6. CONCLUSIONS

Nutrition is at the threshold of new, revolutionary developments and its potentialities for improvement of health are vast however, still maximum population in developing countries is affected by malnutrition particularly micronutrient deficiencies (Singh et al, 2007). Micronutrient deficiency is affecting negatively on the health and socio economic wellbeing of millions of men, women and children (Balutssen, Knai, & Sharan, 2004). According to the World Health Organization (WHO) 2009, Micronutrient deficiency constitutes a significant public health problem requiring immediate attention from governments, researchers and health care practitioners. It is inherently associated with poverty, and is thus particularly prevalent in the developing world, where the problem is often exacerbated by limited access to appropriate health care and treatment. In India serious micronutrient deficiency disorders associated with vitamin A, Iron and Iodine are encountered due to dietary insufficiency and are designated as ‘hidden hunger’ (Allen, 2000).

Actions that promote an increase in the supply, access, consumption and utilization of an adequate quantity, quality and variety of foods for all populations groups should be supported. Policy and programmes responses include food based approaches such as dietary diversification and food fortification, as well as nutrition education, public health and food safety measures, and finally supplementation. Increasing dietary diversity is generally regarded as the most desirable and sustainable option to fight against micronutrient deficiencies. Increasing dietary diversity means increasing both the quantity and the range of micronutrient – rich foods consumed. In practice, this requires the implementation of programmes that improve the availability and consumption of, and micronutrient – rich foods in adequate quantities, especially among those who are at risk for, or vulnerable to micronutrient deficiency (Adefegha & Oboh, 2011). Among the plant foods, green leafy vegetables are the cheapest and locally available foods, rich in micronutrients, especially of beta carotene and iron. Although India is blessed with a number of vegetables and stands second in vegetable production, hardly two percent of the produce is processed and 30-40 percent is being wasted due to lack of processing, preservation infrastructure and ignorance about the nutritional potential of some of the green leafy vegetables (Khan et al., 2012).
Conclusions

Out of ignorance only, a number of green leafy vegetables rich in nutrients are often discarded intentionally, wasted or are used for animal feed. Thus, there is a need to identify the untapped vegetables, preserve them and utilize them. BLANCHING stops all life processes, inactivates enzymes, fixes green color and removes certain harsh flavors common in green leafy vegetables (Gupta & Prakash, 2011). Physical methods like drying or dehydration is one of the most commonly used method of preservation at commercial and household levels. In dehydration, the moisture content of the food is reduced and the growth of microorganisms in the dried food is retarded (Kowsalya & Vidhya, 2004).

To overcome micronutrient deficiency, a concentrated source of micronutrients especially of iron and beta carotene, should be supplemented in large amounts in natural forms to avoid the harmful side effects of the synthetic products. Since data on the nutrient content of dehydrated green leafy vegetables are scanty, the present study was been undertaken to study the effect of processing on nutrient composition of selected green leafy vegetables and formulation of value added products with the following objectives:

- To perform nutritional estimation of selected fresh green leaves.
- To perform nutritional estimation of Blanched dehydrated and Non Blanched dehydrated green leafy vegetables.
- To formulate recipes by incorporating different proportions of dry leafy powder and perform their organoleptic evaluation.
- To assess and compare the effect of various cooking methods on micro nutrient composition of both control and most accepted recipes.
- To study the shelf life of most accepted recipes
- To calculate cost and nutritive value of most accepted products.
The study was divided in the following phases:

**Phase I**: Procurement, Processing and Nutritional estimations of fresh and processed selected leaves (*Daucus carota* and *Brassica oleracea*)

**Phase II**: Product formulation and Organoleptic evaluation

**Phase III**: Effect of cooking on micro nutrient composition of control and most accepted recipe

**Phase IV**: Shelf life study of the most accepted product and dehydrated leaf powder

**Phase V**: Analysis of cost and Nutritive value of most accepted product

**Phase I: Procurement, Processing and Nutritional estimations of fresh and processed selected leaves (*Daucus carota* and *Brassica oleracea*)**

