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Bioavailability of Iron in Dehydrated Anne Greens Enriched Masala Roti

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Abstract: Iron is required for broad spectrum of metabolic functions. Dietary iron bioavailability is low in vegetarians consuming predominantly plant-based diets. Bioavailability of dietary iron is the proportion of iron that is actually available for the absorption and utilization by the body. Green leafy vegetables are the most suitable foodstuffs for enriching dietary iron of the Indians. Though the leafy vegetables contain high total iron, the bioavailability of mineral varies. This study was considered to determine in vitro bioavailability of iron in dehydrated Anne greens enriched masala roti. The bioavailability of iron Anne greens enriched masala roti was determined by in vitro method involving simulated gastrointestinal digestion with suitable modifications. The results are reported as the means _ standard deviation (SD). There was highly significant (F< 0.05) difference between the control and treatments of products indicating that the addition of 10 % of dehydrated leaves of Anne improved the total iron content and in vitro bio availability. The total iron content was found 21.19 mg/100g in masala roti incorporated with dehydrated Anne greens whereas in vitro bioavailability of iron was found 4.16mg/100g.

Keywords: *Dehydrated Greens, Enrichment, Bioavailability, Total Iron*

I. INTRODUCTION

Green leafy vegetables are micronutrient dense foods that provide sufficient vitamins and minerals and are of great importance to the nutrition of population in developing countries. There is a great diversity of flora and fauna in the world and there is lots of potentialities for enormous plant material which is not explored for mass consumption as they are regional specific and due to lack of awareness. Now-a-days, unconventional foods are gaining importance as a means to increase the per capita availability of foods. Unconventional greens are good sources of many nutrients like iron, zinc, chromium, copper, calcium, vitamin C and beta carotene that could help in overcoming micronutrient malnutrition.

Multiple micronutrient deficiencies are wide spread globally with a large negative societal impact. Iron is required for broad spectrum of metabolic functions. Iron deficiency anemia is the most common nutritional deficiency in humans, affecting 1.62 billion people globally (de Benoist, 2008). Part of the problem is related to the iron bioavailability. Dietary

iron bioavailability is low in vegetarians consuming predominantly plant-based diets. Bioavailability of dietary iron is the proportion of iron that is actually available for the absorption and utilization by the body.

The three strategies to combat iron deficiency anemia are dietary modifications and/ or diversification to improve iron bioavailability, selective plant breeding or genetic engineering to increase the iron content or to reduce absorption inhibitors in dietary staples, and supplementation with pharmacological doses, usually without food.

Food enrichment or fortification represents the "addition of one or more essential nutrients to a food whether or not it is normally contained in the food for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups.

Hence, the present study was undertaken to explore the use of unconventional greens, Anne greens in developing iron rich masala roti and evaluating the product for sensory qualities and bio availability of iron content in the products.

Figure 1: Anne greens (Celosia argentea)

II. MATERIALS AND METHODS

Anne greens (*Celosta argentea*) and other ingredients for preparation of *masala roti* were procured from local market of Bangalore city. The edible portion of Anne greens were taken, cleaned, washed, chopped and dried in hot air oven at 60-700 C for 4-5 hours. The dried greens were powdered and sieved using 40 mm mesh, packed in polyethylene bags for further use.

Development of dehydrated *Anne greens* enriched *masala roti*: The process for preparation of masala roti standardized as in Figure 2.

