

**ENRICHMENT OF TRADITIONAL FOODS WITH GREEN  
LEAFY VEGETABLE FOR IRON SECURITY OF  
ADOLESCENT GIRLS**

Thesis submitted to the  
University of Agricultural Sciences, Dharwad  
in partial fulfillment of the requirements for the  
Degree of

**MASTER OF HOME SCIENCE**

in

**FOOD SCIENCE AND NUTRITION**

By

**SEEMA L. KARVA**

**DEPARTMENT OF FOOD SCIENCE AND NUTRITION  
COLLEGE OF RURAL HOME SCIENCE, DHARWAD  
UNIVERSITY OF AGRICULTURAL SCIENCES,  
DHARWAD – 580005**

**SEPTEMBER, 2008**

## ADVISORY COMMITTEE

Dharwad

(PUSHPA BHARATI)

SEPTEMBER, 2008

MAJOR ADVISOR

Approved by:

Chairman : \_\_\_\_\_

(PUSHPA BHARATI)

Members : 1. \_\_\_\_\_

(RAMA K. NAIK)

2. \_\_\_\_\_

(BHARATI CHIMMAD)

3. \_\_\_\_\_

(KASTURIBA B.)

4. \_\_\_\_\_

(A.R.S. BHAT)

# CONTENTS

Sl. No.	Chapter Particulars	Page No.
	CERTIFICATE ACKNOWLEDGEMENT LIST OF TABLES LIST OF FIGURES LIST OF PLATES LIST OF APPENDICES	
1.	INTRODUCTION	
2.	REVIEW OF LITERATURE	
	2.1 Consumption pattern of GLVs among Indian population 2.2 Dehydration of green leafy vegetables 2.3 Value added products of green leafy vegetables	
3.	MATERIAL AND METHODS	
	3.1 Consumption pattern of GLVs 3.2 Selection of green leafy vegetables 3.3 Dehydration protocol of GLVs 3.4 Iron estimation 3.5 Quality of dehydrated <i>rajagira</i> 3.6 Value added products of GLVs 3.7 Statistical analysis	
4.	EXPERIMENTAL RESULTS	
	4.1 Collection of primary data 4.2 Dehydration protocol 4.3 Development of value added products of <i>Rajagira</i>	
5.	DISCUSSION	
	5.1 Consumption pattern of GLVs among adolescent girls 5.2 Dehydration protocol of GLVs 5.3 Value addition to traditional products with <i>Rajagira</i>	
6.	SUMMARY AND CONCLUSIONS	
	REFERENCES	
	APPENDICES	

## LIST OF TABLES

Table No.	Title	Page No.
1	Demographic profile of adolescent girls	
2	Recipes identified by the girls to be prepared using GLVs	
3	Knowledge of adolescent girls regarding utilization of GLVs	
4	Availability of GLVs in local market as perceived by adolescent girls	
5a	Percived knowledge of adolescent girls regarding recommendation of GLVs in disorders	
5b	Percived knowledge of adolescent girls regarding recommendation of GLVs in disorders	
6	Edible portion of GLVs (per bundle)	
7	Time required to dry the GLVs	
8	Yield of dehydrated GLVs (g/100g)	
9	Characteristics of VAPs with <i>rajagira</i>	
10	Rank of the value added products based on sensory scores	
11	Composition and adequacy (%) in blood forming nutrients in VAPs (per serving)	

## LIST OF FIGURES

Figure No.	Title	Page No.
1	Experimental design	
2	Familiarity and consumption pattern of GLVs among adolescent girls	
3	Reasons quoted by adolescent girls for not consuming GLVs	
4	Utilization of GLVs in the raw form among adolescent girls	
5	Practices followed by the subjects for the preliminary processing of GLVs	
6	Perceived health and nutrition knowledge about GLVs	
7	Sources of health and nutrition knowledge among adolescent girls	
8	Iron content of dehydrated GLVs	
9	Rehydration ratio of dehydrated <i>rajagira</i>	
10	Chlorophyll content in dehydrated <i>rajagira</i>	
11	Acceptability of <i>chapathi</i> and <i>poori</i> with <i>rajagira</i>	
12	Acceptability of <i>thalipattu</i> and <i>bhaji-I</i> with <i>rajagira</i>	
13	Acceptability of <i>bhaji-II</i> and <i>bhaji-III</i> with <i>rajagira</i>	
14	Consumer acceptability of <i>chapathi</i> and <i>bhaji</i> with rehydrated <i>rajagira</i>	
15	Increase (%) in blood forming nutrients of VAPs	
16	Essential Amino Acid composition and scores of VAPs	

## LIST OF PLATES

Plate No.	Title	Pages No.
1	Cereal based value added products with <i>rajagira</i>	
2	Pulse based value added products with <i>rajagira</i>	

## LIST OF APPENDICES

Appendix No.	Title	Pages No.
I	Questionnaire for studying the utility of green leafy vegetables among urban adolescent girls	
II	List of green leafy vegetables	
III	Rehydration ratio of dehydrated <i>rajagira</i>	
IV	Chlorophyll content (mg/g) in dehydrated <i>rajagira</i>	
V	Details of value added products	
VI	Score card for evaluation of value added products	
VII	Acceptability scores of value added products	
VIII	Effect of value addition with <i>rajagira</i> on blood forming nutrient composition of products	

# 1. INTRODUCTION

India is a country with diverse agro-climatic conditions which favours the cultivation and availability of wide array of foods specially fruits and vegetables. The country is the second largest producer of vegetables next to China, accounting for about 10 per cent of the world production (Singh *et al.*, 2008). Horticulture products including fruits and vegetables constitute major component of total agricultural produce of the country encompassing large variety of crops. 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 about ten conventional GLVs, more than 40 types find usage in limited area and quantity. However, the consumption of these is restricted to the local area, with the adequacy ranging from 7-10 per cent among adolescents (Hanagi, 2001 and Deepa, 2002), 57 per cent among pregnant women (Angadi, 1990) and 34 per cent among rural lactating mothers (Angadi, 1990). GLVs contain around 2-7 per cent of protein (Narasinga Rao, *et al.*, 1989), around 30 to 3200 mg/100g, iron from 0.09 to 40 mg/100g of iron and carotene ranging from 120 to 14190 µg/100g (Gopalan *et al.*, 2004). On one hand ample amounts of GLVs are available in the country and on the other micronutrient deficiencies are rampant especially of Iron Deficiency Anaemia (IDA) and Vitamin A Deficiency (VAD), major reason being lowered consumption of this group of quality foods among vulnerable population.

IDA is one of the major public health problems of the country among women of reproductive ages. Prevalence of anemia among rural adolescent girls of Dharwad was found to range from 73 to 87 per cent (Hanagi, 2001) and 63 to 85 per cent among urban girls (Deepa, 2002). Iron being an essential element in formation of haemoglobin, main etiological factors contributing to IDA are low dietary intake, poor socioeconomic status and associated deficiencies like Protein Energy Malnutrition, as well as recurrent infections. Additional factors leading to this are lack of awareness and ignorance coupled with false beliefs and superstitions. It is possible to combat IDA using a combination of key intervention strategies viz., supplementation, fortification, deworming, improving water and sanitation facilities/practices, nutrition education and also by increasing production and consumption of foods rich in iron and β-carotene in substantial amounts. In order to mitigate the problem of anaemia the Government of India has launched Anaemia Prophylaxis Programme in 1970. Since then the distribution of iron-folic acid (IFA) tablets containing 60 mg of elemental iron and 100mg of folic acid continues in the country. However, due to the cultural unacceptability, myths, superstitions and digestive discomfort, the consumption of IFA tablets lags behind with very low compliance. Though 98 per cent of the women in reproductive age received IFA tablets under anemia prophylaxis programme in Hubli-Dharwad taluks, only 32 per cent of them were reported to consume all the tablets (Anon, 2006). Hence, anaemia continues to be a major set back in maternal health, creating increased morbidity and mortality.

Now the time has come to look for long term sustainable, culturally acceptable, rational, applicable, feasible, cost effective and suitable natural means to attain nutritional security and eliminate IDA. The strategy of synthetic supplementation in the form of pharmaceuticals provide only the specific nutrients whereas, the food based approach provides a package of both macro and micro nutrients in addition to the antioxidants and nutraceuticals including dietary fiber.

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 non-availability of sufficient storage, transport and proper processing facilities at the production point (Pande *et al.*, 2000). Augmenting utilization and avoiding wastage calls for employing suitable preservation techniques that are sustainable at the household level. Dehydration is one of the traditional methods of preservation of vegetables, which converts the vegetable in to light weight, easily transportable and storable product. Advantage of this method is that the vegetable can be easily converted in to fresh-like form by rehydrating it and can be used throughout the year. 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). The quality of the dehydrated product in terms of rehydration ratio, colour and flavour retention depends on the pretreatments applied and method of drying.

The time has come to put the array of iron rich foods like GLVs to effective use not just for combating anemia but for achieving all round improvement in health. A number of surveys conducted locally and in the country have indicated lower consumption of GLVs among the population in general and adolescent girls in particular. This segment of population not only has rigid likes and dislikes, is figure conscious and weight watchers. Owing to the initiation of menstruation, increased body size and growth spurt they are prone to anaemia and other micronutrient deficiencies along with morbidity. In order to place the GLVs in to the routine diets of this group and to break monotony of the meals, it becomes essential to convert the traditional products in to attractive, value added acceptable products with enhanced content of blood forming nutrients. The present investigation is an attempt to dehydrate the commonly consumed GLVs and to fabricate GLV based value added products for iron security. Specific objectives of the study are as follows:

1. To assess the consumption pattern of green leafy vegetables among urban adolescent girls
2. To standardize the dehydration protocol of green leafy vegetables
3. To fabricate value added products from green leafy vegetables for iron security
4. To determine the blood forming nutrients in value added products
5. To evaluate the protein quality of value added products

## 2. REVIEW OF LITERATURE

Green leafy vegetables form the cheapest source of iron helping in combating nutritional anaemia. Incorporating GLVs in traditional products results in sustainability and acceptability for providing nutritional security. The study was conducted to fabricate GLV based designer foods for iron security of adolescent girls. A view of the work already done helps in planning future research in addition to acting as a stepping stone. Hence, the literature related to consumption pattern of GLVs among Indian population, dehydration of GLVs and value added products of green leafy vegetables are reviewed to substantiate the kind of study undertaken. Keeping in view the objectives set forth for the study, the relevant references available are critically reviewed here.

### 2.1 CONSUMPTION PATTERN OF GLV AMONG INDIAN POPULATION

The studies related to consumption pattern of GLVs among Indian population are reviewed in this section.

Prameela and associates (1995) studied the dietary intake of rural adolescent girls and boys (11-18 years) in Andhra Pradesh. The study showed that the mean intake (and% adequacy) of green leafy vegetables in 11-12, 13-15 and 16-18 year old boys and girls was 1 and 2 g (2 and 4% respectively), 2 and 5 g (2 and 5% respectively), 2 and 6g (2 and 6% respectively) respectively.

Akkamahadevi (1996) conducted a survey on food habits of urban and rural adolescent girls. The study revealed that the green leafy vegetables were not included in the diet of 45.56 per cent of adolescent girls irrespective of the locality, the reason being tasteless.

While surveying urban families to document consumption of green leafy vegetables, Seema (1997) showed that 30 per cent of the population consumed green leafy vegetables daily where as four per cent, 11 per cent and 55 per cent of population consumed weekly, twice a week and thrice a week respectively.

Consumption of vitamin A and  $\beta$ -carotene rich foods among the children from the selected villages of Dharwad district was studied by Kasturiba (1999). Results indicated that GLV's were consumed once a week in 67.97 per cent of the families, followed by twice a week (29.41%) and fortnightly (2.62%).

The study of Chandrashekhar and coworkers in Palakkad district of Tamilnadu (2000) showed that 51.4 per cent of families consumed greens once or twice a week whereas 48 per cent of families consumed thrice or four times a week. The greens liked best by the families were drumstick leaves, amaranth, cowpea leaves, pumpkin leaves, wild colocasia and *churual* for the reasons of nutrition and taste.

Deepa (2002) studied the seasonal variations in the consumption pattern of green leafy vegetables among rural and urban adolescent girls of Dharwad district. The study showed that the rural adolescent girls consumed only *gogu* (2.5 g) while urban adolescent girls consumed *methi* (2.3 g) and shepu (3.8 g) during summer. The increased consumption of amaranth (15.9 g and 9.3 g), *gogu* (5.0 and 8.0 g), and cabbage (0.8 and 5.2 g) was observed during the rainy season by the rural and urban subjects. Consumption of *methi* leaves (1.8 g) was exhibited by urban adolescent girls only.

Dietary intakes of pregnant women from Hisar city of Haryana state was studied by Saroj-Dahia (2002) which showed that the average daily intake of green leafy vegetables was 42 g, which was significantly lower than RDA. The diet of pregnant women was deficient in folic acid (203 mg), iron (20 mg), niacin (12.7 mg) and riboflavin (1.28 mg, 85.3).

The dietary intake of the adolescent girls was studied by Jemima and Bhavani (2004) at Coimbatore. It was reported that the low intake of green leafy vegetables was one of the reasons for the low hemoglobin level. The iron intake being  $9.5 \pm 3.2$  mg was only 30-32 per cent of RDA.

Nalwade *et al.* (2005) reported that daily intake of green leafy vegetables was  $20.30 \pm 19.02$  g among school children of 10-12 yrs in Parbhani district of Maharashtra.

Chacko and Khyrunissa (2007) carried out a study on eating behavior and nutrient intake among adolescent girls from middle income families of Mysore, Karnataka. It was observed that among the vegetables, leafy vegetables were the preferred items and frequently consumed. Around 9-11 per cent of adolescent girls consumed GLV daily, 60-65 per cent frequently, and 20-26 per cent rarely with 76 per cent responding as 'liked'.

## 2.2 DEHYDRATION OF GREEN LEAFY VEGETABLES

Vegetables are highly seasonal and perishable and are available in plenty at a particular season of the year. Large quantity of vegetable gets spoilt due to the glut in the market during season. Preservation can prevent such huge wastage and also increase their availability in the off season. Considering the low bulk density of vegetables drying is considered to be the most suitable and widely used method of preservation. Hence, dehydration of leafy vegetables by reducing the moisture content below a critical level at which enzyme activity and growth of microorganisms is hindered adversely, the vegetables can be preserved for fairly long period. Pre-treatments are necessary pre-requisites for successful dehydration process. Pre-treatments and method of drying check the undesirable physicochemical and enzymatic changes that may occur during drying and help to enhance the keeping quality of dried products.

### 2.2.1 Dehydration protocol

Drying curry leaves in oven at 50°C was reported to be completed in 5.02 hours while drying in sun (35°C±2) and shade (25°C ± 2) required 3.16 and 7.20 days, respectively (Madalgiri *et al.*, 1996). Among the three drying methods, oven drying was superior with emerald green colored curry leaf powder.

A study was conducted by Singh and coworkers, (1997) to dehydrate the selected green leafy vegetables (fenugreek leaves, mustard leaves, *bathu* and spinach) by mechanical and sun drying methods at Amritsar. The dehydration kinetics revealed that the moisture content decreased very rapidly during the first hour of drying with sun drying requiring about eight hours and mechanical drying about four hours to reach the desired moisture level of 9-11 per cent.

Gupta and associates (1999) carried out a study on improvement in rehydration and shelf life stability of hot air dried and sun dried cabbage by predrying treatment. Both treated (soaking in solutions containing 3% salt, 6% sugar and a combination of both at 0-4 °C for 12-16 hours) and untreated (only blanched) cabbage was soaked at room temperature in 0.2 per cent KMS solution for 10 minutes and dried in hot air oven, solar cabinet drier and under direct sun. The results showed that incorporation of sugar increased the drying time of cabbage by one hour in hot air oven (8 hours), four hours in direct sun (13 hours) and three hours in solar cabinet drier (12 hours) apparently due to the humectant effect of sugar.

Lakshmi and Vimala (2000) reported that, sun drying (35-40°C) of amaranth, curry leaves, *gogu* and mint required 14, 10, 24 and 21 hours, respectively, while in cabinet drier (60-70°C) the same leafy vegetables could be dried in 2.5, 1, 3 and 2.5 hours respectively.

According to Pande and associates (2000), *methi* required 4.5, 3.5, 3.0 and 2.5 hours for drying in a forced circulation drier at 40, 45, 50 and 60°C respectively whereas coriander leaves could be dried in 3.5, 3.0 and 2.5 hours at respective temperatures.

Unde *et al.* (2000) reported that the time required for sun drying of cabbage, coriander leaves and *palak* was 4.5, 3.0 and 3.0 hours respectively, while in solar cabinet drier the vegetables could be dried in 14.0, 8.0 and 8.0 hours respectively. The vegetables blanched in osmotic solution of salt (5%) + KMS (0.1%) maintained at room temperature (cold) or at 60°C (hot) produced dehydrated product with 7.5:1, 5.2:1 and 7.4:1 dehydration ratio respectively after drying in electric tray drier. The osmodehydration treatment caused a weight loss of 12.8 and 18.8 per cent in cold and hot brining.

Birar *et al.* (2001) revealed that the total time of five, three and six hours was required for cold and hot brined and unbrined *methi* to be dried in a cabinet drier at 60°C.

Bhosale and Arya (2004) studied the effect of different modes of drying on moisture content and drying time of selected leafy vegetables. The results showed that the cabinet drying was a faster drying mode requiring less time for drying the vegetables than sun and

shade drying. Shade drying required maximum time for drying the samples. The time required for drying cabbage, fenugreek and spinach was 5.30, 2.30 and 3.30 hours, respectively in cabinet drier, 8.30, 5.15 and 6.00 hours, respectively under sun, and 32, 27 and 29 hours, respectively under shade. The moisture content of cabinet tray dried cabbage, fenugreek and spinach (8.05, 7.50 and 8.33% respectively) was significantly less than sun (9.13, 9.16 and 9.53% respectively) and shade dried samples (9.60, 9.25 and 10.26% respectively).

Singh *et al.* (2006) studied the effect of drying conditions on quality of dehydrated leafy vegetables. Drumstick leaves took seven hours for drying while others took six hours under the same drying conditions. Among the driers, cabinet dryer was superior for dehydration of leafy vegetables as it reduced maximum moisture (2.5%) in both curry leaves and *methi*. The moisture content was higher in drumstick leaves (5.5%) and amaranth (5.2%) after dehydration.

### 2.2.2 Impact of dehydration on nutritive value

Dehydration of GLVs not only preserves them for prolonged period but also can act as a rich source of micronutrients for use in sparse season. The process of dehydration might affect the nutritional and other compositions.

While studying the nutritive value of dehydrated green leafy vegetable powders (amaranth, curry leaves, *gogu* and mint) Lakshmi and Vimala (2000) reported that in spite of considerable losses in vitamins, green leafy vegetable powders retained good amounts of protein, fiber and minerals (Ca, Mg, and Fe) and fair amounts of vitamin C and  $\beta$ -carotene. The treatments given to GLVs included, blanching in solutions of sodium chloride (2.0%), magnesium oxide (0.1%), sodium metabisulphate (0.5%), potassium metabisulphate (0.5%) and sodium bicarbonate (0.1 and 0.2%). Among all the treatments given to amaranth, highest ascorbic acid retention was found in samples blanched in 0.1 per cent magnesium oxide (36%) while, the lowest value was recorded in samples blanched in 2.0 per cent sodium chloride (8%). In curry leaf the retention of ascorbic acid was more or less equal in samples blanched using 2.0 per cent sodium chloride (41%) and those blanched in 0.1 per cent magnesium oxide (43%). In *gogu*, 2.0 per cent sodium chloride and 0.5 per cent potassium metabisulphate treated samples showed ascorbic acid retention of 21 and 19 per cent respectively when compared with plain water blanched samples (47%).