Micro nutrient rich greens of *Daucus carota* (Carrot) and *Brassica oleracea* (Cauliflower) though available at no cost are always discarded for human consumption. Therefore considering the micronutrient content and easy availability of the above mentioned leaves, they were selected for the present study. The certified variety of leaves were procured from International Horticulture Innovation and Training Centre, Durga pura, Jaipur. Initially, the leaves were cleaned, washed thoroughly three to four times under the running tap water to remove all the adhering dust and used for nutritional estimations. The leaves were then divided into two lots. The first lot was blanched dehydrated and the second lot was only dehydrated. *Daucus carota* (Carrot) leaves were dehydrated, which took almost 4-5 hours for Non Blanched dehydrated sample and 5-6 hours Blanched dehydrated sample while the *Brassica oleracea* (Cauliflower) leaves took 6-7 hours for Non Blanched Dehydrated and 7-8 hours for Blanched dehydrated sample. Approximately, 15 grams of leaf powder was procured from 100 gram of fresh destalked *Daucus carota* and *Brassica oleracea* leaves

These two lots were further used for nutritional estimations to analyze the effect of processing. The moisture content was determined by drying in an oven at 100°C until constant weight was reached. Ash was estimated by incinerating the samples in a muffle furnace at 550°C for 48 hours. Phenol and Phytate content was determined by UV spectrophotometric method. Total iron in ash solution was
determined by titration method and spectrophotometrically respectively. Phosphorus, Calcium, Ascorbic acid and Oxalate content were determined by titration method. β-carotene was separated by column chromatography and estimated colorimetrically. Crude fiber was determined by Fibra plus (Raghuramulu, Nair, & Kalyansundaram, 2003; AOAC, 2005; Sharma, 2007; Rangana, 2010). Results revealed that processing like dehydration made the leaves a concentrated natural micronutrient rich source. The results of nutritional estimation revealed that the nutrient content (beta carotene, Iron, Calcium, Phosphorus, Ash) of blanched dehydrated leaves were 4 to 7 times more than their fresh counterparts. However, on comparing the anti nutrient content of both processed samples (Blanched dehydrated and Non Blanched dehydrated); it was observed that the values of blanched dehydrated samples were lower in comparison to non blanched dehydrated samples.

Phase II: Product formulation and Organoleptic evaluation

Eight different recipes which are commonly used in Western, Southern and Central India were selected. A recipe which was commonly used by the people of low and medium income group was preferred in the selection. All the recipes were standardized before actually putting into experiments so that they may give identical results. Each recipe was standardized with total 100 gram of weight of the ingredients. This was designated as the “basic recipe” and served as “control” for the purpose of comparison. Leaf powder of both the leaves (*Daucus carota* and *Brassica oleracea*) was then incorporated in this basic recipe at different proportions of 5%, 10% and 15%. Organoleptic evaluation of all the recipes containing different levels of leaf powder on the basis of their Appearance, Color, Taste, Texture and Overall acceptability by a panel of ten judges. Results revealed that leaf powder (*Daucus carota* and *Brassica oleracea*) incorporated at 5 percent level in various traditional food preparations were liked most. However, increasing the incorporation level of greens resulted in rough texture and after taste of the product, and thus it caused regurgitation after consumption.

Phase III: Effect of cooking on micro nutrient content (beta carotene and iron) of control and most accepted recipe

Nutritional composition of control and most accepted recipe was evaluated in order to check the effect of method of cooking on nutrient retention particularly in
terms of micronutrients i.e. Beta carotene and Iron content. Estimation of iron content was done by Wong’s method and beta carotene content was analyzed spectrophotometrically. Nutritional estimation performed before and after cooking highlighted that the beta carotene content was reduced by 2.2 to 10.9 percent in all the value added products. However, the iron content was reduced by 3.4 to 10.9 percent in all the value added products.