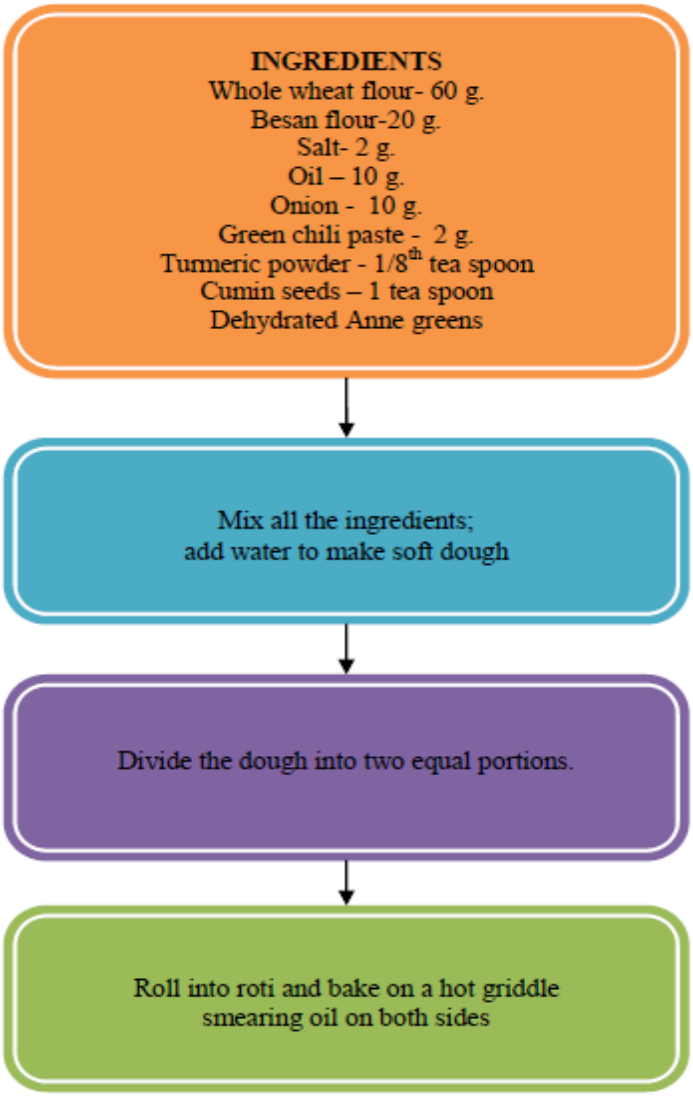

Figure 2: Development of dehydrated *Anne* greens enriched *masala roti*

The preparation of *masala roti* was standardised and the dehydrated greens powder at 8 and 10 per cent levels was incorporated in developing *masala roti*.

Sensory evaluation of developed products:

The sensory attributes are the major criteria after cooking characteristics for the acceptability of the products. However nutritious a product is, unless accepted it does not serve the purpose.

The developed rotis, two variations and a control were evaluated for their sensory attributes by 15 semi trained panels. A nine point hedonic scale was used for sensory evaluation of products. The following sensory parameters were considered namely, appearance, texture, flavour, taste and overall acceptability. The judges were also requested to rank products.

Estimation of iron content and its availability in the developed products:

Standardized control and iron enriched food was dry ashed as described by the Association of Official Agriculture Chemists (AOAC, 2005) and total iron in the mineral solution was estimated by the Thiocynate method. Iron was determined calorimetrically making use of the fact that ferric iron gives a blood red colour with potassium thioecyanate.

Bio availability of iron from standardized control and iron enriched food samples was determined by an in vitro method described by Luten et al (1996), involving simulated gastrointestinal digestion with suitable modifications.

III. STASTICAL ANALYSIS

Values of different parameters are expressed as the mean ± standard deviation. (ANOVA), t-test and critical difference statistical tests were used to analyze the data.

IV. RESULTS AND DISCUSSIONS

The products were developed and standardized by incorporating dehydrated *Anne* greens at different levels to enhance micronutrient content. All the products prepared by incorporating *Anne* greens at 8 and 10 per cent levels were acceptable with scores of above 6.0 ranging from moderately good (6.1) to excellent (8.2) on nine point hedonic scale. The results also revealed that the 8 per cent greens incorporated *masala roti* was found to be similar to control in terms of texture and overall acceptability although significant differences were seen in appearance and colour. In the other sample of 10 per cent level of incorporation significantly lowering of sensory scores with respect to appearance and colour in comparison to control was observed.

Table 1: Sensory scores for dehydrated *Anne* greens enriched *masala roti*

Treatments	Mean Sensory scores				
	Appearance	*Texture*	*Colour*	*Taste*	*Overall acceptability*
Control (T_0)	8.4	8.2	8.3	8.2	8.4
8 % Anne greens (T_1)	7.5	7.7	7.4	7.4	7.7
10 % Anne greens (T_2)	6.9	7.4	6.9	7.1	7.3
Mean	7.6	7.76	7.53	7.56	7.8
SD+/-	0.841	0.520	0.672	0.550	0.585
CD at 5 % level	0.656	NS	0.565	NS	NS

The products with both (8 and 10 per cent) levels of incorporation of dehydrated *Anne* greens were accepted, but highest score found at 8 per cent level of incorporation. A study conducted by incorporating fresh and dried shepu in various products like *chapathi*, rice roti, nippattu and bakery products like masala bun, rusk, flake biscuits and chilly biscuits and the results showed that all products were acceptable at 5 percent level in both fresh and dried shepu greens incorporated products (Naik, 2010). Another study showed that biscuits prepared from 90:10 malted wheat flour: cauliflower leaf powder was adjudged the best with regard to their acceptability and storability (Towseef, 2014)

Moisture, ash and pH of dehydrated *Anne* greens enriched *masala roti* is presented in table 2.