Gupta *et al.* (2003) studied the influence of dehydration on the nutrient composition of green leafy vegetables (GLV). Shepu, *bathua*, *kilkeerae*, curry leaves and *keerae* were steam blanched for five minutes and dried in an oven at 50°C for 10-12 hours. The ascorbic acid,  $\beta$ -carotene and available iron (in the fresh vegetable) ranged from 29-78, 2.70-8.84 and 0.64-2.4 mg/100g respectively, of which 1-9, 20-79 and 16-27 per cent respectively were retained after dehydration. Dehydration did not alter the total iron content of the greens.

Lalitha and Sathya (2003) dehydrated curry leaves, drumstick leaves and coriander leaves to develop instant mixes by incorporating it in powder form. Fresh coriander leaves had the highest moisture (77.9%) and  $\beta$ -carotene (130.8  $\mu$ g) contents. The yield of sun dried powder was less than that of oven dried ones. Oven dried samples of all three leaves retained maximum  $\beta$ -carotene content and among them the retention was higher in drumstick leaves (82.3  $\mu$ g). The incorporation of GLV powders showed an increase of more than 93 per cent in  $\beta$ -carotene content which was also organoleptically acceptable.

Kowsalya and Vidhya (2004) assessed the nutritive value of dehydrated GLVs (*aria keerae*, *mulla keerae*, *paruppu keerae* and drumstick leaves) in Coimbatore. Iron content of dehydrated vegetables ranged from 25.5 mg in sun dried drumstick leaves to 269 mg in *aria keerae*.  $\beta$ -carotene after dehydration ranged from 41.74 mg in sun dried drumstick leaves to 97.85 mg in cabinet dried *paruppu keerae*. Cabinet drying indicated better nutrient retention than sun and shade drying.

### 2.2.3 Impact of dehydration on quality parameters

Processing, pretreatments and methods of drying of vegetables would have a potential impact on the quality of vegetables specially the GLVs, in terms of chlorophyll content, rehydration ratio and alike.

Bajaj and coworkers (1993) studied the effect of blanching treatments on the quality of dehydrated fenugreek leaves. Different blanching treatments consisted of hot water and

solutions containing sodium chloride (2%), magnesium oxide (0.1%), sodium metabisulphate (0.5%), potassium metabisulphite (0.5%), sodium bicarbonate (0.1% and 0.2%) either singly or in combination. Ascorbic acid retention was maximum (39.2%) in samples treated with KMS solution, while chlorophyll loss was minimum (7.3%) in plain water blanched samples. However, MgO solution resulted in better retention of chlorophyll on storage for six months. The rehydration ratio of the dried fenugreek leaves with the different blanching treatments (blanching in water, blanching in solutions either singly or in combination) ranged from 5.9 to 7.2, the highest being with sulphitation treatment.

Dehydration characteristics of spinach, mustard, fenugreek and *bathu* leaves were studied by Singh and associates (1997). The study revealed that maximum chlorophyll retention was observed in blanched *bathu* (65-70%) and least (50%) in spinach. It was indicated that blanching helped in retention of chlorophyll. The colour of sun dried samples was severely deteriorated hence it was not analysed. Among all tray dried and sun dried leafy vegetables, spinach exhibited lowest rehydration ratio. While, fenugreek recorded maximum rehydration ratio when sun dried, *bathu* registered highest when dried in trays in shade.

Blanched cabbage was treated with three per cent salt and six per cent sugar before drying by different methods (Gupta and coworkers, 1999). The rehydration percentage increased from 41.7 (untreated) to 68.4 (treated) in hot air oven drying, 33.1 to 54.0 in drying under direct sun and from 43.6 to 66.2 in solar cabinet drier.

Lakshmi and Vimala (2000) tried various blanching treatments (blanching in solution of 2% sodium chloride, 0.1% magnesium oxide, 0.5% sodium metabisulphate, 0.5% potassium metabisulphate, 0.1 and 0.2% sodium bicarbonate) in preparing leafy vegetable powders (amaranth, curry leaves, *gogu* and mint). Amaranth and mint leaves blanched in hot water containing magnesium oxide (0.1%) registered higher retention of chlorophyll (39 and 30% respectively) compared to other methods of blanching. Curry leaves retained maximum chlorophyll (51%) when blanched with sodium chloride (2%). *Gogu* treated with both sodium chloride (2%) and sodium metabisulphite (5%) showed greater retention of chlorophyll (38%). The rehydration ratio of amaranth, curry leaves, *gogu*, and mint was found to be higher in sun dried samples (7.38, 4.06, 5.86 and 6.09 respectively) and lower in cabinet dried samples (6.81, 3.74, 5.46 and 6.46 respectively).

The study of Unde *et al.* (2000) revealed that cabbage, coriander and *palak*, blanched in osmotic solution (5% salt + 0.1% KMS) produced rehydration ratio of 5.2:1, 4.0:1 and 4.5:1 respectively after drying in electric tray drier.

Blanching of amaranth in hot water ( $95 \pm 3^\circ\text{C}$ ) for one minute followed by cooling in running tap water and dipping in 0.5 per cent solution of potassium metabisulphite for one minute prior to drying in cabinet drier showed higher retention of chlorophyll,  $\beta$ -carotene and lowered non-enzymatic browning (Negi and Roy, 2001).

The effect of blanching prior to dehydration in cross air flow drier was studied in seven leafy vegetables *viz.*, *dhantu*, *khirkhire*, *honagone*, *chakota*, *palak*, *kachi* and fenugreek (Premavalli *et al.*, 2001). The GLVs were blanched in boiling water containing sodium bicarbonate (0.1%) + MgO (0.1%) and sodium metabisulphate (0.2%) for two minutes prior to dehydration. The highest retention of chlorophyll was found in fenugreek (95%), followed by *palak* (89.3%), *Khirkhire* (88%) and *chakota* (87.3%). Least retention was observed in *honagone* (51.35%) followed by *kachi* (59.80%). Retention of total carotenoids on dehydration was highest in *chakota* (94%) followed by *palak* (82.7%) and *kachi* (79.3%). *Dhantu* (71.4%) and fenugreek (71.2%) showed similar retention of total carotenoids. Least retention was observed in *honagone* (36.1%) followed by *khirkhire* (66%).

Kowsalya and Vidhya (2004) assessed total carotenoids present in dehydrated GLVs which ranged from 91.58 mg (drumstick leaves) to 189.56 mg (*arai keera*). In comparison with shade and sun drying, all cabinet dried vegetables showed relatively less rehydration ratio. The rehydration time was 30 minutes for all the greens and rehydration was better in boiling water.

Singh *et al.* (2006) carried out a study on effect of drying conditions on the quality of dehydrated leafy vegetables (amaranth, curry leaves, drumstick leaves, *methi* and *palak*). The data revealed that the rehydration ratio was higher in the product dehydrated in cabinet drier

and it was comparatively low in the products dried at low temperature and in solar drier. Among all the driers the cabinet drier was found to retain higher proportion of chemical constituents such as  $\beta$ -carotene (2685 to 4850  $\mu\text{g} / 100 \text{ g}$ ) and chlorophyll (70.0 to 130.3  $\mu\text{g} / 100 \text{ g}$ ) than solar and low temperature drier. The loss of ascorbic acid was higher in the solar dried vegetables as compared to cabinet and low temperature dried vegetables. Maximum loss of ascorbic acid was observed in *palak* and amaranth and least in curry leaves followed by drumstick leaves.

#### 2.2.4 Organoleptic evaluation of dehydrated leafy vegetables

The dehydration processes not only affects the colour and other pigments but also the sensory attributes like colour, appearance, texture, aroma and overall quality to a varying degree. These variations depend not only on the type of vegetable but also on the method of processing.

Bajaj *et al.* (1993) evaluated culinary quality of blanched and dehydrated fenugreek leaves. Color, texture, aroma and overall quality of blanched leaves received significantly higher scores than unblanched. Among the blanching treatments, plain water, magnesium oxide (0.1%) and sodium bicarbonate (0.1%) were found to be better blanching solutions in terms of quality.

Blanching as a pre-treatment prior to drying in sun and shade resulted in organoleptically acceptable product from fenugreek. On comparison with untreated fenugreek, blanched fenugreek leaves obtained better scores for all sensory parameters even up to three months of storage. It was also concluded that drying of vegetables under sun is effective method (Sukanya *et al.* 1995).

Singh *et al.* (1997) studied sensory evaluation of dehydrated leafy vegetables viz., spinach, mustard leaves, fenugreek, *bathu* by using four point scale. The sensory data revealed that a desirable color was obtained in case of tray drying (4), while the color of sun dried products was unacceptable (2). However, the flavor of all vegetables was found to be better in case of sun dried products (4) as compared to tray dried (3) except fenugreek wherein both methods of drying were on par (3). There was no difference in scores obtained for texture by fenugreek and mustard leaves in both the methods of drying (3). While, *bathu* and spinach dried under sun received scores of three and four respectively, those dried under cabinet received the scores of four and three respectively. The overall acceptability of the products was excellent (4). Among tray dried samples fenugreek performed the best followed by spinach, *bathu* and mustard leaves, while the scores were lowest for sun dried fenugreek followed by *bathu*, mustard leaves and spinach.

The treated samples with sugar (6%) alone and in combination with salt (3%) and sugar (6%) brought about considerable improvement in colour (natural), appearance (nearly full and full), texture (tender and very tender with crisp) and overall acceptability (very good and excellent respectively) than in untreated cabbage (Gupta *et al.*, 1999).

Lakshmi and Vimala (2000) evaluated the powders of amaranthus, curry leaf, *gogu*, mint and their blended forms after rehydration, for color, texture, taste and overall acceptability which ranged from average to excellent. It was possible to retain the bright green, whereas the original flavor of leaves could not be retained completely.

The overall acceptability of dehydrated cabbage, coriander and *palak* ranged between 5.0 and 6.8 on a nine point hedonic scale (Unde *et al.*, 2000). Overall *palak* was better accepted (6.8) than coriander (6.4) and cabbage (5.6).

The sensory evaluation of dehydrated *methi* leaves after rehydration was carried out by Birar *et al.* (2001). Results revealed that the samples pretreated with 15 per cent hot brine (60 °C) received higher scores for color and appearance (7.5), flavor (7.9), texture (7.3), taste (8.0) and overall acceptability (7.7)

Singh and associates (2006) carried out organoleptic evaluation (5 point hedonic scale) of selected dehydrated leafy vegetables on five point hedonic scale with one denoting excellent. The study showed that the sensory score for all the GLVs viz., amaranth, curry leaves, drumstick leaves, *methi*, *palak* was excellent under cabinet drier. Amaranth was excellent in color (1.1), flavor (1.3) and good in texture (2.2). Curry leaves and *palak* scored alike as excellent in flavor (1.1 and 1.5) and texture (1.2 and 1.1) while good in color (2.4 and

2.2). The overall high score was obtained by cabinet dried vegetables while solar dried vegetables were poor in sensory characteristics.

## 2.3 VALUE ADDED PRODUCTS OF GREEN LEAFY VEGETABLES

Dehydrated leafy vegetables are concentrated source of several nutrients including iron and  $\beta$ -carotene. Development of the products by incorporation of the dehydrated GLVs in traditional preparations can assist to meet the daily nutritional requirements of the adolescent girls. These products if included in routine diet can help to reduce the incidence of iron deficiency anaemia. Relevant literatures pertaining to these aspects are reviewed in this section.

### 2.3.1 Value addition with green leafy vegetables

The acceptability of products with cauliflower leaves was carried out by Kowsalya and Mohandas (1999). The study revealed that cauliflower leaves were used in the common south Indian preparations such as, *poriyal* and *kootu*. The drumstick leaves *poriyal* and *kootu* were used as standard for comparison. Identical scores were obtained for both standard and test *poriyal* with respect to appearance (4), color (4), and texture (3.8) on four point numerical rating scale. The higher total score was obtained for cauliflower leaf *poriyal* (19.8) with 90 per cent of panel members opting it. Standard and test *kootu* was equally acceptable for appearance and colour (4) but the total score was highest for drumstick leaves *kootu* (19.6).

Lakshmi and Vimala (2000) dehydrated amaranth, curry leaves, *gogu* and mint leaves to prepare powders for incorporation in different products which were evaluated by panel of trained judges. The food products prepared using powders of amaranth (soup, *dhal* with greens and *pesarattu*), curry leaves (hot powder, *pakodi* and *pesarattu*), *gogu* (*dhal* with greens, *chutney* and mutton curry) and mint (vegetable *biryani*, *chutney* and bone soup) were rated as highly acceptable for all the sensory attributes and were scored from good (4) to excellent (5) on five point scale. However, soup with amaranth powder received slightly lower scores of 3.8 for overall acceptability, taste and flavour.

Value added traditional products of Bangalore were acceptable with scores of 4.2 (*upma* and *dosa*) 4.1 (*majjigehuli*, *ambode* and *ladoo*) to 3.9 (*Bisebele bhath*) on five point scale in a study conducted at Bangalore (Anon 2003). *Masala* bun with *knolkhol* greens received lowest scores of 3.3.

Report from Hisar indicated that value added products (VAPs) with underutilized leafy vegetables, fruits and other vegetables were highly acceptable with scores of more than 7.0 on nine point hedonic scale (Anon 2003).

*Oogal namakpara* of Pantanagar was less acceptable with score of 7.0 (Anon 2003). Other VAPs namely *soy chat*, *soy mathari*, *soy leaves pakora* received the overall acceptable scores of 7.5 and 8.0.

Kaur and Bajwa (2003) studied effect of green leafy vegetables on the quality attributes of vegetable impregnated *paneer*. The leafy vegetables (coriander and mint) were blanched (steam or water) prior to impregnation in *paneer* and then evaluated for sensory scores by using nine point hedonic scale. The study revealed that steam blanched coriander in *paneer* received higher scores for colour (7.67) compared to water blanched (7.17) and unblanched (6.08). Colour influenced on appearance of *paneer*, the unblanched samples receiving significantly lower scores than blanched. The coriander-impregnated *paneer* with unblanched leaves had comparatively stronger coriander flavor which was contributed to higher flavor profile (8.50). The overall acceptability was found to be highest for the samples prepared by incorporating steam blanched coriander (7.32). However, texture was not affected by incorporation of coriander. Similarly, *paneer* with steam blanched mint leaves received higher scores for all sensory attributes compared to water blanched and unblanched.

A study was conducted by Kulkarni (2003) to explore the utility of underutilized leafy vegetables to enrich routine diets for nutrition security. Five underutilized leafy vegetables were selected on the basis of the micronutrient profile (drumstick, *chakramuni*, bengal gram leaves, *chandanabatta* leaves and *sambar soppu*) and 14 value added traditional foods were developed by incorporating these at different levels (10 or 25 or 50%). The products were

evaluated for sensory characteristics using nine point hedonic scale by 10 semi trained judges. The results showed that coconut *chutney* with *sambar soppu* scored highest for all sensory attributes followed by *bisebilebath* and little millet *upma* with drumstick leaves and the least scores were obtained for barnyard millet *upma* with drumstick leaves.

Lalitha and Sathya (2003) incorporated curry leaves, drumstick leaves and coriander leaves powder in commonly used instant mixes such as dhal powder, *bajji* mix and *vadai* mix at two levels viz. 100:25 (variation-I) and 100:50 (variation-II) and evaluated the sensory quality. It was reported that all products were equally acceptable. However the mean scores obtained by *bajji* mix incorporated with curry leaves powder of variation-I were significantly lower for appearance and taste.

Singh and Awasthi (2003) conducted a study to investigate the effect of powder made from *kachnar*, drumstick, colocasia and curry leaves incorporated food products viz., biscuits, *murukku*, *mathri* and *namakpare* on sensory parameters. Green leafy vegetable powders were incorporated at five, 10, 15 and 20 per cent level and products were evaluated organoleptically. Acceptable level of GLV in biscuits, *murukku*, *mathri* and *namakpare* was 15, 10, 20 and 10 per cent respectively.

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 *prantha* with 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). *Puri* with turnip and carrot greens was 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.

Shah (2005) carried out a study to develop value added products by incorporating bengal gram leaf powder. Sixteen recipes, based on cereals, pulses, oilseed, were developed by incorporation of bengal gram leaf powder at four, eight, 12 and 16 per cent level. The products were evaluated for sensory attributes using five point hedonic scale. The results indicated that among the cereal based recipes (stuffed *paratha*, *puri*, *dhapate* and *thalipeeth*), the scores for overall acceptability ranged from 4.41 to 5.00, for pulse based recipes (plain *dal*, *mung dal*, *masoor dal* and moth bean *usal*) from 4.66 to 5.00, for nuts and oil seed based *chutneys* (prepared from ground nut, sesamum, niger seed and linseed) from 4.58 to 5.00 and snacks (*udad dal wada*, *chakli*, *mung dal wada* and *shev*) from 4.75 to 4.83.

Nande *et al.* (2007) studied acceptability of recipes prepared from different varieties of betel leaves. Three recipes namely coconut *burfi*, cutlet and *muthia* were developed and the recipes prepared from spinach served as control. Sixty grams of leaves was incorporated in coconut *burfi* and cutlet whereas, 70 g leaves was incorporated in *muthia* preparation. Coconut *burfi* prepared from sweet betel leaves was given high scores ranging from 4.17 (colour) to 4.34 (taste) on five point scale followed by *kapuri* betel leaves (3.61 to 4.17) and *bangla* betel leaves (2.54 to 3.50) respectively. *Burfi* with spinach received high scores of 4.5. Cutlets prepared from *kapuri* betel leaves (3.83 to 4.49) were highly acceptable and very close to spinach cutlets (4.17 to 4.61) for all sensory characteristics followed by cutlets prepared from sweet betel leaves (3.67 to 4.34) and *bangla* betel leaves (2.45 to 4.17). *Muthia* with betel leaves and control showed significant difference for their overall acceptability ( $t = 3.1$ ,  $P < 0.01$  for spinach versus sweet;  $t = 2.2$ ,  $P < 0.05$  for spinach versus *kapuri* and  $t = 9.2$ ,  $P < 0.01$  for spinach versus *bangla* betel leaves).

Nambiar *et al.* (2007) standardized traditional Indian recipes with drumstick (*moringa olifera*) leaves. Freshly blanched drumstick leaves were incorporated in three pulse based recipes commonly consumed in India such as boiled and seasoned *mung* (*phaseolus aureus*), *Kabuli chana* (*Cicer arietinum*) and *desi chana* (*Cicer aritinum*). One serving of each of these recipes (30 g raw weight of pulses which is equivalent to approximately 100 g cooked weight) could blend with a maximum of 20 g of fresh drumstick leaves. The study showed that all the three recipes (*mung*, *Kabuli chana* and *desi chana*) were found to be acceptable by the panel

of judges (18 to 21 years old women), with an overall composite score ranging from 3.06 to 3.53 (on a scale of 1 to 5) for the three test recipes. The overall composite score for *desi chana* was highest at  $3.53 \pm 0.71$ , followed by *kabuli chana* at  $3.4 \pm 0.49$  and *mung* at  $3.06 \pm 0.57$ .

### 2.3.2 Blood forming nutrients in value added products

Mere presence of blood forming nutrients in the GLV does not ensure its availability in the value added products. Processing protocols result in the alteration of the nutritive value. Hence, it is important to study the nutrient content in products rather than raw materials alone.