**Phase IV: Shelf life study of the most accepted product and dehydrated leaf powder**

Six most acceptable recipes were selected for the evaluation of shelf life. The prepared recipes were Khakhra, Atta-ladoo, Besan-ladoo (Sattu), Panjiri, Nan-khatai and Biscuits. Idli and Khaman were not selected for the shelf life study as steamed products are perishable and have higher moisture content. Shelf life study of the best acceptable variation among all the six recipes was prepared. Products were kept at room temperature and then were analyzed for its shelf life. Shelf life study was assessed by sensory evaluation, Microbial analysis and Peroxide value. Results revealed that the shelf life of all the value added products prepared when compared with control recipe. Results revealed that Khakhra, Nan-khatai and Biscuits were acceptable till 30\(^{th}\) days, Atta-ladoo and Besan-ladoo were acceptable till 15\(^{th}\) day and Panjiri was acceptable at 10\(^{th}\) day. Thereafter, the number of colonies developed and peroxide value crossed the permissible limit. Shelf life of dehydrated leaf powder was assessed by total viable count. The microbial load of dehydrated leaf powder was negligible till one month of storage. Thereafter, the colonies developed and a remarkable increment in number was observed on the completion of 2\(^{nd}\) month.

**Phase V: Analysis of cost and Nutritive value**

The cost and nutritive value of the most accepted recipe was calculated on the hundred gram basis. Nutritive value of various ingredients used for preparing different value added recipes was taken up from Nutritive Value of Indian Foods (NIN), 2000.
The Salient Findings of the study

**Phase I: Procurement, Processing and Nutritional estimations of the selected leaves (Daucus carota and Brassica oleracea)**

- The total time required for drying the green leafy vegetables varied: Daucus carota leaves took 4 to 7 hours and Brassica oleracea leaves took 5 to 8 hours.
- Approximately 15 gram of leaf powder was procured from 100 gram of fresh destalked Daucus carota (Carrot) and Brassica oleracea (Cauliflower) leaves.
- Fresh Daucus carota (Carrot) leaf sample had 8.12 mg/100g of iron, 319.22 mg/100g of calcium, 104.31 mg/100g of phosphorus, 4,008 µg/100g of beta carotene, 69.84 mg/100g of vitamin C, 92.34% of moisture, 4.2 g/100g of ash, 59.29 mg/100g of phenol, 2.01 g/100g of fiber, 43.41 mg/100g of oxalate and 21.82 mg/100g of phytate.
- Fresh Brassica oleracea (Cauliflower) leaf sample had 32.93 mg/100g of iron, 604.02 mg/100g of calcium, 100.68 mg/100g of phosphorus, 5,239 µg/100g of beta carotene, 7.31 mg/100g of vitamin C, 88.4% of moisture, 4.6 g/100g of ash, 54.25 mg/100g of phenol, 2.15 g/100g of fiber, 8.46 mg/100g of oxalate and 2.83 mg/100g of phytate.
- The iron content of Blanched dehydrated sample had 36.90 mg/100g (Daucus carota) and 192.52 mg/100g (Brassica oleracea) whereas non blanched sample had 33.11 mg/100g (Daucus carota) and 187.69 mg/100g (Brassica oleracea).
- The estimated calcium content of the processed Daucus carota leaf sample was 1432.76 mg/100g in blanched dehydrated sample and 1416.88 mg/100g in non blanched dehydrated sample. However, in the case of processed Brassica oleracea leaf sample, it was estimated to be 3100.57 mg/100g in blanched dehydrated and 3087.64 mg/100g in non blanched dehydrated sample.
- There was a statistically significant improvement in phosphorus content of non blanched dehydrated sample in comparison to blanched dehydrated sample in both the green leafy vegetables (Daucus carota and Brassica oleracea).
In processed *Daucus carota* leaf samples, it was analyzed to be 13,708.56 µg/100g in blanched dehydrated sample and 12,402.2 µg/100g in non blanched dehydrated sample. In *Brassica oleracea* leaf sample, it was researched to be 15,406.84 µg/100g in blanched dehydrated and 14,289.69 µg/100g in non blanched dehydrated sample.

