. The green colour of dehydrated leaves became dull to some extent and the texture become crispy. Per cent weight of edible parts of Bengal gram leaves was 74.95. The per cent yield of dehydrated leaves from fresh leaves was found to be 7.87. The chlorophyll content of dehydrated Bengal gram leaves was observed as 16 ± 0.42 mg/100g in cabinet tray drying. Karava et al. (2010) reported that microwave drying of rajagiraleaves resulted in highest chlorophyll content (12.40 mg/g) irrespective of the treatments, followed by drying in hot air oven (12.38 mg/g). It was obvious that sun drying resulted in minimum chlorophyll content (6.85 mg/g) irrespective of treatments as direct exposure to sun inactivates chlorophyllase enzyme and pigments get bleached due to exposure to ultra violet radiation. Rehydration ratio of dehydrated Bengal gram leaves was found to be 4.07. Karava et al (2010) reported samples of Rajagira leaves dried under sun exhibited lowest rehydration ratio of 4.55 followed by shade drying (5.06). Rajagira leaves dried in microwave oven after blanching and sulphitation registered highest rehydration ratio (6.29) followed by hot air oven with the same pretreatment (5.6).

Table 2 reveals the nutritional composition of dehydrated Bengal gram leaves. The protein content of dehydrated leaves was found to be 24.39 per cent. Reema (2002) reported 28.7 per cent protein in cauliflower leaves. Bedi (2002) also reported higher crude 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. The fat content of dehydrated leaves was found to be 3.27 ± 0.31. Punia et al. (2004) found 4.55 per cent fat in Khondhara leaves. The total ash content of leaves was found to be 11.83 ± 0.15/100g. The fiber, carbohydrate and energy content of Bengal gram leaves was reported as 13.89 ± 0.16g, 49.6 g and 325

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**TABLE 1: Dehydration parameter of Bengal gram leaves (Cicer arietinum)**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Bengal gram leaves (BL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanching time</td>
<td>120 second</td>
</tr>
<tr>
<td>Blanching temperature</td>
<td>80°C</td>
</tr>
<tr>
<td>Required time for cabinet drying</td>
<td>5 Hour</td>
</tr>
<tr>
<td>Required temperature for cabinet drying</td>
<td>60°C</td>
</tr>
<tr>
<td>Wt. of edible part (g) / one bundle (200 g)</td>
<td>150 (g)</td>
</tr>
<tr>
<td>Yield of Dehydrated GLVs (g/100g)</td>
<td>7.875 ± 0.79</td>
</tr>
<tr>
<td>Rehydration ratio</td>
<td>4.07</td>
</tr>
<tr>
<td>Chlorophyll content of dehydrated leaves (mg/100g)</td>
<td>16 ± 0.42</td>
</tr>
</tbody>
</table>
Table 2: Nutritional composition of dehydrated Bengal gram leaves on dry matter basis per 100 g

<table>
<thead>
<tr>
<th>Nutritional composition of dehydrated Bengal gram leaves</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>7.87±0.12</td>
</tr>
<tr>
<td>Protein (g/100g)</td>
<td>24.39±0.02</td>
</tr>
<tr>
<td>Fat (g/100g)</td>
<td>3.27±0.31</td>
</tr>
<tr>
<td>Ash (g/100g)</td>
<td>11.83±0.15</td>
</tr>
<tr>
<td>Fiber (g/100g)</td>
<td>13.89±0.16</td>
</tr>
<tr>
<td>Carbohydrate (g/100g)</td>
<td>49.6</td>
</tr>
<tr>
<td>Energy (Kcal)</td>
<td>325</td>
</tr>
<tr>
<td>Total iron (mg/100g)</td>
<td>111.83±0.08</td>
</tr>
</tbody>
</table>