Vijayalakshmi and coworkers (1994) carried out a study on enhancing the nutritive value of convenience foods by incorporating green leafy vegetables. It was concluded from the study that addition of coriander and curry leaves in *vadai* mix and *bhaji* mix increased the nutritive value of convenience foods with respect to protein,  $\beta$ -carotene, calcium and iron. The protein,  $\beta$ -carotene, calcium and iron contents before adding greens were 16 g, 0.0  $\mu$ g, 42 mg and 13 mg in *vadai* mix and 16 g, 0  $\mu$ g, 50 mg and 7 mg in *bhaji* mix which increased to 12 g, 2171  $\mu$ g, 181 mg and 12.9 mg (*vadai* mix) and 12 g, 2170  $\mu$ g, 187 mg and 8.9 mg in *bhaji* mix respectively.

Protein, iron and  $\beta$ -carotene contents of selected vegetable preparations were evaluated by Nalwade and others (2002). The study revealed that, colocasia and *chana* leaves curries had the highest amount of protein (7.28 g and 7.26 g respectively) while, spinach curry recorded lowest value (2.33 g). *Methi-mung* dhal curry had maximum calcium and iron contents of 400 mg and 27.33 mg respectively. Colocasia curry contained the highest amount of  $\beta$ -carotene (10321  $\mu$ g) followed by shepu-mung dhal curry (5094  $\mu$ g).

Underutilized leafy vegetables namely *anne* greens and knolkhol leaves were incorporated at 20-50 per cent in 10 traditional routinely consumed products of Bangalore for iron security (Anon, 2003). Protein and calcium contents doubled with value addition whereas  $\beta$ -carotene enhanced by three fold, the increase ranging from 330-9105 per cent. *Dosa* and *idli* traditional fermented products with greens contained highest  $\beta$ -carotene while *upma* had maximum iron. However, a multifold increase of iron content (207 to 1002%) was reported with addition of underutilized leafy vegetables in all traditional products of Bangalore (Anon, 2003).

Improvised mixes or flours were developed in a study from Bihar (Anon, 2003) by incorporation of underutilized leafy vegetables like amaranth leaves and drumstick leaves. The protein content improved from 6.5 to 13 per cent in the improvised flour. Addition of 10 per cent dried amaranth along with *chana* and *moong dal* enhanced nutritive value of *kichadi* mix tremendously providing 23 g protein, 396 Kcal of energy, 194 mg of Ca, 2.5 mg of Fe and 4260 mg of  $\beta$ -carotene as against 3.1 g, 78 Kcal, 7.6 mg and 24.2  $\mu$ g respectively in traditional *kichadi*. Incorporation of five per cent drumstick leaves to maize *dalia* augmented the  $\beta$ -carotene to 2284  $\mu$ g from 90  $\mu$ g / 100g.

Uncommon foods like soybean leaves, buckwheat grains and leaves, horse gram and rice bean were incorporated in traditional products like *chapathi*, biscuit, *dhokla*, *namakpara*, etc. at Pantnagar (Anon, 2003). Soy or buckwheat leaves when incorporated in potato *bhaji*, protein enhanced to 10.02 g / serving from 2.5 g / serving; iron from 1.30 mg to 10.6 mg / serving. Soy mixed veg and soy *sag* supplied 8700 and 8509  $\mu$ g of  $\beta$ -carotene / serving.

An enhancement of 90 Kcal of energy and 65 mg of Ca / serving was recorded in maize *dhokla* with the addition of green leafy vegetables (Anon, 2003).

Kaur and Bajwa (2003) developed *paneer* by impregnating coriander and mint leaves at 10 per cent level. The study revealed that there was a significant increment of protein, iron and ascorbic acid in coriander *paneer* (16.65, 0.65, and 2.00%) and mint *paneer* (17.18, 1.04 and 2.38%) than plain variety.

Kulkarni (2003) developed number of value added food products using underutilized leafy vegetables. The nutrients such as protein, iron,  $\beta$ -carotene and ascorbic acid ranged from 2.43 g (ground nut *chutney* with *chakramuni* leaves) to 15.71 g (barnyard millet *upma* with drumstick leaves), 1.40 mg (groundnut *chutney* with *chakramuni* leaves) to 12.94 mg (little millet *dosa* with *chakramuni* leaves), 15.63  $\mu$ g (groundnut *chutney* with *chakramuni*

leaves) to 2338.09 µg (drumstick *chapathi* with soybean) and 0.40 mg (coconut *chutney*) to 946.80 mg (both variations of *turdal bhaji* with *chakramuni* and *chandanaabatta* leaves) per serving respectively.

Singh and Awasthi (2003) calculated nutrient composition of the products namely, biscuits, *murukku*, *mathri*, and *namakpare* incorporated by *kachnar*, drumstick, colocasia and curry leaves. The protein, iron and β-carotene contents of the products ranged from 11.6 to 23.8 g /100 g, 2.16 to 5.62 mg /100 g and 819.2 to 3017.75 µg /100 g respectively.

Jemima and Bhavani (2004) reported that the *porial* prepared with cauliflower leaves provided 16.4, 262.9 and 13.85 mg /100 g of iron, calcium and vitamin C respectively, whereas, fresh cauliflower leaves had 25.1 mg of iron, 260 mg of calcium and 29 mg of ascorbic acid per 100 g.

*Paratha* prepared by incorporating amaranth leaves recorded more protein, total iron, ascorbic acid and β-carotene contents on dry weight basis as compared to amaranth leaves *poori* (Punia *et al.*, 2004). Among the four products prepared by *kondhara* leaves (*sag*, *raita*, leaves with Bengal gram and leaves with green gram dhal) protein content ranged from 19.23 to 30.44 g, total iron from 3.23 to 4.10, ascorbic acid from 34.80 to 60.83 mg /100 g and β-carotene from 92953 to 10557 µg /100 g on dry weight basis. Among the *kondhara* leaf products, *sag* was the richest source of nutrients like iron, ascorbic acid and β-carotene.

A study on nutritional evaluation of products prepared from dried spinach leaves (Singh *et al.*, 2004), showed that, the moisture and protein contents of cake, biscuits, *pakora*, *vada*, *namakpara* and *kurmura* ranged from 1.43 to 40.87 per cent and 9.61 to 16.62 per cent respectively. Ascorbic acid content was higher in products prepared from fresh spinach as compared to that prepared from dried powder. β-carotene content was found to be highest in *namakpara* prepared from dried leaves. Total iron content of spinach products ranged from 4.10 to 15.00 mg /100 g on dry weight basis. Ionizable iron and in vitro iron (% of total iron) was reported to be maximum in biscuits. The investigation revealed that the products developed with the spinach contained appreciable amounts of iron and β-carotene.

Shah (2005) carried out a study on proximate composition of recipes with bengal gram leaves. The study revealed that protein and iron content in *shev*, *chakli*, *mung dal* and *udad dal wada* were 16.66 g and 7.8 mg, 11.66 g and 21.58 mg, 21.58 g and 9.50 mg, 16.91 g and 9.10 mg respectively.

Singh and coworkers (2005) carried out a study on nutritional evaluation of products prepared from cauliflower leaf powder. The study showed that protein content was maximum in *kurmura* (12.25%) and minimum in biscuit (7.42%). Ascorbic acid and β-carotene contents of biscuit, cake, *namakpara*, *kurmura* ranged from 2.21 to 4.29 mg and 2.04 to 4.98 mg respectively. Total iron content was highest in cake (9.90 mg) and ionizable iron was maximum in biscuit (2.63 mg).

Kasturiba *et al.* (2007) reported that the *chapathi* prepared with fenugreek and drumstick leaves had β-carotene content of 2422 and 2420 µg per serving, respectively.

Nande *et al.* (2007) evaluated nutritive value of the recipes prepared from spinach and betel leaves. The data revealed that betel leaves recipes had higher content of all nutrients but there was no significant difference between them. Among all the recipes prepared viz. coconut *burfi*, cutlet and *muthia*, *muthia* with spinach and betel leaves showed highest content of protein (11.29 and 11.49 g respectively), carotene (1081.21 and 1114.05 µg respectively), folic acid (61.18 and 51.87 µg respectively) and iron (4.07 and 5.80 mg/100g respectively).

Nambiar and associates (2007) calculated the nutritive value of the recipes supplemented with drumstick leaves by using standard values for Indian foods. Twenty grams of drumstick leaves provided 3938 µg of β-carotene. Three recipes of boiled and seasoned pulses (*kabuli chana*, *desi chana* and *mung*) provided similar amounts of protein (6.5 - 8.6), vitamin C (45 - 47 mg), iron (1.5 - 1.6 mg) and β-carotene (3966 - 3995 µg).

### 3. MATERIAL AND METHODS

The present study was planned to fabricate green leafy vegetable based designer foods to secure the daily requirements of iron for adolescent girls. The study was carried out in three phases as follows.

#### Phase I

To elicit information on consumption pattern of green leafy vegetables among adolescent girls (Fig.1).

#### 3.1 CONSUMPTION PATTERN OF GLV

Primary data was collected on consumption and utilization of green leafy vegetables among adolescent girls by personal interview method.

##### 3.1.1 Selection of sample

The list of schools was obtained from Block Education Office of Dharwad. A group of 10 government and private schools were selected by random sampling method. From each school 100 adolescent girls of 12 to 16 yrs age were selected totaling 1000 subjects for the study.

##### 3.1.2 Development of a questionnaire

The questionnaire which included general information, consumption pattern of green leafy vegetables, commonly consumed recipes prepared using green leafy vegetables, seasonal availability and general knowledge regarding nutrition and health benefits of GLVs was developed in consultation with nutrition experts, statisticians and literature.

##### 3.1.3 Pretesting of the questionnaire

The developed questionnaire was pretested in non sample area to test its suitability and to avoid ambiguity.

##### 3.1.4 Collection of the primary data

The girls of seventh standard to tenth standard of different schools were personally interviewed to elicit required information using developed questionnaire and the data obtained was tabulated and analyzed.

#### Phase II

Dehydration protocol of selected leafy vegetables was set by giving different treatments and using different methods of drying (Fig.1).

#### 3.2 SELECTION OF GREEN LEAFY VEGETABLES

On the basis of survey five most commonly consumed GLVs (fenugreek, spinach, *rajagira*, *shepu* and *kiraksali*) were selected for the study.

#### 3.3 DEHYDRATION PROTOCOL OF GLVs

The protocol for dehydration of GLVs was studied in terms of time and temperature of drying, pretreatments and methods of drying.

##### 3.3.1 Procurement and preparation of vegetables

The raw material required for dehydration studies were procured from local market. The green leafy vegetables were sorted with tender stem and healthy leaves. Selected GLVs were washed by dipping in water for one minute. The procedure was repeated till the vegetable are devoid of dirt and soil.

Sorted and cleaned GLV was divided in to four lots.

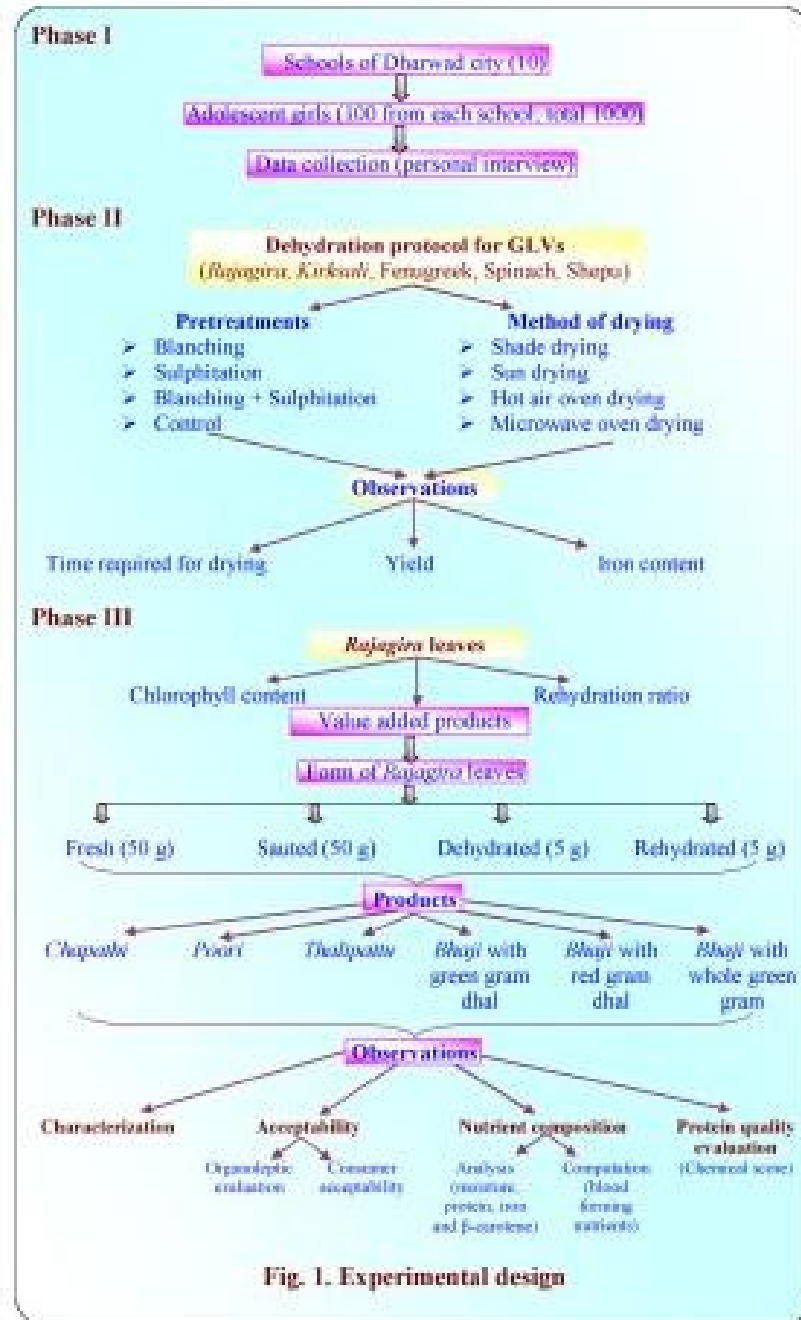


Fig. 1: Experimental design

### 3.3.2 Pretreatments

The GLVs were subjected to different treatments prior to the dehydration. The pretreatments employed in the study are indicated below

3.3.2.1 Blanching: The GLVs were tied in destarched muslin cloth and kept immersed in boiling water for one minute and drained in colander to remove excess water.

3.3.2.2 Sulphiting: Prior to dehydration GLVs were exposed to the steam of sodium bisulphate (3.3%) solution for one minute.

3.3.2.3 Blanching and sulphiting: In this treatment sulphitation was carried out to the GLVs as detailed in 3.3.2.2 followed by blanching (3.3.2.1).

3.3.2.4 Control: Last lot was dehydrated without any pretreatment.

### 3.3.3 Dehydration of GLV

The pretreated GLVs were dried by four methods using microwave oven, hot air oven, sun and shade drying. Time required for drying and yield (%) obtained was recorded.

#### 3.3.3.1 Microwave drying

The pretreated GLVs were spread in a single layer in microwave safe tray and allowed to dry at 100 per cent power (2250 Hz). Drying was continued till the GLVs became crisp and the time taken for drying was recorded.

#### 3.3.3.2 Hot air oven drying

The pretreated GLVs were spread over the aluminum trays and dried at 60° C till leaves became brittle and could be crushed easily when handled between fingers. Time taken for drying was recorded.

#### 3.3.3.3 Sun drying

Pretreated GLVs spread on a cotton cloth in a tray for surface drying for one hour and then shifted to sunlight (38-42° C). Drying continued till the vegetables became crisp. Care was taken to avoid contamination by covering the tray with thin muslin cloth. Time taken for drying was recorded.

#### 3.3.3.4 Shade drying

Shade drying was accomplished by spreading pretreated leaves on a paper tray in a clean well ventilated room till the vegetables became crisp. Time taken for drying was noted.

The dehydrated GLVs were packed in low density polyethylene bags and stored in air tight aluminum containers for future use.

## 3.4. IRON ESTIMATION

The GLVs dehydrated without any pretreatment were ignited in muffle furnace, converted in to mineral solution and iron content was estimated using Atomic Absorption Spectrophotometer (Lindsay and Norwell 1978). The GLV having maximum iron content was utilized for further study.

## 3.5 QUALITY OF DEHYDRATED *RAJAGIRA*

The dehydrated *rajagira* leaves were evaluated for physical characteristics such as color (chlorophyll), texture and appearance by visual observation.

### 3.5.1 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.

The leaf sample (0.25 g) was cut into small pieces and homogenized with pure acetone in a mortar with pestle. The supernatant was decanted through a Whatman No. 42 filter paper in to a 25 ml volumetric flask. Eighty percent acetone was added to the residue in the mortar and the extraction was repeated until residue was decolorized. Then the volume was made up to 25 ml with 80 percent acetone and the absorbance of the extract was measured at 652 nm in spectrophotometer using 80 percent acetone as blank. The chlorophyll content was calculated using formula shown below.

$$\text{Chlorophyll (mg/g dry wt.)} = \frac{27.8 \times A \times V}{1000 \times W \times a}$$

Where,

A = Absorbance at specific wavelength (652nm)

V = Final volume of the chlorophyll extract (ml)

W = Fresh wt of the sample (g)

a = Path length of light (1 cm)

### 3.5.2 Rehydration ratio

The rehydration ratio of dehydrated *rajagira* leaves with different treatments and types of drying 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 suction for 2-3 min. The drained rehydrated material was weighed and the rehydration ratio calculated as follows.

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

### Phase III

Value addition to the commonly consumed traditional recipes by incorporating GLVs for iron security and evaluating the quality of value added products in terms of organoleptic and nutritional characters (Fig.1).

## 3.6 VALUE ADDED PRODUCTS (VAPS) OF GLV

Acceptable, nutritive products were developed using GLV, so as to meet 1/3<sup>rd</sup> of the Recommended Dietary Allowances of iron for adolescent girls.

### 3.6.1 Selection of the recipes

On the basis of survey, a total of four recipes (*Chapathi, Poori, Thalipattu* and *Bhaji* with pulses) which are traditionally prepared and consumed daily by higher proportion of adolescent girls were selected for value addition.

### 3.6.2 Level of incorporation

Dehydrated, rehydrated and fresh (sautéed or unsautéed) GLVs were incorporated in selected recipes. Amount of GLVs to be incorporated was determined based on the iron content so as to meet minimum of 1/3<sup>rd</sup> requirement of iron.

### 3.6.3 Characterization of the value added products

I *Chapathi, Poori* and *Thalipattu*

Characterization of the products viz., *chapathi*, *poori* and *thalipattu* was carried out in terms of water required for dough making, rollability, puffability, and weight of final product. Oil absorption by *poori* was recorded by the difference between the oil required for frying and left over.

#### II *Bhaji*

Characterization of the different variations of *bhaji* with different pulses was carried out in terms of characteristics such as water absorption, cooking time and weight after cooking.

### 3.6.4 Acceptability of the value added products

Value added products were evaluated at laboratory level by panel of judges and at the consumer level by adolescent girls and young adult women.

#### 3.6.4.1 Laboratory level

The sensory parameters such as appearance, texture, taste, flavor and overall acceptability of the products were evaluated on a nine point hedonic scale using ten trained panel of judges.

#### 3.6.4.2 Consumer level

Since the ultimatum of any product is acceptability by the consumers, recipes which received highest rank at laboratory level were tested for acceptability by consumers. Girls residing in hostels, laborers, staff and students of the University of Agricultural Sciences served as consumers. One serving of the product was provided to each consumer and were requested to indicate the opinion as 'like, dislike or neutral'.