- Vitamin C was the only nutrient, which reduced after processing. The vitamin C content of *Daucus carota* was 35.61 mg/100g in blanched dehydrated sample and 42.65 mg/100g in non blanched dehydrated sample however, in the case of *Brassica oleracea* leaf sample, it was researched to be 4.17 mg/100g in blanched dehydrated sample and 5.66 mg/100g in non blanched dehydrated sample.

- The dried leaves had 2 to 4 percent of moisture and more than 95% of dry matter.

- The ash content of processed *Daucus carota* and *Brassica oleracea* sample was varied from 13.7 to 15.8 g/100g. The high ash content is a reflection of the mineral contents preserved in the leaf samples.

- The phenol content of processed *Daucus carota* and *Brassica oleracea* sample was varied from 201.96 mg/100g to 224.69 mg/100g.

- The values of non blanched dehydrated sample had (14.45 g/100g in *Daucus carota* and 14.86 in *Brassica oleracea* leaves) fiber content in comparison to the blanched dehydrated sample (12.52 g/100g in *Daucus carota* and 12.73 in *Brassica oleracea* leaves).

- Blanching had a significant impact on the anti nutrient content as the oxalate and phytate content was reduced by 5 to 10 percent in blanched dehydrated sample in comparison to non blanched dehydrated sample.

- As the nutrient composition of blanched dehydrated sample was better in comparison to non blanched dehydrated sample as well as anti nutrient components like fiber, oxalate and phytate were low in blanched dehydrated sample which made the other nutrients more net bioavailability. Therefore, the blanched dehydrated sample was used for value addition and product formulation.
Conclusions

Phase II: Product formulation and Organoleptic evaluation

- The “basic recipe” served as “control” which was prepared without incorporating the green leaves for the purpose of comparison. Leaf powder of both the leaves (*Daucus carota* and *Brassica oleracea*) was then incorporated in this basic recipe at different proportions of 5%, 10% and 15% by replacing the basic ingredient.
- All the prepared recipes were well acceptable at 5% level of incorporation.
- All the sweet preparations formulated by the incorporation of leaf powder (*Daucus carota* and *Brassica oleracea*) were more acceptable in comparison to the salty products. Reason being, that sweetness of the product suppressed grassy flavor and bitter taste of the greens.

Phase III: Effect of cooking on micronutrient content (beta carotene and iron content)

- Effect of cooking was analyzed by estimating the nutrient content (Beta carotene and Iron) before cooking as well as after cooking of control as well as most accepted recipe.
- It was observed that after roasting, the beta carotene content reduced by 2.2 to 4.3 percent and the iron content was reduced by 3.4 to 4.4 percent; after steaming, the beta carotene content reduced by 5.3 to 6.6 percent and the iron content was reduced by 4.9 to 6.7 percent; after baking, the beta carotene content was reduced by 9.3 to 10.9 percent and the iron content was reduced by 9.1 to 10.9.

Phase IV: Shelf life study of the most accepted product and dehydrated leaf powder

- Steamed products like *Idli* and *Khaman* were not selected for the shelf life study as they have higher moisture content and are perishable.
- The sensory attributes, total viable count and the peroxide value (permissible limit is 10 meg/1000g) of the roasted product, *Khakhra* remained acceptable till 30 days.
Conclusions

- *Atta-ladoo* and *Besan-ladoo* stored till 15 days was acceptable whereas, a significant reduction in acceptability was found after 15 days in terms of sensory attributes, total viable count and peroxide value.