In the scores of sensory attributes i.e. colour, appearance, flavour, texture, taste and overall was observed in treatment as compared to control. Kaur and Kochar (2005) carried out a study on organoleptic evaluation of preparations using underexploited greens (greens of cauliflower, radish, turnip and carrot). To evaluate the products for sensory attributes Hopkin’s seven point scale was used. The study revealed that the most acceptable level for pranthawith radish and cauliflower greens was 30 per cent whereas, in case of carrot and turnip greens it was 50 per cent. The respective scores for overall acceptability ranged from 5.42 (cauliflower greens) to 6.02 (radish greens). Bhurji prepared by using cauliflower greens scored highest (6.08). Poori with turnip and carrot greens scored 5.54 and 6.52 at 50 and 60 per cent incorporation respectively. Acceptable pulav could be developed by incorporating carrot and turnip greens at 30 and 40 per cent with scores 5.78 and 5.52 respectively. Pakora prepared by incorporating cauliflower and radish leaves at 40 per cent was best acceptable with scores of 5.42 and 6.30 respectively.

Table 3 reveals the mean sensory scores of Chapati with dehydrated Bengal gram leaves. The results elucidated that the highest mean scores for colour, appearance, flavour, texture and taste were obtained by value added product of treatment T2 i.e. 8.6, 8.1, 8.4, 7.8 and 8.2 followed by the control treatment T0. The overall acceptability of value added Chapati with dehydrated leaves powder was found in between 8.4 at 7.5% level which observed as very good. Karva et al. (2010) also reported the overall acceptability of charathi andthalipattu with rehydrated rajagiraleaves was found to be extremely good (8). The acceptability of Chapati was found to be decreased when the per cent level of dehydrated green leaves was increased. A significant difference in the scores of sensory attributes i.e. colour, appearance, flavour, texture, taste and overall was observed in treatment as compared to control. Kaur and Kochar (2005) carried out a study on organoleptic evaluation of preparations using underexploited greens (greens of cauliflower, radish, turnip and carrot). To evaluate the products for sensory attributes Hopkin’s seven point scale was used. The study revealed that the most acceptable level for pranthawith radish and cauliflower greens was 30 per cent whereas, in case of carrot and turnip greens it was 50 per cent. The respective scores for overall acceptability ranged from 5.42 (cauliflower greens) to 6.02 (radish greens). Bhurji prepared by using cauliflower greens scored highest (6.08).

Table 3: Mean sensory scores of Chapati with dehydrated Bengal gram leaves

<table>
<thead>
<tr>
<th>Chapati</th>
<th>Colour</th>
<th>Appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>7.4</td>
<td>7.8</td>
<td>7.2</td>
<td>7.8</td>
<td>8</td>
<td>7.6</td>
</tr>
<tr>
<td>T1</td>
<td>7.2</td>
<td>6.2</td>
<td>5.6</td>
<td>6.2</td>
<td>6.2</td>
<td>6.8</td>
</tr>
<tr>
<td>T2</td>
<td>8.6</td>
<td>8.1</td>
<td>8.4</td>
<td>7.8</td>
<td>8.2</td>
<td>8.4</td>
</tr>
<tr>
<td>T3</td>
<td>5.6</td>
<td>5.1</td>
<td>5.8</td>
<td>5.8</td>
<td>6.1</td>
<td>5.4</td>
</tr>
<tr>
<td>F-ratio</td>
<td>42.25</td>
<td>52.01</td>
<td>56.88</td>
<td>32.01</td>
<td>15.85</td>
<td>30.61</td>
</tr>
</tbody>
</table>