### 3.6.5 Nutrient composition

Nutrient composition of the selected standardized recipes incorporated with *rajagira* such as *Chapathi*, *Poori*, *Thalipattu* and *Bhaji* with different pulses was computed by Annapurna software. Further blood forming nutrients including protein, iron and  $\beta$ -carotene were analyzed using suitable analytical methods.

#### 3.6.5.1 Moisture

Moisture content of VAPs was determined by standard procedure of AOAC, (1990). Difference in the weight of the samples before and after drying was considered as moisture content.

#### 3.6.5.2 Ash

Ash or mineral content of VAPs was analyzed by igniting known weight of sample in a muffle furnace for four hours at 600°C and weighed. The difference in weight was taken as the weight of ash (Anon, 1990).

#### 3.6.5.3 Protein

The crude protein content of the products was estimated using micro kjeldahl method (AOAC 1995) by converting the organic nitrogen in to ammonium sulphate in presence of a catalyst and titrating the ammonia liberated with suitable acid. The estimation was carried using Kjel plus for digestion and distillation. The protein content was calculated by multiplying with factor 6.25.

#### 3.6.5.4 Iron

Iron content of VAPs was analyzed as detailed in 3.4.2

#### 3.6.5.5 $\beta$ -carotene content

$\beta$ -carotene content was estimated according to the method of Association of Vitamin Chemists (Anon, 1951) utilizing acetone-hexane solvent for extraction.  $\beta$  carotene was separated on a column of aluminium oxide and the absorbance of elutes was measured spectrophotometrically at 450 nm for calculating the concentration of  $\beta$ -carotene.

### 3.6.5.5.1 Preparation of the column

The clean sintered glass was filled with the slurry of aluminium oxide in hexane to obtain a 10cm long column. The absorbent was pressed down firmly once or twice with a plunger. The column was always kept wet with hexane. The column was washed thoroughly with 25 to 30ml of solvent. When the last one cm of the solvent was remaining on top of the column, 5ml of sample extract was loaded on the column and subsequently 5ml elutions were collected using a mixture of acetone and hexane (9:91 v/v) as an eluent. Washings were carried till elute was colorless. All the colored elutes were collected together and the total eluent volume was measured. Absorbance was measured at 450 nm using the acetone hexane mixture (9:91 v/v) as the blank.

### 3.6.5.5.2 Extraction of $\beta$ -carotene

Ten grams of the fresh sample was homogenized in an electrical blender with an equal volume of acetone. The homogenate was then transferred to a 100ml beaker soaked in 30ml of acetone and hexane mixture (3:7 v/v) and kept overnight in a dark place for extraction. For the dehydrated material, 2g of the sample was rehydrated with 100ml distilled water, drained for five minutes and then kept for extraction using the same method as used for the fresh material.

The extract was filtered through glass wool and the volume of the extract was measured. If the volume was much more than that needed for loading on the column then the extract was concentrated by evaporating off the excess hexane. The volume of the remaining solutions was readjusted to 5ml with 9:91 (v/v) acetone hexane mixture and loaded on the column.

### 3.6.5.5.3 Preparation of standard curve for $\beta$ -carotene

Ten milligrams of  $\beta$ -carotene standard (Himedia Laboratories. Pvt. Ltd., Bombay) was dissolved in 1.0 ml chloroform and the volume made up to 50ml with hexane. An amount of 0.5ml, 1ml, 1.5ml, 2.0ml, and 2.5ml of the solution was loaded on the column and the intensity of the yellow color of the  $\beta$ -carotene was measured at 450nm. The  $\beta$ -carotene content of the sample was calculated using the formula.

$$\beta\text{-carotene } (\mu\text{g} / 100\text{g}) = \frac{\text{SR} \times \text{C} \times \text{VE} \times \text{V}}{\text{SR}_1 \times \text{VE}_1 \times \text{S}} \times 100$$

Where, SR = Sample Reading (Abs).

SR<sub>1</sub> = Standard Reading (Abs).

C = Concentration ( $\mu\text{g}$ ) of the standard.

VE = Total Volume (ml) of elute.

VE<sub>1</sub> = Aliquot (ml) loaded on column.

V = Volume (ml) after extraction and

S = weight (g) of sample.

The conversions for arriving at an estimate of  $\beta$ -carotene in  $\mu\text{g} / 10 \text{ g}$  of dry matter were carried out as follows:

$$\beta\text{-carotene } (\mu\text{g}/ 100\text{g of dry matter}) = \frac{\text{Y} \times 100}{\text{X}}$$

Where, X = Dry matter of sample = 100 - % moisture.

Y = Estimate of  $\beta$ -carotene in  $\mu\text{g} / 100 \text{ g}$  fresh material.

### 3.7 STATISTICAL ANALYSIS

The results obtained were analyzed by using suitable statistical methods.

- Frequency and percentage were calculated to interpret the results of survey.
- One factor Completely Randomized Design was used to interpret the results of time taken for drying of GLVs, mean acceptability scores of VAPs of *rajagira* and analyzed nutrient composition of the value added products.
- Two factor Completely Randomized Design was applied to moisture and dry matter content of GLVs, retention of chlorophyll content and rehydration ratio of dehydrated *rajagira*.

## 4. EXPERIMENTAL RESULTS

The study on 'Fabrication of GLV based designer foods for iron security of adolescent girls' was carried out during 2007 - 08 at the Department of Food science and Nutrition, College of Rural Home Science, University of Agricultural Sciences, Dharwad and the results pertaining to the investigation are presented in this chapter.

### 4.1 COLLECTION OF PRIMARY DATA

Results of information on consumption pattern, recipes prepared, utilization, seasonal availability, health and nutrition related knowledge and taboos attached to the consumption of GLVs, obtained by personal interview of 1000 school going adolescent girls are presented in this section.

#### 4.1.1 Demographic profile of the adolescent girls

The demographic profile of the selected adolescent girls is shown in Table 1. Majority of the adolescent girls selected for the study belonged to 14-15 years of age (55.6%) followed by 12-13 years (37.8%). Very low percent of the subjects were older than 15 years (6.6%). Nearly 71 per cent of the girls belonging to nuclear family set up were residing in the family having 4-6 members. The percentage of adolescent girls belonging to joint family were 26.5 whereas, only 2.2 per cent of girls were residing in extended family. Five per cent each of the subjects were residing in the families with 1-3 and more than nine members while, 18.7 per cent of the girls belonged to the families with seven to nine members.

Majority of the girls (61.8%) were belonging to the families having income of less than Rs.5000 (61.8%) followed by Rs.5000 to 10,000 (24.9%). Nearly 11.8 per cent of the girls belonged to the family having monthly income of Rs.10,000-30,000 and only 15 subjects (1.5%) belonged to the families having income of more than Rs.30,000 per month.

Higher percent of the parents of study subjects (36% fathers & 42.2% mothers) were educated up to secondary school. While 135 (13.5%) of the fathers and 170 (17%) of the mothers were not educated, 177 (17.7%) of the fathers and 101 (10.1%) of the mothers had education up to degree level. Very few of the parents 117 (11.7%) and 36 (3.6%) had professional degree.

Nearly equal numbers of fathers of adolescent girls were engaged in professional jobs (185) and labor work (184). One hundred and sixty four and 163 of the fathers respectively were engaged in government and private jobs. Majority of the mothers (78.2) were unemployed while, 3.7 per cent of fathers were not engaged in any kind of gainful employment.

#### 4.1.2 Consumption pattern of GLVs among adolescent girls

The GLVs known and consumed by the adolescent girls is given in Fig. 2. Among the 1000 adolescent girls surveyed more than 50 per cent of them reported the familiarity with (Appendix-II) fenugreek (874), spinach (653) *rajagira* (646), shepu (600), *kiraksali* (563), coriander (582) and curry leaves (519) of which, lesser percentage of them consumed these vegetables namely fenugreek (769), spinach (613), *rajagira* (575), shepu (563), *kiraksali* (534) and coriander (541). Less than 10 per cent of the study subjects were aware of GLVs like *haravi* (6.0%), safflower leaves (3.8 %), *hunchik* (3.3 %) and cabbage (3.3%). While 120 and 129 of the study subjects were familiar with bengal gram leaves and drumstick leaves, only 66 and 99 of them consumed these two leafy vegetables.

Underutilized leafy vegetable like *goli soppu*, pea leaves, *chakota*, *honagone*, *vandelaga*, *chekkurmani* were known and consumed by less than one per cent of the study subjects.

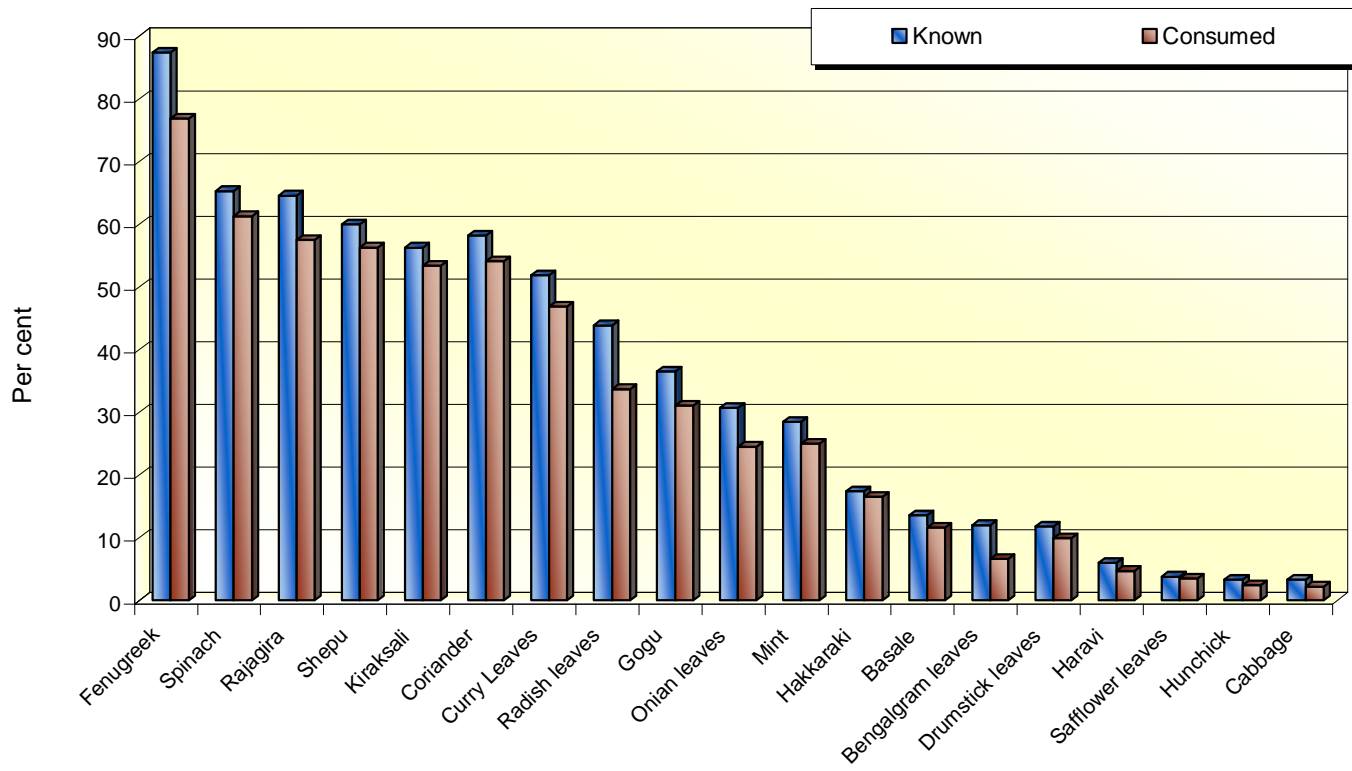
Reasons quoted by adolescent girls for not consuming or not including the GLVs in their diet are depicted in Fig.3. Higher number of subjects were not consuming GLVs because the taste was not liked (240) followed by aroma (126). Less than 10 per cent of the girls (100) did not consume GLVs as the colour (78, 7.8%), flavour (36, 3.6%) and appearance (24, 2.4%) was not liked.

Table 1. Demographic profile of adolescent girls

(N = 1000)

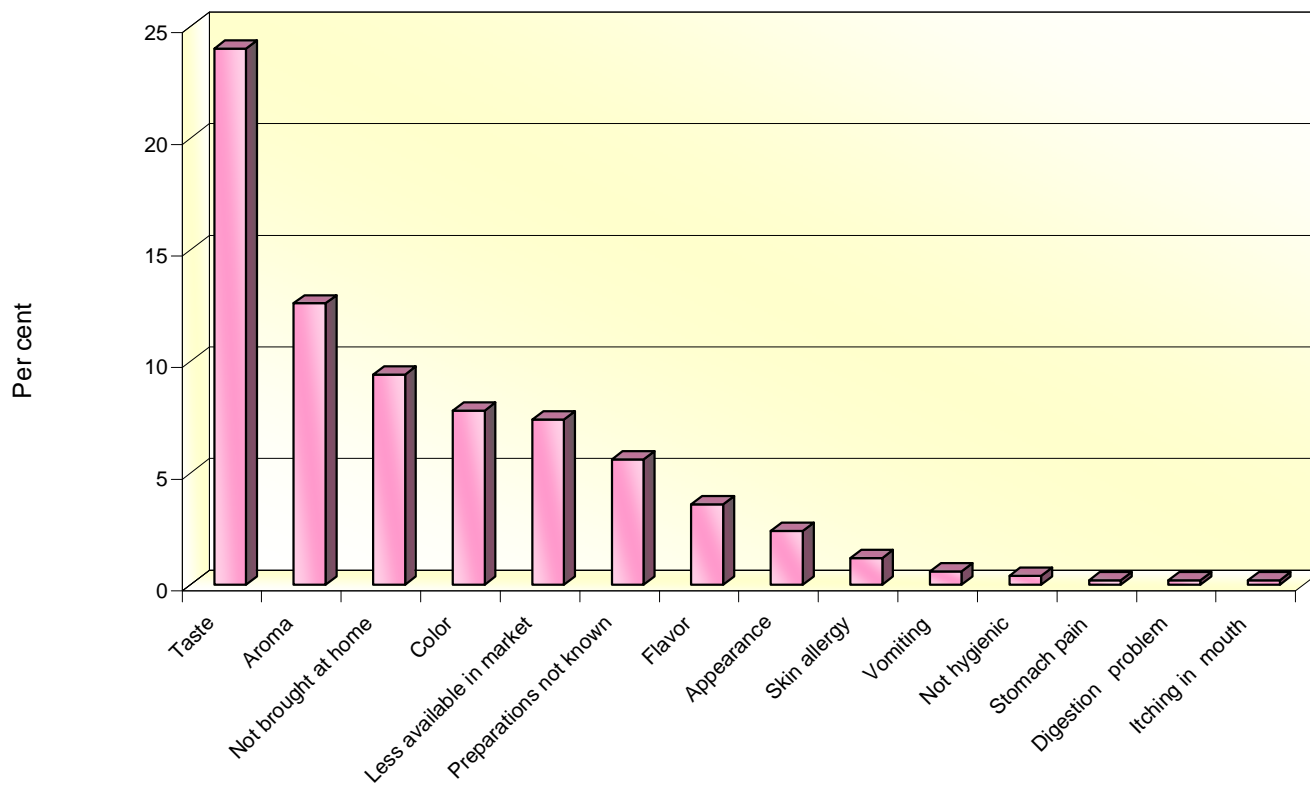
Sl. No.	Demographic characteristics	Categories	No.	Percentage		
1	Age (yrs)	12-13	378	37.8		
		14-15	556	55.6		
		>15	66	6.6		
2	Type of family	Nuclear	709	70.9		
		Joint	269	26.9		
		Extended	22	2.2		
3	Family size	1-3	49	4.9		
		4-6	713	71.3		
		7-9	187	18.7		
		> 9	51	5.1		
4	Family income (Rs. Per month)	<5000	618	61.8		
		5000-10,000	249	24.9		
		10,000-30,000	118	11.8		
		>30,000	15	1.5		
5	Parents' education level	Categories	Father		Mother	
			No.	%	No.	%
		Illiterate	135	13.5	170	17.0
		Primary	91	9.1	141	14.1
		Secondary	360	36.0	422	42.2
		Pre University	120	12.0	130	13.0
		Degree	177	17.7	101	10.1
		PG / Professional Degree	117	11.7	36	3.6
6	Parents' occupation	Agriculture	65	6.5	2	0.2
		Government employee	164	16.4	55	5.5
		Professionals	185	18.5	12	1.2
		Business	149	14.9	15	1.5
		Petty business	45	4.5	13	1.3
		Private job	163	16.3	28	2.8
		Laborer	184	18.4	91	9.1
		Unemployed*	37	3.7	782	78.2

\*Deceased parents: Father - 7; Mother - 2



**Fig. 2. Familiarity and consumption pattern of GLVs among adolescent girls**

Fig. 2. Familiarity and consumption pattern of GLVs among adolescent girls



**Fig. 3. Reasons quoted by adolescent girls for not consuming GLVs**

Fig. 3. Reasons quoted by adolescent girls for not consuming GLVs

It was surprising to note that few of the subjects experienced 'skin allergy' (1.2%), 'vomiting' (0.6%), 'stomach pain' (0.2%), 'digestion problem' (0.2%) and 'itching in mouth' (0.2%). Nearly nine per cent of the girls (94) did not consume GLVs as it was not brought at home or not available in the market (74) or did not know the preparations (56). It was astonishing that four girls reasoned non-consumption of GLVs as unhygienic, and hence were not consuming the same.

Knowledge of the adolescent girls regarding the recipes prepared using GLVs is indicated in Table 2. Adolescent girls reported that higher number of recipes were prepared using spinach (13) followed by fenugreek (11). Around five to seven recipes were reported to be prepared with shepu, *rajagira*, coriander and mint. Similarly, radish leaves, *gogu*, *basale*, curry leaves, *hunchik*, *hakkaraki* and onion leaves were reported to be used for preparation of less than five recipes. The GLVs such as *kiraksali* (27.2%), bengal gram leaves (14.8%), drumstick leaves (3.9%) and *haravi* (1.5%) were used only for preparation of *bhaji*.

All the GLVs were reported to be used in the preparation of *bhaji* except curry leaves, mint and coriander leaves. More than 60 per cent of the respondents reported that spinach (66.2) and fenugreek (61.0) were used for the preparation of *bhaji* while, less than one per cent (0.7 and 0.2) of them responded for the preparation of *chutney*. Only spinach was reported to be used for the preparation of soup (6.3%), *poori* (5.8) and *chakli* (1.1%) whereas, shepu was noted to be used for the preparation of *vada* (109). Fifty four and 12 girls reported that only shepu and fenugreek were used in *dosa* preparation.

Spinach, fenugreek and shepu were reported to be used in the cereal based recipes like *chapathi* (8.7, 33.9 and 9.6, respectively), *paratha* (14.4, 20.1 and 3.5%, respectively) and rice (4.4, 4.7 and 2.9%, respectively). Similarly, *thalipattu* was reported to be prepared with spinach (15.4%), fenugreek (16.7), coriander (2.8%) and radish leaves (1.2%). Higher per cent of the subjects reported the use of radish leaves as salad (32.8) and coriander leaves as *chutney* (40.4). Under utilized GLVs such as *hunchik*, *hakkaraki* and onion leaves were used in the preparation of *bhaji*, *sambar* and salad.