Table 2. Per cent moisture, ash and pH of dehydrated *Anne* greens enriched *masala roti*

Treatments	Mean ± SD		
	Moisture (%)	*Ash (%)*	*pH*
T_0	30.15 ± 0.17	2.14 ± 0.04	6.50 ± 0.08
T_1	29.37 ± 0.14	3.54 ± 0.17	6.32 ± 0.03
T_2	29.02 ± 0.17	3.80 ± 0.14	6.29 ± 0.05
F value	31.7146	114.1249	9.1068
P value	0.0006	6.45 E -03	0.0152

The moisture content of *masala roti* varied from 29.02 per cent (T2) to 30.15 per cent (T0). This difference in moisture content of the products may be due to variation in composition of the products. The ash content of the products of different treatments differed significantly. The highest ash content (3.80) was recorded in *masala roti* with 10 per cent addition of dehydrated *Anne* greens (T2). The product T2 registered significantly higher ash content which presumed the enhanced minerals. The pH of the products ranged between 6.29 to 6.5. similar results were drawn by Patted et al., (2010) wherein green leafy vegetable *bhajis* cooked in iron utensils significantly increased the ash content (10.57%) and had similar moisture when cooked in iron, hindalium and teflon coated utensils.

Table 3. Total and Bio available iron of dehydrated *Anne* greens enriched *masala roti*

Treatments	Mean ± SD		
	Total Iron (mg/100g)	*Bio available Iron*	
		mg/100g	*Per cent of total Iron*
T_0	10.24 ± 0.10	0.57 ± 0.03	5.63 ± 0.37
T_1	18.54 ± 0.26	2.79 ± 0.14	15.05 ± 1.00
T_2	21.18 ± 0.14	4.17 ± 0.08	19.66 ± 0.48
F value	2707.1090	854.0955	325.2107
P value	1.36E-09	4.29E-08	7.64E-07

The Total and Bio available iron of dehydrated *Anne* greens enriched *masala roti* is depicted in table 3. Among products, *masala roti* with 10 percent dehydrated *Anne* greens (T2) recorded significantly higher total and bioavailable iron (21.19 mg/100 g and 4.16 mg/100 g respectively). Prasad et al., 2014 found that the total iron content as 11.69mg/100g in paratha incorporated with Bathua (*Chenopodium album*) and Fenugreek (*Trigonella foenum graecum*) leaves whereas *in vitro* bioavailability of iron as 2.16mg/100g in paratha and results also showed that the total iron content was found 15.16mg/100g in laddoo incorporated with dehydrated GLVs whereas *in vitro* bioavailability of iron was found 2.78mg/100g in laddoo.

Food to food fortification is a simple and effective way of iron enrichment. Iron rich food sources when added to a recipe, enhances its iron content. This has been observed from the results of the present study wherein addition of dehydrated Anne greens increased their iron content. The highest soluble iron percentage at pH was observed in biscuits, whereas the control biscuit had 54 per cent soluble iron, the variants had percentages above 80, whereas ionisable iron percentage ranged from 5 to 25. (Jain, 2013)

CONCLUSION

It is concluded that incorporation of dehydrated Anne greens in masala roti are well acceptable based on sensory evaluation and nutrient concentration. Sensory evaluation of masala roti incorporated with different levels of dehydrated greens revealed that they could be incorporated at level of 10 per cent with no detrimental effects on sensory quality. Masala roti with addition of 10 percent dehydrated Anne greens was rich in iron content. In vitro bioavailability of iron was also found to be significantly higher (4.16mg/100g) in masala roti with10 percent dehydrated Anne greens. Hence, as the green leafy vegetables are inexpensive foods rich in micronutrients, utilization of unconventional green leafy vegetables can be explored to overcome iron deficiency.

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