Table 4: Mean sensory scores of Poori with dehydrated Bengal gram leaves

<table>
<thead>
<tr>
<th>Poori</th>
<th>Colour</th>
<th>Appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>7.8</td>
<td>7.8</td>
<td>7.6</td>
<td>7.9</td>
<td>7.6</td>
<td>8.0</td>
</tr>
<tr>
<td>T1</td>
<td>7.5</td>
<td>6.3</td>
<td>6.0</td>
<td>6.4</td>
<td>6.5</td>
<td>6.58</td>
</tr>
<tr>
<td>T2</td>
<td>8.3</td>
<td>8.0</td>
<td>8.6</td>
<td>8.2</td>
<td>8.6</td>
<td>8.44</td>
</tr>
<tr>
<td>T3</td>
<td>5.2</td>
<td>5.6</td>
<td>4.96</td>
<td>5.8</td>
<td>5.78</td>
<td>6.42</td>
</tr>
<tr>
<td>F-ratio</td>
<td>50.12</td>
<td>11.61</td>
<td>83.61</td>
<td>21.51</td>
<td>34.13</td>
<td>31.68</td>
</tr>
</tbody>
</table>
difference in the score for sensory attributes i.e. colour, appearance, flavour, texture, taste and overall was observed in treatment as compared to control. Verma et al (2012) estimated fortification of mathri with fresh and dehydrated vegetables and assessment of nutritional quality. Levels of incorporation of fresh greens (spinach, mint and carrot) in mathri were 8 per cent whereas powder of dry green vegetables (spinach, mint, carrot and lotus stem) was added in mathri at 7 per cent. Result shows that the fresh vegetables mathri showed the highest overall acceptability (7.8± 0.199) attributes and the score was fall in the range of like very much. Nutritional analysis shows that protein and iron content of dried vegetables mathri i.e. 7.44 g and 5.37 mg was higher as compared to fresh vegetables mathri.

The mean sensory attribute scores for Paratha are presented in Table 5. The colour scores of Parathawere 7.6, 7.5 and 8.4 and 5.6 for T0, T1, T2 and T3 and the appearance scores were 7.8, 7.1, 8.42 and 5.4 were found respectively. Table 5 further revealed the flavour scores i.e. 7.8, 7.4, 8.4, 5.9 and texture scores i.e. 7.8, 6.4, 8.16 and 5.98 for treatment T0, T1, T2 and T3 respectively. The overall acceptability of value added Paratha with rehydrated leaves powder was found in the range of 7.9 to 6.12. Treatment T3 had got highest acceptability i.e. 8.34 which observed as very good. The acceptability of Paratha was found to be decreased when the percent level of dehydrated green leaves were increased. A significant difference in the score for sensory attributes i.e. colour, appearance, flavour, texture, taste and overall was observed in treatment as compared to control.

The total, soluble and ionizable iron content of all accepted value added products has been presented in the Table 6. Total iron content was estimated higher in chapati (14.787mg/100g) supplemented with dehydrated Bengal gram leaves than Poori (12.87mg/100g) and Paratha (13.33mg/100g) which may be attributed to the addition of fat in Poori and Paratha during cooking. Soluble iron was also estimated highest in chapati (5.98mg/100g) using dehydrated Bengal gram leaves. The ionizable iron content of the value added products was higher than their control, which may be attributed that basic constituents of recipes was replaced by leaves powder have higher iron content than the basic constituents of recipe. Singh and Kawatra (2006) studied the ionizable iron content of products viz., pakora, vada, namakpara, kumurabiscuit and cake prepared with addition of fresh and dried powder of amaranthus leaves. Ionizable iron content of products ranged from 1.3 in kumurato 2.9 mg/100 g in biscuit prepared from dried leaves. Ionizable iron expressed as per cent of total iron was highest in biscuit (57.4%) followed by cake (27.5%) and namakparaprepared with dried and fresh amaranthus leaves (25% and 23.7%, respectively),

### TABLE 5: Mean sensory scores of Paratha with dehydrated Bengal gram leaves

<table>
<thead>
<tr>
<th>Paratha</th>
<th>Colour</th>
<th>Appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>7.6</td>
<td>7.8</td>
<td>7.6</td>
<td>7.8</td>
<td>7.8</td>
<td>7.9</td>
</tr>
<tr>
<td>T1</td>
<td>7.5</td>
<td>7.1</td>
<td>7.4</td>
<td>6.4</td>
<td>6.4</td>
<td>6.18</td>
</tr>
<tr>
<td>T2</td>
<td>8.4</td>
<td>8.42</td>
<td>8.4</td>
<td>8.1</td>
<td>8.16</td>
<td>8.34</td>
</tr>
<tr>
<td>T3</td>
<td>5.6</td>
<td>5.4</td>
<td>5</td>
<td>5.9</td>
<td>5.98</td>
<td>6.12</td>
</tr>
<tr>
<td>F ratio</td>
<td>31.436</td>
<td>59.3</td>
<td>64.27</td>
<td>25.36</td>
<td>13.46</td>
<td>17.11</td>
</tr>
</tbody>
</table>