The knowledge of adolescent girls regarding utilization of GLVs is given in Table 3. It was reported by the adolescent girls that about 24 types of leafy vegetables were used as major ingredient in the preparations and 15 as secondary ingredient. Fenugreek was reported to be used as major ingredient (76.2%) and secondary ingredient (53.5%) by 762 and 535 respondents respectively. Similarly spinach was reported to be used as a major and secondary ingredient by 64.0 and 38.0 per cent of the respondents respectively, while shepu was used by 43.4 and 32.7 per cent of the respondents respectively.

The GLVs used only as a major ingredient included *kiraksali* (33.5%), *basale* (11.9%), *haravi* (2.2%), *honnagone* (0.5%) and *chakota*, *chekkurmani*, *goli*, *colocasia*, *vandelaga* and pea leaves (0.2%). While 204 girls reported that curry leaves was used as a seasoning ingredient, 580 and 25 girls reported that coriander leaves and mint were used as garnishing ingredients.

Perusal of Fig. 4 indicates that coriander leaves was reported to be consumed in raw form by 68 per cent of the subjects followed by fenugreek (62%) and radish leaves (52.52%). Two hundred and eight and 111 of the respondents reported the consumption of onion leaves and curry leaves in the raw form respectively. Less than 10 per cent of the respondents reported the consumption of *hakkaraki* (9.4%), spinach (9.1%), *rajagira* (5.6%), *gogu* (3.9%) and mint (2.5%) in raw form.

The seasonal availability of GLV as perceived by the subjects is presented in Table 4. The adolescent girls reported that all the GLVs were available throughout the year. However, fenugreek (52.8%), *rajagira* (41.2%) and *kiraksali* (31.9%) were reported to be available in all seasons by majority of the subjects. Shepu (38.41), radish leaves (36.7%) and spinach (30.5%) were reported to be available in winter by 384, 367 and 305 adolescent girls, respectively. Similarly, the GLVs like spinach (23.6%), curry leaves (14.5%) and shepu (13.2%) were reported to be available in monsoon by 236, 145 and 132 subjects respectively. None of the girls reported that *basale*, shepu and *haravi* were available in the market during summer. The GLVs reported by least per cent of the subjects as available in all seasons in the local market were shepu (4.7) and *haravi* (4.6). Least number of the subjects reported the availability of *hakkaraki* in summer (0.7%); winter (3.6%), and in monsoon (1.9%).

Table 2. Recipes identified by the girls to be prepared using GLVs

(N = 1000)

Sl. No.	GLVs	Recipes
1	Spinach	<i>Bhaji</i> (66.2), <i>Curry</i> (21.0), <i>Palak paneer</i> (15.8), <i>Thalipattu</i> (15.4), <i>Paratha</i> (14.4), <i>Pakoda</i> (12.6), <i>Chapathi</i> (8.7), <i>Soup</i> (6.3), <i>Poori</i> (5.8), <i>Rice</i> (4.4), <i>Sambar</i> (3.5), <i>Chakali</i> (1.1), <i>Chutney</i> (0.7)
2	Fenugreek	<i>Bhaji</i> (61.0), <i>Chapathi</i> (33.9), <i>Salad</i> (21.9), <i>Paratha</i> (20.1), <i>Thalipattu</i> (16.7), <i>Curry</i> (5.4), <i>Sambar</i> (5.4), <i>Dosa</i> (5.4), <i>Rice</i> (4.7) <i>Pakoda</i> (3.5), <i>Chutney</i> (0.2)
3	Shepu	<i>Bhaji</i> (47.3), <i>Vada</i> (10.9), <i>Chapathi</i> (9.6), <i>Paratha</i> (3.5), <i>Curry</i> (3.5) <i>Rice</i> (2.9), <i>Dosa</i> (1.2)
4	<i>Rajagira</i>	<i>Bhaji</i> (29.2), <i>Curry</i> (10.6), <i>Paratha</i> (2.5), <i>Sambar</i> (1.6), <i>Chutney</i> (1.5), <i>Rice</i> (1.0).
5	Coriander	<i>Chutney</i> (40.4), <i>Salad</i> (24.4), <i>Sambar</i> (5.8), <i>Rice</i> (5.1), <i>Thalipattu</i> (2.8)
6	Mint	<i>Chutney</i> (27.3), <i>Sambar</i> (2.5), <i>Paratha</i> (2.5), <i>Rice</i> (1.7), <i>Curry</i> (0.2)
7	Radish leaves	<i>Salad</i> (32.8), <i>Bhaji</i> (10.6), <i>Thalipattu</i> (1.2), <i>Paratha</i> (2.7)
8	<i>Gogu</i>	<i>Chutney</i> (21.6), <i>Bhaji</i> (21.4), <i>Curry</i> (2.7)
9	<i>Basale</i>	<i>Curry</i> (4.4), <i>Bhaji</i> (2.7), <i>Sambar</i> (0.8)
10	Curry leaves	<i>Salad</i> (21.2), <i>Chutney</i> (13.3), <i>Sambar</i> (7.5)
11	<i>Hunchik</i>	<i>Sambar</i> (1.5), <i>Bhaji</i> (0.4)
12	<i>Hakkaraki</i>	<i>Bhaji</i> (5.9), <i>Salad</i> (4.5)
13	Onion leaves	<i>Bhaji</i> (4.7), <i>Salad</i> (4.2)

Note: *Kiraksali* (27.2), Bengalgram leaves (14.8), Drumstick leaves (3.9) and *Haravi* (1.5) were used in the form of *bhaji* only.

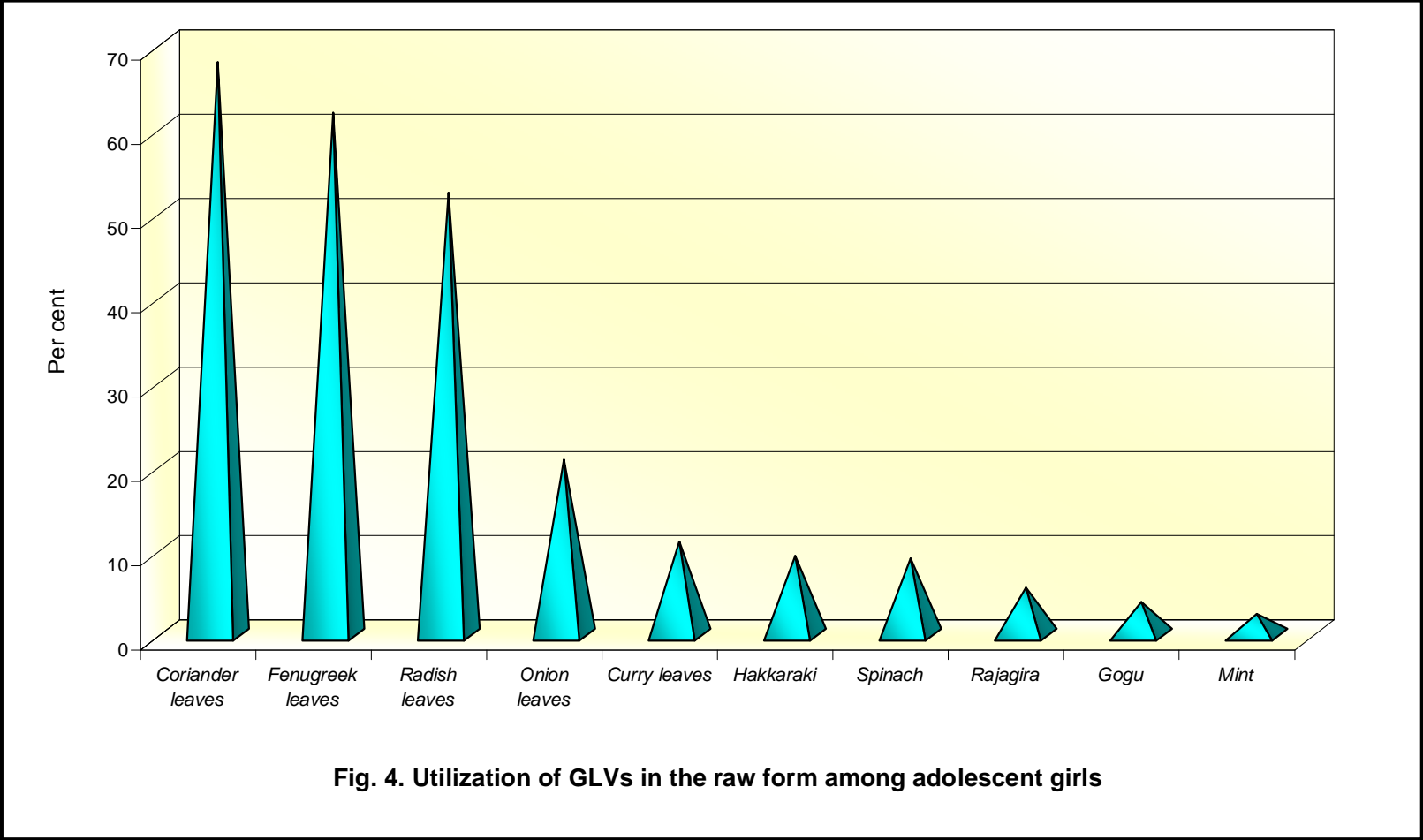
Figures in parenthesis indicate per cent adolescent girls.

Table 3. Knowledge of adolescent girls regarding utilization of GLVs

(N = 1000)

Sl. No.	Utilized as	GLVs
1	Major ingredient	Fenugreek leaves (76.2), Spinach (64.0), Shepu (43.4), <i>Gogu</i> (36.3), <i>Kiraksali</i> (33.5), <i>Rajagira</i> (19.2), <i>Basale</i> (11.9), Radish leaves (10.6), <i>Hakkaraki</i> (5.9), Onion leaves (4.7), Bengalgram leaves (4.1), Safflower leaves (3.2), <i>Haravi</i> (2.2), <i>Honnagone</i> (0.5), <i>Hunchik</i> (0.4) and <i>Chakota</i> , <i>Chekkurmani</i> , <i>Goli</i> , Mustard leaves, Drumstick leaves, Pea leaves, Colocasia, <i>Vandelaga</i> were at 0.2 per cent
2	Secondary ingredient	Fenugreek leaves (53.5), Spinach (38.0), Shepu (32.7), Mint (26.3), <i>Gogu</i> (23.1), Coriander leaves (22.6), Radish leaves (22.6), Curry leaves (10.8), Drumstick leaves (9.6), <i>Hakkaraki</i> (4.5), Onion leaves (4.2), Bengalgram leaves (3.1), Safflower leaves (2.8), <i>Rajagira</i> (2.5), <i>Hunchick</i> (1.5)
3	Seasoning	Curry leaves (20.4)
4	Garnishing	Coriander leaves (58.0), Mint (2.5)

Figures in parenthesis indicate per cent adolescent girls.



**Fig. 4. Utilization of GLVs in the raw form among adolescent girls**

Fig. 4. Utilization of GLVs in the raw form among adolescent girls

Table 4. Availability of GLVs in local market as perceived by adolescent girls

(N = 1000)

Sl. No.	GLVs	Seasonal availability							
		All seasons		Summer		Winter		Monsoon	
		No.	%	No.	%	No.	%	No.	%
1	Fenugreek	528	52.8	17	1.7	48	4.8	35	3.5
2	<i>Rajagira</i>	412	41.2	64	6.4	76	7.6	48	4.8
3	<i>Kiraksali</i>	319	31.9	60	6.0	27	2.7	32	3.2
4	Coriander leaves	187	18.7	32	3.2	28	2.8	23	2.3
5	Mint	184	18.4	20	2.0	53	5.3	28	2.8
6	Curry leaves	150	15.0	92	9.2	132	13.2	145	14.5
7	Onion leaves	123	12.3	61	6.1	84	8.4	37	3.7
8	<i>Hakkaraki</i>	112	11.2	07	0.7	36	3.6	19	1.9
9	<i>Basale</i>	108	10.8	-	-	15	1.5	12	1.2
10	Radish leaves	95	9.5	35	3.5	367	36.7	66	6.6
11	Spinach	80	8.0	32	3.2	305	30.5	236	23.6
12	Shepu	47	4.7	-	-	384	38.4	132	13.2
13	<i>Haravi</i>	46	4.6	-	-	18	1.8	21	2.1

Note: The GLVs such as *Chakota*, *Chekkurmani*, Drumstick leaves, *Goli*, Mustard leaves, Pea leaves, Colocasia leaves, *Hunchik* and *Vandelaga* were not available in market.

However, many leafy vegetables such as *chakota*, *chekkuramani*, drumstick leaves, *goli soppu*, *kadagi*, mustard leaves, pea leaves, *colocasia* leaves, *hunchik* and *vandelaga* were not available in the market and were procured from nearby agricultural lands for consumption purpose.

Fig. 5 depicts the practices followed by the subjects for preliminary processing of GLVs. Around 56 per cent of the subjects (55.8) reported that cutting of GLVs was done after washing while 44 per cent of the girls (44.2) reported that washing was done after cutting. Three fourth of the respondents (75.5) reported that GLVs were washed in plain water while one fourth (24.0) of them reported that salt water was used for cleaning the vegetables. Surprisingly, five girls (0.5%) reported the use of potassium permanganate for cleaning GLVs at home.

Higher percent of adolescent girls reported that GLVs were sorted with tender stalk (40.0%) followed by only leaves (37.6%) and leaves with complete stalk (26.4%).

Health and nutrition related knowledge of GLVs reported by the subjects is shown in Fig. 6. The adolescent girls reported the use of GLVs for the health benefits such as 'Good for eyes' (33.5%) 'Helps in blood formation (32.7%) 'Good for diabetes' (15.1%) and 'Prevents constipation (10.0%)'. Majority of the adolescent girls reported that GLVs contain fat soluble vitamins (320), water soluble vitamin (295) and proteins (104). Iron, fiber and energy were also reported to be the nutrients present in GLVs by 96, 97 and 88 subjects respectively. It was surprising and worrying to note that nearly one third of the respondents (343) did not know the health and nutritional benefits of GLVs.

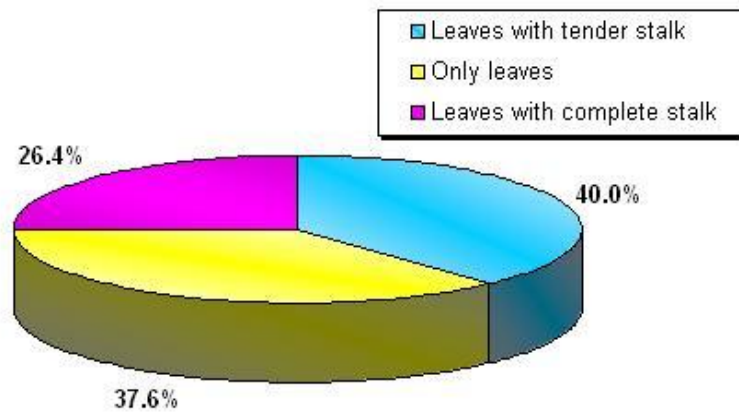
The source of knowledge regarding health and nutritional aspects of GLVs, among 657 responded subjects is depicted in Fig. 7. Text books were referred to as the source of health and nutrition knowledge of GLVs among 207 subjects followed by general books (135), teachers (134) and relatives (118). Around 11 per cent of the subjects reported that parents, neighbours, internet or newspaper as source of knowledge, while (6.3%) and (6.0%) subjects reported that television and magazines were the sources of the health and nutrition knowledge with regard to GLVs. Least number of subjects (53 and 47) reported that radio and friends respectively were the source of having the knowledge.

Table 5a and 5b. denotes the knowledge of the adolescent girls regarding recommendation of GLVs in different disorders or health conditions. Among the GLVs, adolescent girls opined that fenugreek was recommended for 15 different types of disorders followed by spinach (9), *kiraksali* (8) and radish leaves (8).

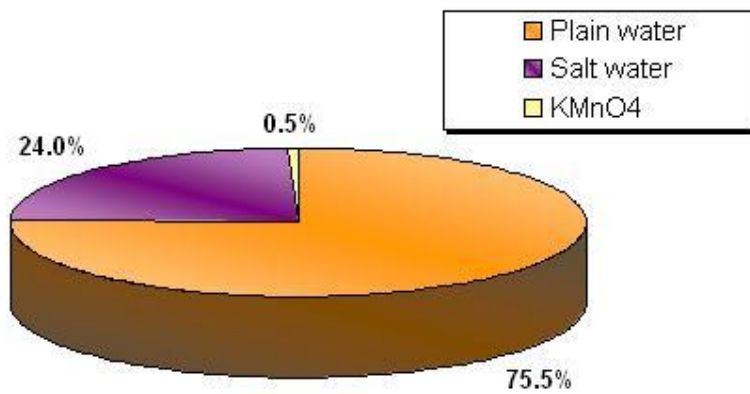
The study subjects felt that ten GLVs were recommended for anemia and eye disorders, (Table 5b) where as five were recommended for diabetes and four for diarrhea, piles and kidney disorders. Fenugreek was the only leafy vegetable recommended for eradication of round worm infection and respiratory disorders; spinach for skin disorders, joint pain and vomiting; radish leaves for jaundice and body pain; mint for gastritis, bad breath, asthma and acidity; curry leaves for mental stress and shepu was the only vegetable recommended for bone growth as perceived by the subjects. The adolescent girls felt that *colocasia* leaves (0.6) and *basale* (0.3) were recommended only for kidney disorders. Only 0.3 per cent of the girls felt that *kiraksali* can be used for diabetes, eye disorders, anemia hypertension, cholera, diarrhoea, and vomiting and body heat control.

Two hundred and twenty eight subjects (%) felt that radish leaves could be recommended for piles, whereas, less than one per cent of the girls (10) recommended it for prediction of diarrhoea (0.8), jaundice (0.3), body pain (0.3) and body heat control (0.3). For the disorders like cough and cold (9.5%), mint was used as opined by the girls. Less than one per cent of the subjects had the opinion that *rajagira* leaves was recommended for the disorders like cold (0.4), eye disorders (0.4), anaemia (0.3) and diarrhoea (0.3), cholera (0.2), and diabetes (0.2). Similarly, shepu was recommended for cold (0.3), fever (0.3), piles, eye disorders (0.3) and bone growth (0.3), while 1.5 per cent of the girls opined that shepu was recommended for control of anaemia. Around one per cent of the subjects recommended drumstick leaves for eye disorders (1.0), cough and cold (0.8), while less than one per cent of the subjects felt that it contributes for overcoming weakness (0.5) and anaemia (0.3).