- *Panjiri* prepared by roasting was acceptable till 10 days; *Nan-khatai* and *Biscuit* were acceptable till 2 weeks. After 2 weeks, the deterioration in the recipes was started and the total viable count as well as peroxide value crossed the permissible limit.

- The microbial load of dehydrated leaf powder was negligible till one month of storage. Thereafter, the colonies developed and a remarkable increment in number was observed on the completion of 2nd month. From this it can be interpreted that the dehydrated leaf powder could be stored and consumed over a considerable period of time in our daily diet.

**Phase V: Analysis of cost and Nutritive value**

- The price of all the value added products per 100 gram was within 15 rupees.

- Nutritive value of incorporated *Daucus carota* leaf powder in all the roasted products (*Khakhra, Atta-ladoo, Besan-ladoo* and *Panjiri*) had ranged between 390.56 to 512.23 Kcal of energy, 5.73 to 11.51 of protein, 2.76 to 6.12 of iron and 443.54 to 699.21 µg of beta carotene per 100 gram of ingredient.

- In the case of *Brassica oleracea* incorporated roasted products (*Khakhra, Atta-ladoo, Besan-ladoo* and *Panjiri*), the nutritive value was calculated to be 390.61 to 512.25 Kcal of energy, 5.88 to 11.93 g of protein, 5.82 to 13 mg of iron and 475.83 to 774.35 µg of beta carotene per 100 gram of ingredient.

- Nutritive value of Steamed products like *Idli* and *Khaman* had ranged between 313.38 to 327.47 Kcal of energy, 8.67 to 10.60 g of protein, 2.58 to 3.87 mg of iron and 732.87 to 889.69 µg of beta carotene per 100 gram of ingredient when *Daucus carota* leaf powder was incorporated.

- Nutritive value of *Brassica oleracea* incorporated Steamed products (*Idli* and *Khaman*) was calculated to be 313.41 to 327.50 Kcal of energy, 8.92 to 10.31 g of protein, 7.70 to 8.12 mg of iron and 788.16 to 936.09 µg of beta carotene per 100 gram of ingredient.

- In the case of *Daucus carota* incorporated Baked products (*Nan-khatai* and *Biscuit*), the nutritive value was calculated to be 500.34 to 513.46 Kcal of energy, 5.75 to 8.02 g of protein, 6.10 to 8.57 mg of iron and 558.28 to 714.09 µg of beta carotene per 100 gram of ingredient.
Conclusions

energy, 5.93 to 6.01 g of protein, 2.28 to 2.30 mg of iron and 497.13 to 532.91 µg of beta carotene per 100 gram of ingredient.

- *Brassica oleracea* leaves incorporated Baked products (*Nan-khatai* and Biscuit) had 500.37 to 513.48 Kcal of energy, 6.10 to 6.20 g of protein, 6.11 to 6.28 mg of iron and 538.96 to 576.46 µg of beta carotene per 100 gram of ingredient.

**Recommendations:**

- The present study recommends the prospect of more aggressive introduction and utilization of green leafy vegetables by food sector. It also implies that it may be worthwhile for industry to take up the production of dehydrated powder for underutilized greens.

- These efforts could also be an additional source of income generation, employment and exports providing a viable alternative to imported food supplies to treat malnutrition in poor countries.

- Value addition of commonly consumed traditional recipes by some low cost micronutrient sources like green leafy vegetables should be promoted in order to ensure the consumption of beta carotene and iron rich foods. Consumption of value added products should be encouraged both in the National and regional supplementary feeding programmes, Mid day Meal programme as well as at the household level.

- There is need to develop and popularize low cost technologies for preservation of green leafy vegetables to make them available in summer as well as monsoon seasons and to improves their shelf life.

There is need to develop and popularize low cost technologies for preservation of Beta carotene and Iron rich foods to make them available summer and monsoon seasons. Nutritional analysis of fresh and processed micronutrient rich foods for their Beta carotene and Iron content by appropriate methods should be pursued.