### TABLE 6: Total, soluble and ionizable iron content and % bioavailability of iron in cereal based value added accepted product (mg/100g DM basis)

<table>
<thead>
<tr>
<th>Value added products</th>
<th>Total iron</th>
<th>Soluble iron</th>
<th>Ionizable iron</th>
<th>% bio-availability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chapatti</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (Without supplementation)</td>
<td>7.37</td>
<td>4.89</td>
<td>0.5</td>
<td>3.68</td>
</tr>
<tr>
<td>Chapatti + 7.5% dehydrated BL</td>
<td>14.7</td>
<td>5.98</td>
<td>2.5</td>
<td>8.49</td>
</tr>
<tr>
<td>Poori</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control(Without supplementation)</td>
<td>6.67</td>
<td>4.98</td>
<td>0.5</td>
<td>4.01</td>
</tr>
<tr>
<td>Poori + 7.5% dehydrated BL</td>
<td>12.87</td>
<td>5.94</td>
<td>2</td>
<td>7.8</td>
</tr>
<tr>
<td><strong>Paratha</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control(Without supplementation)</td>
<td>6.23</td>
<td>4.06</td>
<td>0.6</td>
<td>5.02</td>
</tr>
<tr>
<td>Paratha + 7.5% dehydrated BL</td>
<td>13.33</td>
<td>4.52</td>
<td>2.65</td>
<td>9.84</td>
</tr>
</tbody>
</table>

Note: BL = Bengal gram leaves
pakora with fresh leaves (19.3%), kurmura with dried leaves (16.1%), vada (16.2%) and kurmura with fresh leaves (22.4%). Per cent bioavailability in Bengal gram leaves supplemented products was found to be higher as compared to the control. Per cent bioavailability in Bengal gram leaves supplemented Paratha (9.84%) was estimated higher than Chapati (8.49%) and Poori (7.8%).  

Enrichment of traditional recipes with dehydrated Bengal gram leaves could meet the daily requirement of iron. If GLVs incorporation in the products practiced for routine products can turn out to be a sustainable strategy for iron security and can improve the iron status of population and prevent the problem of anaemia. Addition of dehydrated GLVs increased the micronutrient especially iron of all value added traditional products.

Economics of the enriched traditional recipes i.e. Chapatti, Poori and Paratha was worked out Rs. 2.00, 3.00 and 4.00 as per servings which was very less in cost per serving (Table 7). The cost of all value added products were calculated by addition of total cost of raw ingredient used for preparation of per serving. Three Chapati, 3-4 Poori and 2 Paratha will provide about 50% of the daily requirement of iron of adolescent girls (13-15 yrs). Value addition of traditional products with dehydrated Bengal gram leaves can be advocated as a feasible food based approach to combat micronutrient deficiency.

**CONCLUSION**

It can be concluded that sensory evaluation done on all the recipes revealed that addition of dehydrated Bengal gram leaves in rehydrated form to the traditional products significantly improved their organoleptic quality and contributed to their high acceptance. The fact that these recipes are inexpensive and nutritious makes them potentially effective in solving some of the nutrition problems especially iron deficiency facing vulnerable group such as adolescent girls in India and other developing countries.

It can be recommended that dehydration protocol of GLVs and its addition in cereal, pulses and vegetables would be a successful dietary approach to overcome the problem of iron deficiency and other micronutrient deficiency among the vulnerable groups especially adolescent girls because the initiation of menstruation, increased body size and growth spurt they are prone to anaemia.

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