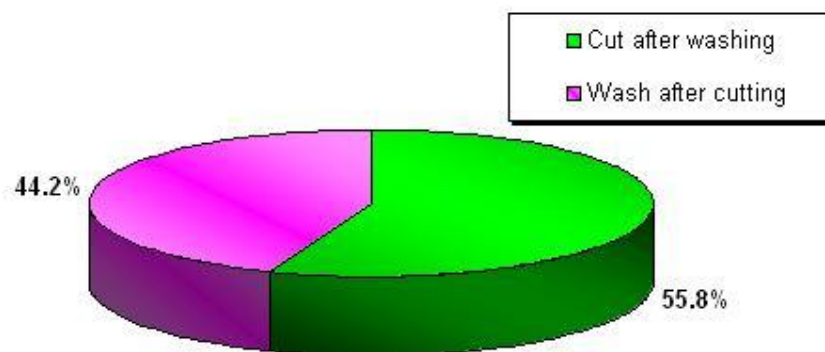
Underutilized leafy vegetable *hakkaraki* was opined to be recommended against diabetes (1.8%), anaemia (0.5%), tuberculosis (0.5%) and weakness (0.3). Amaranth was



Sorting of GLVs

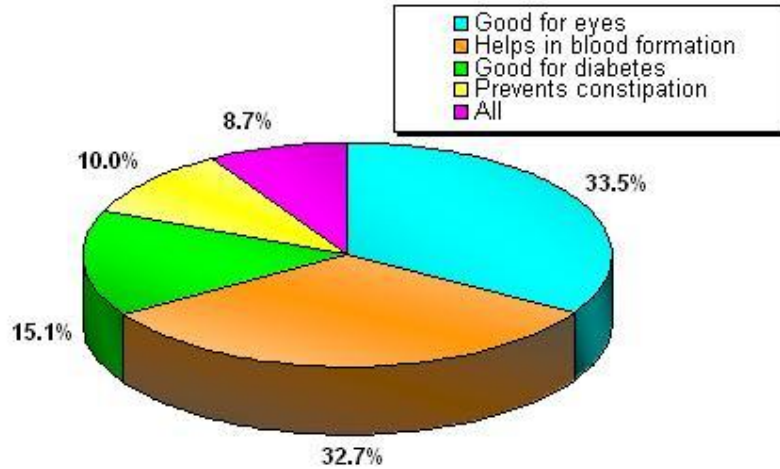


Cleaning of GLVs

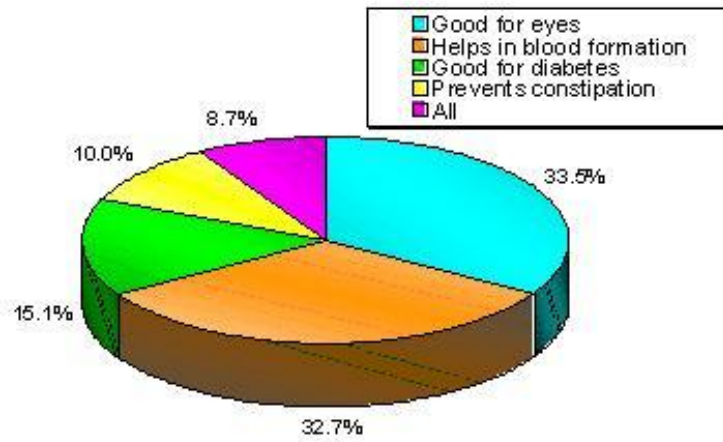


Cutting GLVs

Fig. 5. Practices followed by the subjects for preliminary processing of GLVs

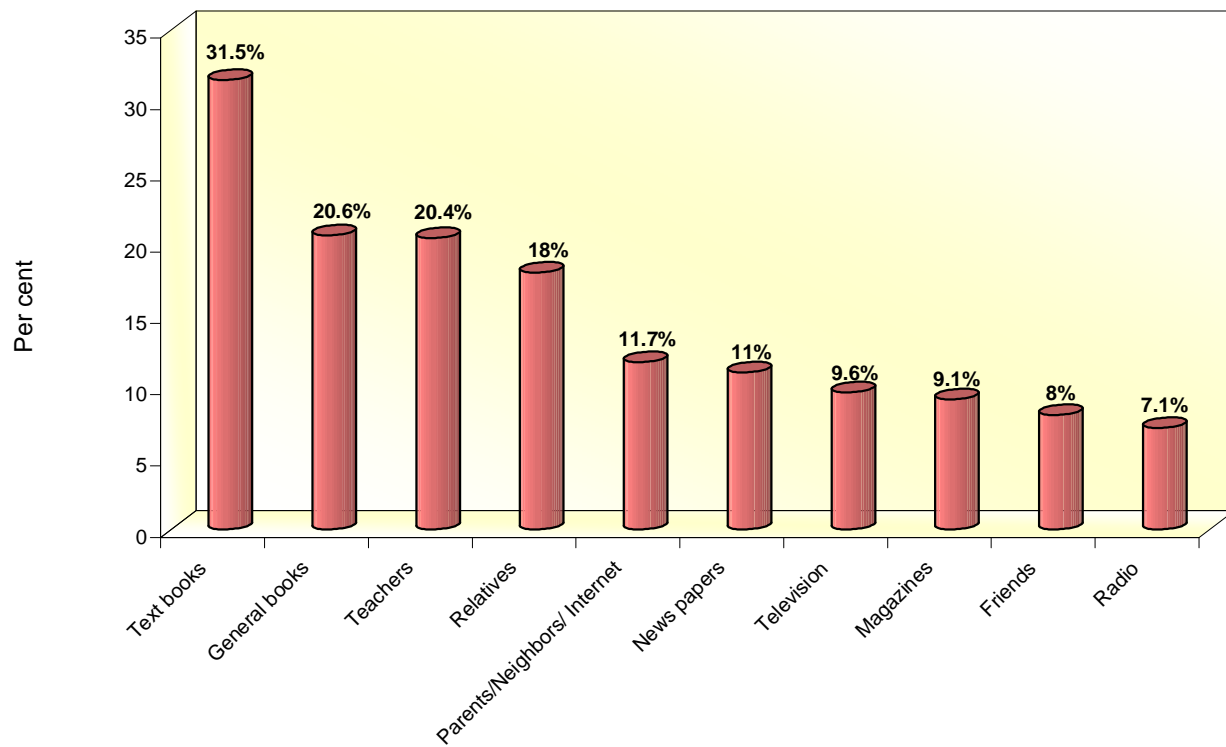


Health benefits of GLVs



Health benefits of GLVs

Fig. 6. Perceived health and nutrition knowledge about GLVs



**Fig. 7. Sources of health and nutrition knowledge among adolescent girls**

Fig. 7. Sources of health and nutrition knowledge among adolescent girls

Table 5a. Perceived knowledge of the adolescent girls regarding recommendation of GLVs in disorders

(N = 1000)

Sl. No.	GLVs	Disorders
1	Fenugreek leaves	Diabetes (7.5), Eye disorders (5.8), Anaemia (1.8), Hair fall (1.3), Stomachache (1.0), Heart disease (1.0), Respiratory disorders (0.8), Round worm infection (0.5), Diarrhea (0.5), Pregnancy (0.3), Hypertension (0.3), Obesity (0.3), Constipation (0.3), Piles (0.3), Weakness (0.3)
2	Spinach	Anaemia (2.3), Obesity (1.5), Skin disorder (0.8), Eye disorders (0.5), Diabetes (0.4), Joint pain (0.4), Kidney disorders (0.3), Heart disease (0.3), Piles (0.3)
3	Radish leaves	Piles (22.8), Constipation (5.3), Eye disorders (1.5), Anaemia (1.0), Diarrhea (0.8), Jaundice (0.3), Body pain (0.3), Body heat control (0.3)
4	<i>Kiraksali</i>	Diabetes, Eye disorders, Anaemia, Hypertension, Cholera, Diarrhea, Vomiting and Body heat control (each 0.3 %)
5	Mint	Cough and cold (9.5), Stomachache (2.3), Gastritis (1.3), Bad breath (0.3), Asthma (0.3), Acidity (0.3), Eye disorders (0.3)
6	Curry leaves	Hair fall (7.5), Eye disorders (2.3), Anaemia (1.0), Obesity (0.81), Mental stress (0.3), Stomachache (0.3)
7	<i>Rajagira</i>	Cold (0.4), Eye disorders (0.4), Anaemia (0.3), Diarrhoea (0.3), Cholera (0.2), Diabetes (0.2)
8	Shepu	Anaemia (1.5), Cold (0.3), Fever (0.3), Piles (0.3), Eye disorders (0.3), Bone growth (0.3)
9	Drumstick leaves	Eye disorders (1.0), Cough and could (0.8), Weakness (0.5), Anaemia (0.3)
10	<i>Hakkaraki</i>	Diabetes (1.8), Anaemia (0.5), Tuberculosis (0.5), Weakness (0.3)
11	<i>Amaranth</i>	Fever (0.5), Kidney disorders (0.3)
12	<i>Basale</i>	Anaemia (0.5), Eye disorders (0.3), Kidney disorder (0.3)
13	Colocasia	Kidney disorders (0.6)

Table 5b. Perceived knowledge of the adolescent girls regarding utilization of GLV in disorders

(N = 1000)

Sl. No.	Disorders	Green leafy vegetables
1	Anaemia	spinach (2.3), fenugreek (1.8), shepu (1.5), radish leaves (1.0), curry leaves (1.0), <i>hakkaraki</i> (0.5), <i>kiraksali</i> (0.3), <i>rajagira</i> (0.3), drumstick leaves (0.3), <i>basale</i> (0.5),
2	Eye disorders	fenugreek (5.8), radish leaves (1.5), spinach (0.5), <i>kiraksali</i> (0.3), mint (0.3), curry leaves (2.3), <i>rajagira</i> (0.4), shepu (0.3), drumstick leaves (1.0), <i>basale</i> (0.3)
3	Diabetes	fenugreek (7.5), <i>hakkaraki</i> (1.8), spinach (0.4), <i>kiraksali</i> (0.3), <i>rajagira</i> (0.3),
4	Diarrhoea	radish leaves (0.8), fenugreek leaves (0.5), <i>kiraksali</i> (0.3), <i>rajagira</i> (0.3)
5	Piles	radish leaves (22.8), fenugreek (0.3), spinach (0.3), shepu (0.3)
6	Kidney disorders	spinach (0.3), amaranth (0.3), colocasia leaves (0.3), gogu (0.3)
7	Obesity	spinach (1.5), curry leaves (0.8), fenugreek (0.3),
8	Weakness	drumstick leaves (0.5), fenugreek leaves (0.3), <i>hakkaraki</i> (0.3)
9	Cough and cold	mint (9.5), drumstick leaves (0.8), shepu (0.3),
10	Stomachache	mint (2.3), fenugreek (1.0), curry leaves (0.3)
11	Hair fall	curry leaves (7.5), fenugreek (1.3)
12	Heart disease	fenugreek (1.0), spinach (0.3)
13	Hypertension	fenugreek (0.3), <i>kiraksali</i> (0.3)
14	Constipation	radish leaves (5.3), fenugreek (0.3),
15	Cholera	<i>kiraksali</i> (0.3), <i>rajagira</i> (0.2)
16	Body heat control	<i>kiraksali</i> (0.3), radish leaves (0.3)
17	Fever	amaranth (0.5), shepu (0.3)
18	Respiratory disorders, Round worm infection and Pregnancy	fenugreek leaves (0.8), (0.5) and (0.3) respectively
19	Skin disorder and Joint pain	spinach (0.8) and (0.4) respectively
20	Vomiting	<i>Kiraksali</i> (0.3)
21	Jaundice and Body pain	radish leaves (0.3)
22	Asthma, bad breath, acidity and Gastritis	mint (0.3) and (1.3) respectively
23	Mental stress	curry leaves (0.3)
24	Bone growth	shepu (0.3)

recommended against fever (0.5%) and kidney disorders (0.3%). Whereas, *basale* was thought to be recommended for anaemia (0.5%) and eye disorders (0.3%).

## 4.2 DEHYDRATION PROTOCOL

The green leafy vegetables which were commonly known and consumed by the adolescent girls of Dharwad city and were commonly available in all the seasons in local market were selected for further study.

### 4.2.1 Per cent edible portion per bundle

Edible part obtained per bundle (as sold in local market) is presented in Table 6. Weight of each bundle of *rajagira* was higher (164.76 g) than spinach (139.10 g) and shepu (119.31 g) whereas, least amount per bundle was obtained in case of fenugreek (98.78 g) followed by *kiraksali* (102.91 g). Among the selected GLVs, the weight of edible part per bundle was found to be highest in spinach (59.24%) followed by *kiraksali* (53.94%) and *rajagira* (51.65%) while shepu (40.53%) recorded lowest edible part followed by fenugreek (45.56%). When the inedible part is considered, shepu (59.46) had higher percentage followed by fenugreek (54.44), while spinach had lowest per cent inedible part (40.76) followed by *kiraksali* (46.05) and *rajagira* (48.34).

### 4.2.2 Time taken for drying

Irrespective of the treatments, shade drying of all the selected GLV took more time to attain the crispness followed by hot air oven drying. It was obvious that the vegetables could be dried in very less time of few minutes in microwave oven drying (Table 7). Among the leafy vegetables, *shepu* could be dried in shorter time of 1.10 hrs (sun), 33.82 (shade), 1.48 hrs (hot air oven) and 2.24 min (microwave oven) irrespective of the treatments.

With regard to pretreatments *rajagira* leaves without any treatment (control) and sulphited before drying took significantly higher time of 1.3 hours for drying under sun (38-42°C) compared to blanching with or without sulphitation. But when dried in shade, blanching with sulphitation took significantly less time (30.15 hrs) compared to other pretreatments while, the leaves without any treatment could be dried in significantly higher time of 64.15 hours followed by sulphitation (62.08 hrs) at the temperature of 24.5 to 25°C. Under controlled conditions of hot air oven (60°C), *rajagira* leaves could be dried at significantly less time of 2.05 and 2.08 hours when the sample was blanched with or without sulphitation. Sulphitation alone without blanching took significantly higher time of 2.45 hours compared to other treatments. Sample without any treatment took significantly higher time of 3.14 hours.

On the contrary, blanched and sulphited *rajagira* leaves took significantly higher time of 3.21 minutes to dry to crispness in microwave oven compared to the sample without any treatment (3.04 min). Whereas, all other treatments were on par with regard to time taken for drying in microwave oven at 100 per cent power.

Untreated and sulphited *Kiraksali* could be dried in significantly higher time of 1.20 and 1.25 hours for drying under sun (38-42°C) compared to blanching with sulphitation (1.09 hours). But when dried in shade, blanching with or without sulphitation were on par with significantly lower time of 42.10 hours compared to other treatments. The leaves without any treatment could be dried in significantly higher time of 62.04 hours followed by sulphitation (54.04 hrs) at the laboratory temperature of 24.5 to 25°C. Under controlled conditions of hot air oven (60°C), *kiraksali* without any treatment and sulphited took equal time of 3.05 hours while, the leaves could be dried at significantly less time of 2.31 and 2.06 hours when the sample was blanched with or without sulphitation.

In line with other GLVs, *kiraksali* without any treatment took significantly less time of 2.44 minutes to dry to crispness in microwave oven compared to the sample without any treatment. Whereas, all other treatments were on par with regard to time taken for drying in microwave oven at 100 per cent power.

Fenugreek leaves without any treatment could be dried at 1.30 hours (sun drying), 74.04 hours (shade), 3.04 hours (hot air oven) which was significantly higher than other methods of drying. Blanching with or without sulphitation was on par with regard to the time taken for drying.

Table 6. Edible portion of GLVs (per bundle)

Sl. No.	GLVs	Wt. of bundle (g)	Wt. of edible part		Wt. of inedible part	
			(g)	%	(g)	%
1	<i>Rajagira</i>	164.76	85.10	51.65	79.66	48.34
2	<i>Kiraksali</i>	102.91	55.51	53.94	47.40	46.05
3	Fenugreek	98.78	45.00	45.56	53.78	54.44
4	Spinach	139.10	82.40	59.24	56.70	40.76
5	Shepu	119.31	48.36	40.53	70.95	59.46

Note: 1. Inedible part includes mud and other foreign matter

2. GLVs obtained from local market
3. Average of 15 bundles

Microwave oven drying was faster compared to other methods of drying, with ranging from 3.02 minutes (untreated) to 3.42 (blanched)

Spinach without any treatment took significantly more time for drying under sun and shade compared to all other treatments. The, time taken by all other treatments were on par for drying under shade at temperature 24.5 to 25°C. While, the blanched leaves with sulphitation could be sun dried in significantly less time of 1.05 hrs at temperature 38-42°C, under controlled conditions of hot air oven (60°C), spinach could be dried at significantly less time of 1.54 and 1.51 hrs when the sample was blanched with or without sulphitation. Only sulphitation without blanching took significantly higher time of 2.45 hours under shade. Spinach without any treatment took significantly less time of 2.31 minutes to dry to crispness in microwave oven at 100 per cent power whereas, all other treatments were on par.

#### 4.2.3 Yield of dehydrated GLVs and Iron content

A perusal of Table 8 indicated that the yield of dehydrated GLV ranged from 4.41 (sun dried spinach) to 12.75 per cent (shade dried *kiraksali*). The yield obtained by shade drying was significantly higher in *rajagira*, *kiraksali*, fenugreek, spinach and shepu (12.01, 12.75, 10.35, 5.15 and 10.19 % respectively), whereas, least yield (%) was observed by drying under the sun in *rajagira* (9.27), *kiraksali* (11.00), fenugreek (9.64), spinach (4.41) and shepu (9.98). Microwave drying resulted in significantly higher yield of 9.97 per cent than hot air oven drying (9.30 %) in *rajagira* leaves. All other GLVs (*kiraksali*, fenugreek, spinach and shepu) were on par with regard to yield obtained by microwave, hot air oven and sun drying.

Irrespective of the methods of drying GLVs without any treatment were found to result in higher yield of 10.56 per cent in *rajagira*, 12.20 per cent in *kiraksali*, 10.19 per cent in fenugreek, 4.85 per cent in spinach and 11.79 per cent in shepu whereas, blanching with sulphitation resulted in lower yields of 9.72, 10.78, 9.50, 4.38 and 8.31g/100g for *rajagira*, *kiraksali*, fenugreek, spinach and shepu respectively. It was observed that there was no significant difference in per cent yield obtained in all dehydrated GLVs with sulphitation and without giving any treatment and also among blanched GLVs with or without sulphitation.

Iron content of GLVs on dry weight basis is shown in Fig.8. *Rajagira* was having highest iron content of (222.57 mg/100 g) among the selected GLVs followed by *kiraksali* (54.59 mg/100 g). Fenugreek contained the lowest amount of 26.19 mg of iron per 100 g.

Table 7. Time required to dry GLVs#

Sl. No.	GLVs	Treatments	Methods of drying			
			SN (hrs)	SH (hrs)	HT (hrs)	MI (min)
1	<i>Rajagira</i>	C	1.30	64.15	3.14	3.04
		B	1.14	31.06	2.08	3.18
		S	1.26	62.08	2.45	3.08
		B +S	1.08	30.15	2.05	3.21
		Mean	1.20	46.86	2.43	3.13
		SEM $\pm$	0.03	0.06	0.03	0.04
		CD	0.12**	0.25**	0.12**	0.16*
2	<i>Kiraksali</i>	C	1.20	62.04	3.05	2.44
		B	1.10	42.10	2.06	3.37
		S	1.25	54.04	3.05	3.29
		B +S	1.09	42.10	2.31	3.36
		Mean	1.16	50.07	2.62	3.12
		SEM $\pm$	0.03	0.02	0.02	0.02
		CD	0.11**	0.08**	0.10**	0.11**
3	Fenugreek	C	1.30	74.04	3.04	3.02
		B	1.10	54.04	2.07	3.42
		S	1.20	62.04	2.38	3.09
		B +S	1.08	53.54	2.07	3.38
		Mean	1.17	60.92	2.39	3.23
		SEM $\pm$	0.02	0.14	0.03	0.03
		CD	0.10**	0.61**	0.12**	0.13**
4	Spinach	C	2.03	114.04	3.02	2.31
		B	1.30	93.05	1.51	3.05
		S	1.33	93.09	2.45	3.02
		B +S	1.05	93.04	1.54	3.05
		Mean	1.43	98.31	2.13	2.86
		SEM $\pm$	0.02	0.03	0.03	0.02
		CD	0.10**	0.11**	0.12**	0.07**
5	Shepu	C	1.15	41.04	2.04	2.48
		B	1.10	28.06	1.23	2.04
		S	1.11	38.10	1.34	2.38
		B +S	1.02	28.07	1.31	2.04
		Mean	1.10	33.82	1.48	2.24
		SEM $\pm$	0.03	0.03	0.02	0.03
		CD	0.11**	0.15**	0.10**	0.12**

Each value represents average of 4 determinations

SN- Sun drying, SH- Shade drying, HT- Hot air oven drying, MI- microwave drying

C- No treatment, B- Blanching, S- Sulphitation, B + S- Blanching and Sulphitation

# - Temperature used: SN - 38 to 42°C; SH - 24.5 to 25°C; HT - 60°C; MI - 100 % power

\*\* Significant at 1% level

\* Significant at 5% level

Table 8. Yield of Dehydrated GLVs (g/100g)

Sl. No.	GLVs	Treatments	Methods of drying				Mean	
			SN	SH	HT	MI		
1	<i>Rajagira</i>	C	9.87	12.38	9.89	10.11	10.56	
		B	8.74	11.73	8.78	9.91	9.79	
		S	9.80	12.26	9.81	10.03	10.48	
		B +S	8.68	11.66	8.71	9.84	9.72	
		Mean	9.27	12.01	9.30	9.97	10.14	
				Method		Treatment		M x T
		SEM ±	0.04		0.04		0.07	
		CD	0.14**		0.14**		0.27**	
2	<i>Kiraksali</i>	C	11.79	13.46	11.75	11.80	12.20	
		B	10.29	12.68	10.33	10.51	10.95	
		S	11.58	12.84	11.69	11.77	11.97	
		B +S	10.32	12.00	10.40	10.41	10.78	
		Mean	11.00	12.75	11.04	11.12	11.48	
				Method		Treatment		M x T
		SEM ±	0.06		0.06		0.12	
		CD	0.23**		0.23**		0.47**	
3	Fenugreek	C	9.90	10.97	9.93	9.96	10.19	
		B	9.42	9.76	9.44	9.48	9.53	
		S	9.87	10.92	9.89	9.91	10.15	
		B +S	9.38	9.74	9.41	9.46	9.50	
		Mean	9.64	10.35	9.67	9.70	9.84	
				Method		Treatment		M x T
		SEM ±	0.04		0.04		0.08	
		CD	0.15**		0.15**		0.30**	
4	Spinach	C	4.54	5.63	4.60	4.63	4.85	
		B	4.31	4.73	4.33	4.35	4.43	
		S	4.51	5.57	4.53	4.58	4.80	
		B +S	4.27	4.66	4.28	4.31	4.38	
		Mean	4.41	5.15	4.44	4.47	4.61	
				Method		Treatment		M x T
		SEM ±	0.04		0.04		0.09	
		CD	0.17**		0.17**		0.34**	
5	Shepu	C	11.71	11.98	11.73	11.75	11.79	
		B	8.29	8.44	8.31	8.33	8.34	
		S	11.67	11.92	11.7	11.72	11.75	
		B +S	8.26	8.42	8.27	8.30	8.31	
		Mean	9.98	10.19	10.00	10.03	10.05	
				Method		Treatment		M x T
		SEM ±	0.04		0.04		0.17	
		CD	0.09**		0.09**		0.33**	

Each value represents average of 4 determinations

SN- Sun drying, SH- Shade drying, HT- Hot air oven drying, MI- microwave drying

C- No treatment, B- Blanching, S- Sulphitation, B + S- Blanching and Sulphitation

\*\*Significant at 1 % level

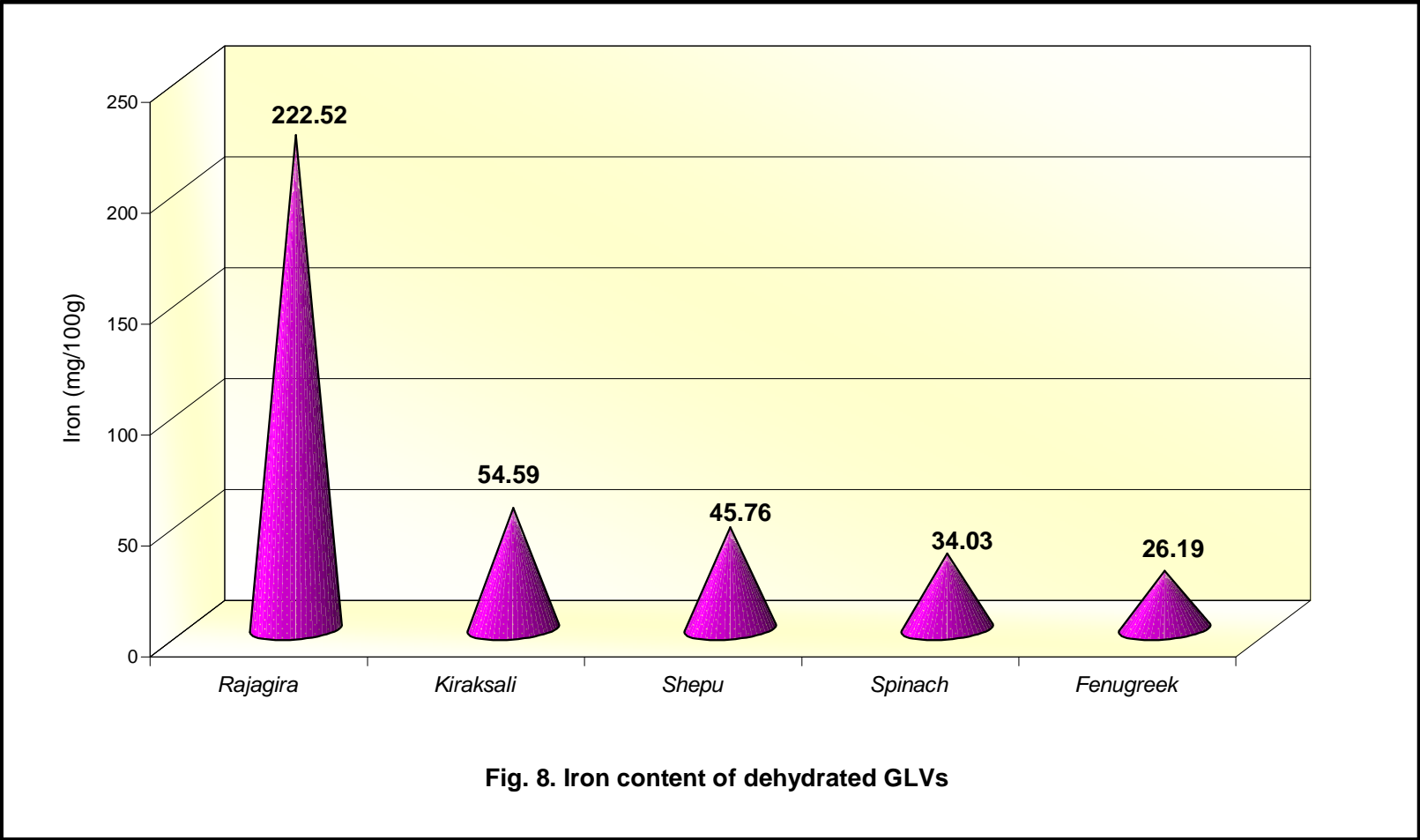


Fig. 8. Iron content of dehydrated GLVs

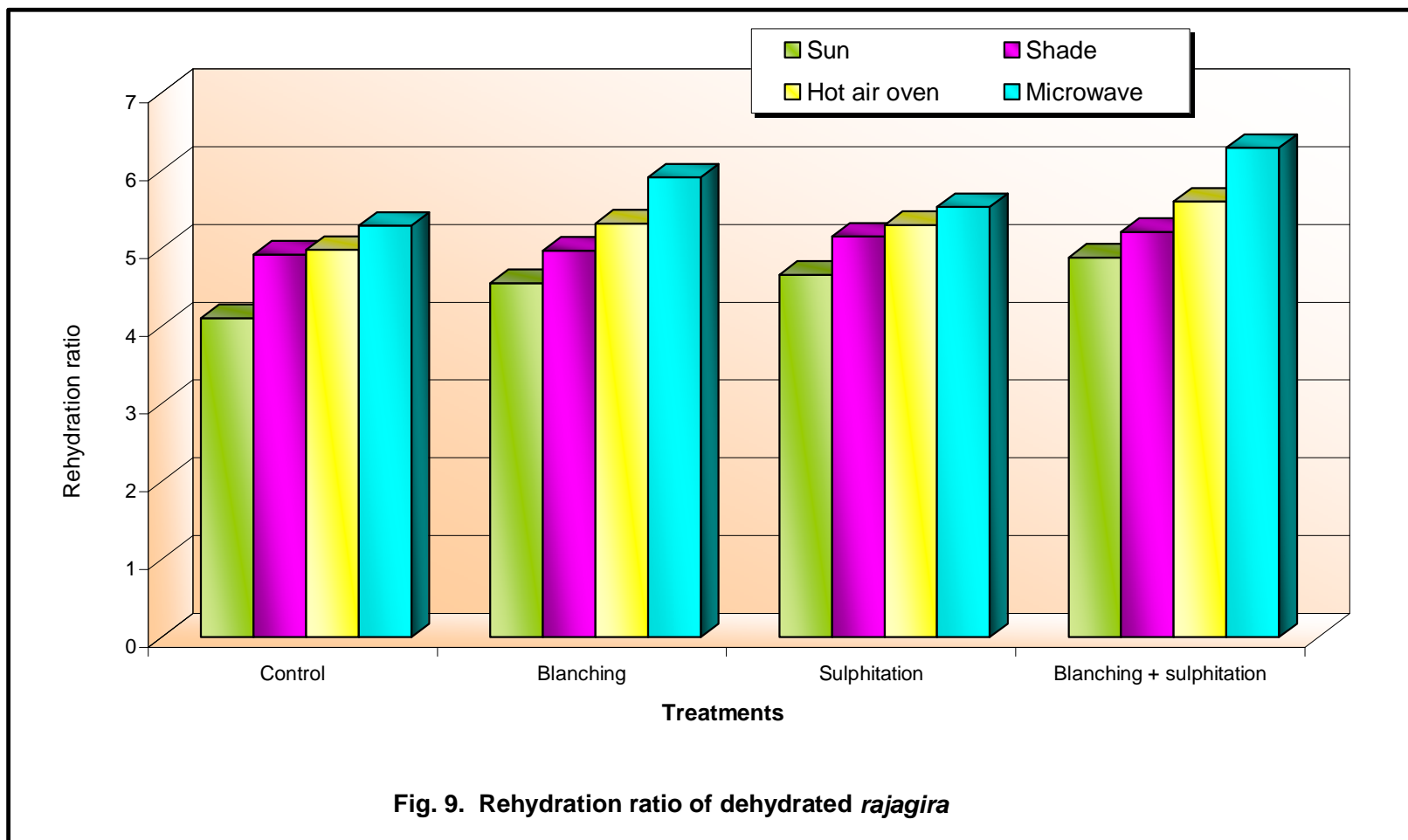
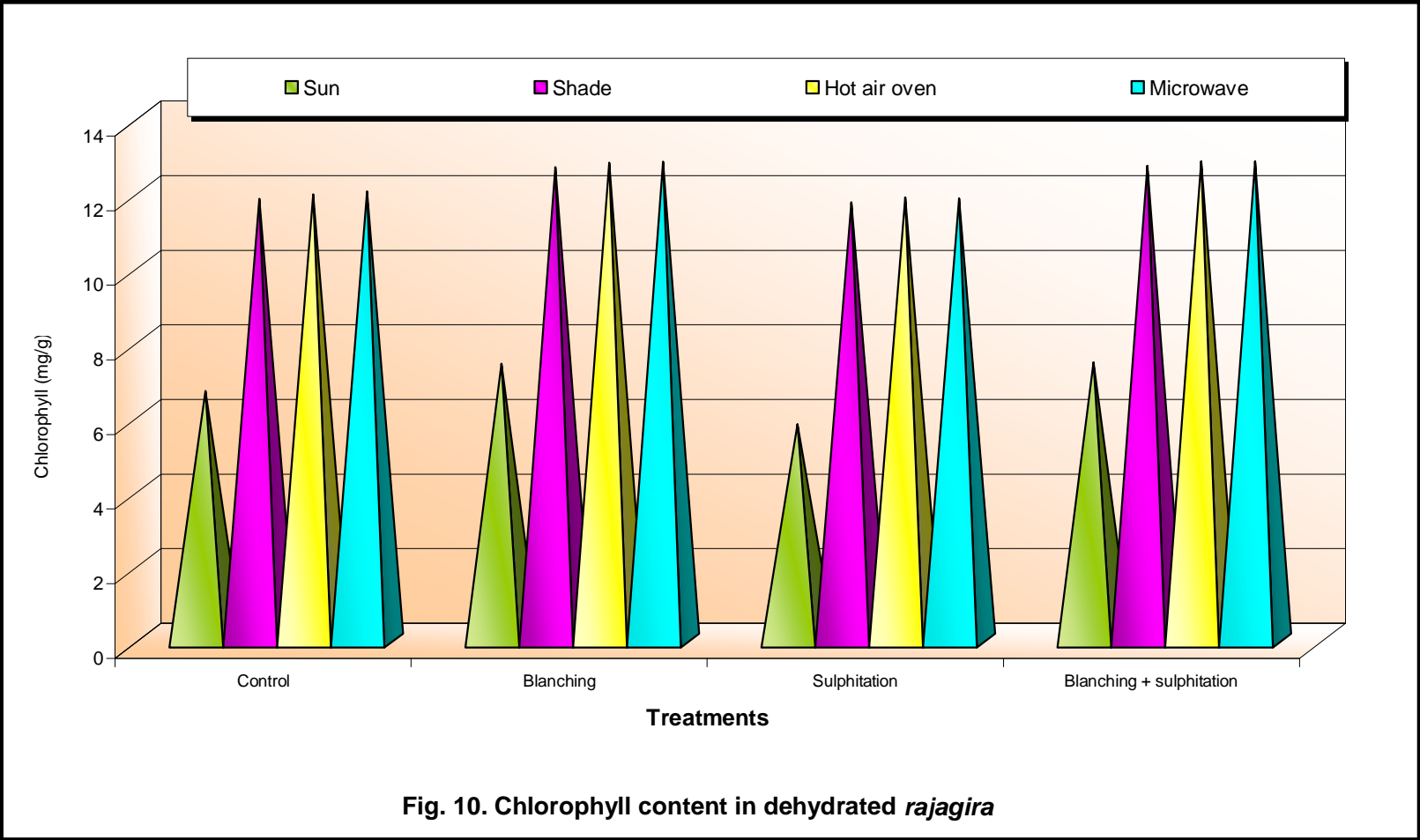


Fig. 9. Rehydration ratio of dehydrated rajagira



**Fig. 10. Chlorophyll content in dehydrated *rajagira***

Fig. 10 Chlorophyll content in dehydrated rajagira

#### 4.2.4 Quality of dehydrated *rajagira* leaves

Quality of dehydrated *rajagira* leaves having highest iron content was assessed in terms of rehydration ratio and chlorophyll content.

Rehydration ratio of dehydrated *rajagira* leaves is depicted in Fig. 9. The rehydration ratio ranged from 4.82 (no treatment) to 5.50 (blanching with sulphitation), irrespective of the method of drying. Similarly, irrespective of the predrying treatments, microwave drying resulted in higher rehydration ratio followed by hot air oven drying. Samples dried under sun exhibited lowest rehydration ratio of 4.55 followed by shade dried samples. Highest rehydration ratio (6.29) was observed in *rajagira* dried in microwave after pretreatments with blanching and sulphitation whereas, lowest ratio was observed in sun dried *rajagira* without any treatment (4.10). Rehydration ratio of the samples differed significantly among the methods of drying and pretreatments.

The chlorophyll content in dehydrated *rajagira* is depicted in the Fig.10. Microwave drying of *rajagira* 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. Among the pretreatments sulphitation without blanching resulted in minimum chlorophyll (10.32 mg/g) but blanching before sulphitation resulted in maximum retention of chlorophyll (11.48 mg/g). Shade, hot air oven and microwave oven drying of the leafy vegetables without any treatment were on par with sulphitation before drying with regard to chlorophyll content. Similarly, blanching with or without sulphitation were on par with each other in all the methods of drying. However, the interaction between method of drying and pretreatments was not significant as indicated by two way Anova.

### 4.3 DEVELOPMENT OF VALUE ADDED PRODUCTS OF *RAJAGIRA*

Each region has its own traditional food habits. *Rajagira* leaves having highest iron content, were selected for incorporation in different traditional recipes in the fresh, dehydrated and rehydrated form, as the traditional products are culturally accepted, consumed by all in sufficient quantity and are sustainable. The most commonly and routinely consumed products like *chapathi*, *poori*, *thalipattu*, and *bhaji* were selected for value addition. Green leafy vegetable *bhajis* are generally prepared with varieties of pulses and green gram, either whole or split and red gram dhal being the most common pulses used in routine diets of people in this region, the three pulses were included in the study.

#### 4.3.1 Characteristics of value added products

Fifty grams of fresh *rajagira* (FR) was incorporated in traditional products and the same quantity was sauted (SA) before incorporation. Five grams of dehydrated *rajagira*, the amount sufficient to provide required quantity of iron (around 10 mg) was providing equal quantity of iron incorporated in products (DE) and the same quantity was rehydrated (RE) before incorporation in different products. The details of the preparations are given in Appendix-V. The characteristics of the VAPs prepared by incorporating fresh (FR), sauted (SA), dehydrated (DE) and rehydrated (RE) *rajagira* is shown in Table 9.

Water required for different products was found to be higher in the *bhaji* with green gram (60.66 ml) followed by *bhaji* with red gram dhal (51.66 ml), irrespective of the form of *rajagira* used in the preparations. In preparation of *chapathi*, *poori* and *thalipattu* the water uptake was 30, 27 and 43 ml respectively. It is but natural that rehydrated *rajagira* incorporated products absorbed less water while dehydrated consumed higher proportion of water in all the products prepared.

Rollability of *chapathi*, *poori* and *thalipattu* was found to be very easy when rehydrated *rajagira* was incorporated whereas with dehydrated *rajagira* rollability was difficult. Sauted or fresh leafy vegetables incorporated products could be rolled easily. It was obvious that *thalipattu* did not puff with any form of leafy vegetable, whereas all the variations of *chapathi* and sauted *rajagira poori* were found to puff partially. Both dehydrated and rehydrated *rajagira poories* could puff completely.

Table 9. Characteristics of VAPs with *rajagira*

Sl. No.	Characteristics	<i>Chapathi</i>			<i>Poori</i>			<i>Thalipattu</i>				<i>Bhaji-I</i>			<i>Bhaji-II</i>			<i>Bhaji-III</i>		
		SA	DE	RE	SA	DE	RE	FR	SA	DE	RE	FR	DE	RE	FR	DE	RE	FR	DE	RE
1	Water uptake (ml)	30	40	20	25	45	11	45	41	54	33	30	95	15	35	100	20	50	100	32
2	Rollability	E	H	VE	E	H	VE	E	E	H	VE	-	-	-	-	-	-	-	-	-
3	Puffability	PP	PP	PP	PP	FP	FP	NP	NP	NP	NP	-	-	-	-	-	-	-	-	-
4	Cooking/baking time (min)	1.5	1.5	1.5	1.0	1.0	1.0	2.5	2.5	2.5	2.5	15	20	10	17	22	12	18	24	13
5	Product Weight in grams (No. /Katori)	97 (2)	96 (2)	97.6 (2)	100 (4)	93 (4)	94.4 (4)	169 (2)	168 (2)	155 (2)	160 (2)	92 (1k)	85 (1k)	93 (1k)	94 (1k)	87 (1k)	90 (1k)	95 (1k)	88 (1k)	93 (1k)

Each value represents average of 4 determinations

Note: 1. *Bhaji I, II* and *III* were based on green gram dhal, red gram dhal and whole green gram respectively.

2. Form and quantity of *rajagira*: FR – Fresh (50 g), SA- Sauted, DE- Dehydrated (5 g), RE - Rehydrated.

3. Rollability: D- Difficult, E - Easy and VE - Very easy.

4. Puffability: FP - Fully puffed, PP - Partially puffed and NP - Not puffed.

5. 10 ml of oil was used for all the products except *Poori*.

6. Figures in parenthesis indicate measures (No. / katorie) of serving

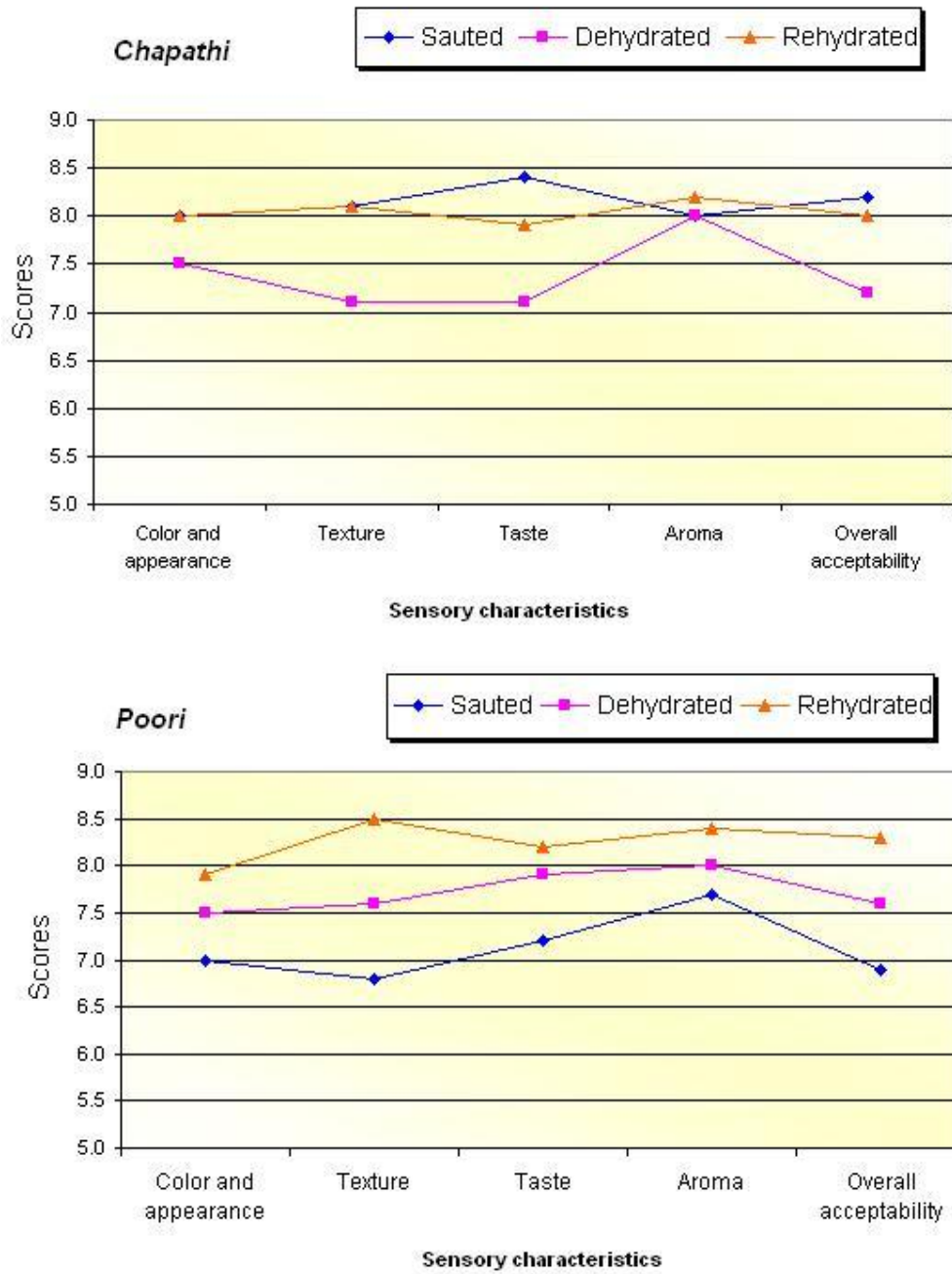


Fig. 11. Acceptability of chapathi and poori with rajagira

Though there was no difference in time taken for baking different forms of *rajagira* incorporated *chapathi*, *poori*, *thalipattu*; latter required more time (2.5 min) followed by *chapathi* (1.5). *Poori* could be fried in very less time of one minute. The mean time taken for cooking the *bhajis* with *dhals* of green gram, red gram and with whole green gram was 15.00, 17.00 and 18.33 minutes, respectively. With regard to the form of *rajagira*, dehydrated leaves took longer duration of 22 minutes followed by fresh (16.66 min) and rehydrated (12.00 min) *rajagira* in the preparation of *bhajis* with different pulses.

Only 10 g of oil was used in all the VAPs except *poori*, which absorbed 11.00, 9.00, 13.00 ml of oil per serving for sauted, rehydrated and dehydrated leaf incorporated *poories*, respectively.

#### 4.3.2 Acceptability of VAPs

The products developed using *rajagira* were characterized and evaluated for all sensory parameters using nine point hedonic scale by 10 trained panel of judges at laboratory level. Regularly consumed value added products were evaluated by 300 adolescent girls to indicate their acceptability as 'liked', 'disliked' or 'neutral'.

##### 4.3.2.1 Acceptability at laboratory level

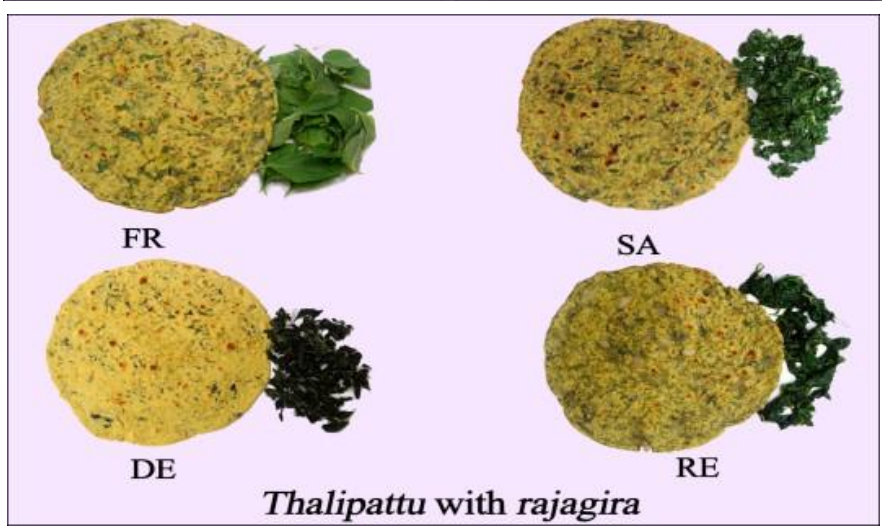
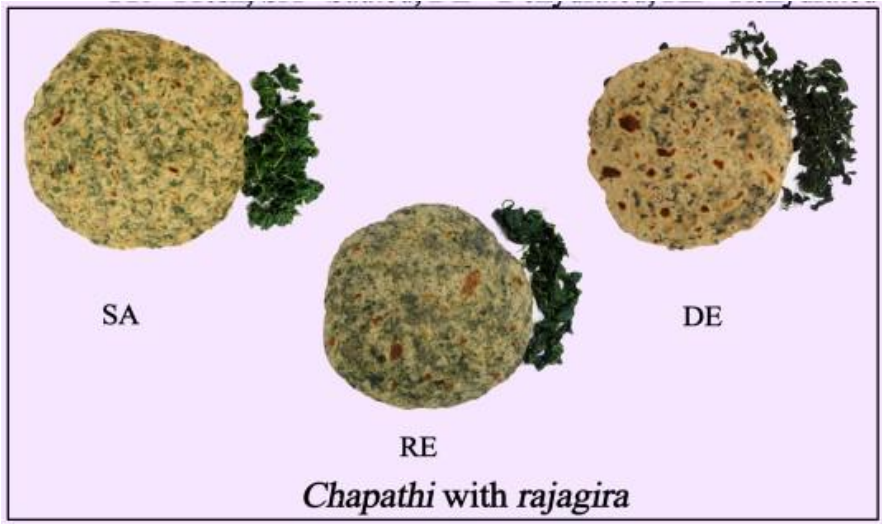
Acceptability of *rajagira chapathi* and *poori* is depicted in Fig. 11. The *chapathi* incorporated with sauted leafy vegetable exhibited highest scores for all the sensory parameters compared to dehydrated and rehydrated forms. However, the form of *rajagira* whether sauted, dehydrated or rehydrated did not significantly influence the scores for colour and appearance or aroma. Incorporation of dehydrated leafy vegetable in *chapathi* resulted in lower level of acceptability with regard to all the sensory parameters studied. Nevertheless, all the three forms of GLV incorporated *chapathies* were scored between good and excellent, with mean scores ranging between 7.7 (texture) to 8.1 (aroma).

The texture and overall acceptability of *poori* (Fig. 11) with sauted GLV was scored between moderately good and very good with scores of 6.8 and 6.9 respectively, whereas, all the other parameters were scored between very good and extremely good. While aroma of *poori* with dehydrated *rajagira* was scored as extremely good (8.0), the other parameters received the scores between very good and extremely good. However, rehydrated *rajagira* incorporated *poori* was highly accepted with scores between extremely good and excellent. Nevertheless, *poori* with rehydrated *rajagira* leaves received significantly higher scores compared to that with sauted leafy vegetable as indicated by 'F' test.

The acceptability scores for *thalipattu* and *bhaji-I* (green gram dhal based) with incorporation of *rajagira* in different forms is depicted in the Fig. 12. The *thalipattu* in which sauted leafy vegetable was incorporated received significantly highest scores (8.6) with respect to overall acceptability. However, the form of *rajagira* whether sauted, dehydrated or rehydrated did not significantly influence the scores for colour and appearance, taste and aroma. The texture of *thalipattu* with rehydrated *rajagira* was scored between extremely good and excellent with 8.6 scores. Whereas, all the other parameters were scored between very good and extremely good. Incorporation of dehydrated leafy vegetable in *thalipattu* resulted in lower level of acceptability with regard to all the sensory parameters studied. In spite of the numerical differences, all the three forms of GLV incorporated *thalipattu* were acceptable and scored between good and excellent, with mean scores ranging between 7.6 (colour and appearance and texture) to 8.6 (texture).

The highest scores were received by the *bhaji-I* with rehydrated *rajagira* irrespective of all sensory parameters. *Bhaji* with fresh *rajagira* was scored between very good and extremely good for the colour and appearance with scores of 7.6 and between extremely good and excellent for overall acceptability with score of 8.1. Whereas, the *bhaji* with rehydrated *rajagira* was scored between very good and extremely good for texture (7.7) and between extremely good and excellent for taste (8.2). With regard to aroma, *bhaji* with rehydrated and fresh *rajagira* received significantly higher scores (7.4 each) than *bhaji* with dehydrated *rajagira* (6.7). Though *bhaji* with dehydrated *rajagira* received lowest scores for all the sensory parameters studied, it was above the acceptable level of 6.00.

The mean acceptability scores for *bhaji-II* (red gram dhal based) and *bhaji-III* (whole green gram based) with incorporation of fresh, rehydrated and dehydrated *rajagira* is depicted



FR – Fresh SA – Sauted, DE – Dehydrated, RE – Rehydrated  
 Plate 1. Cereal based value added products with rajagira

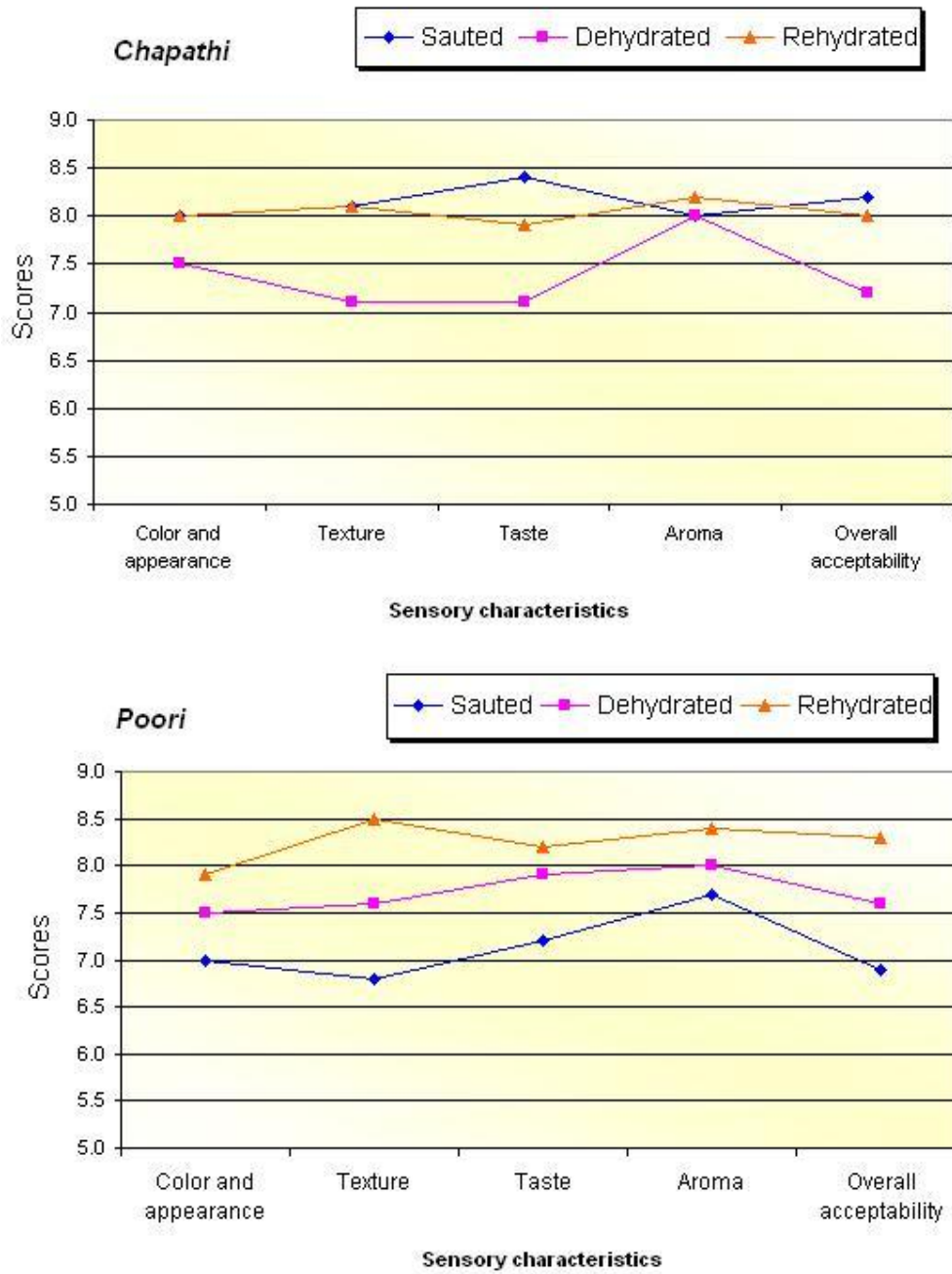


Fig. 12. Acceptability of thalipattu and bhaji – I with rajagira

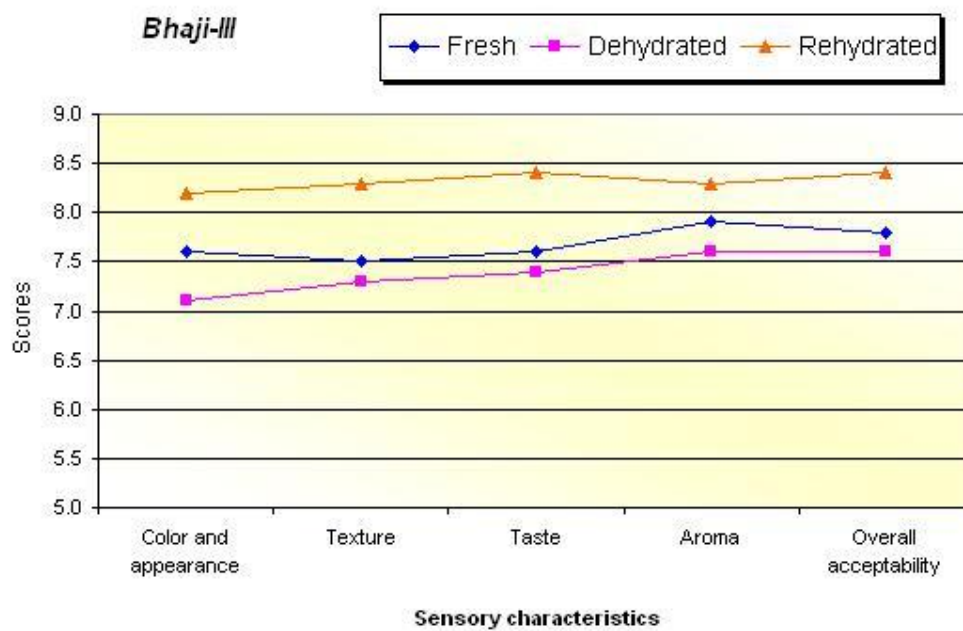
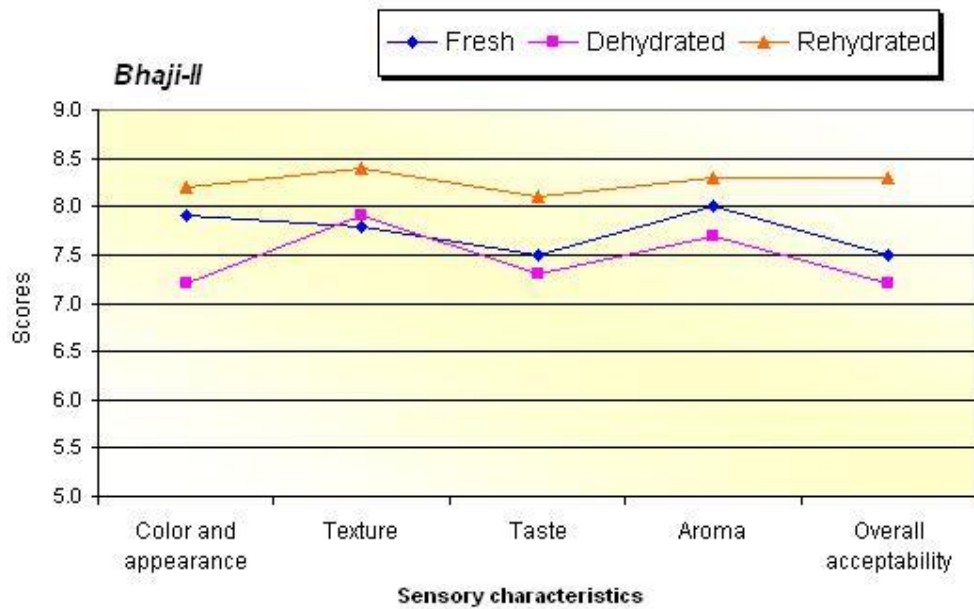


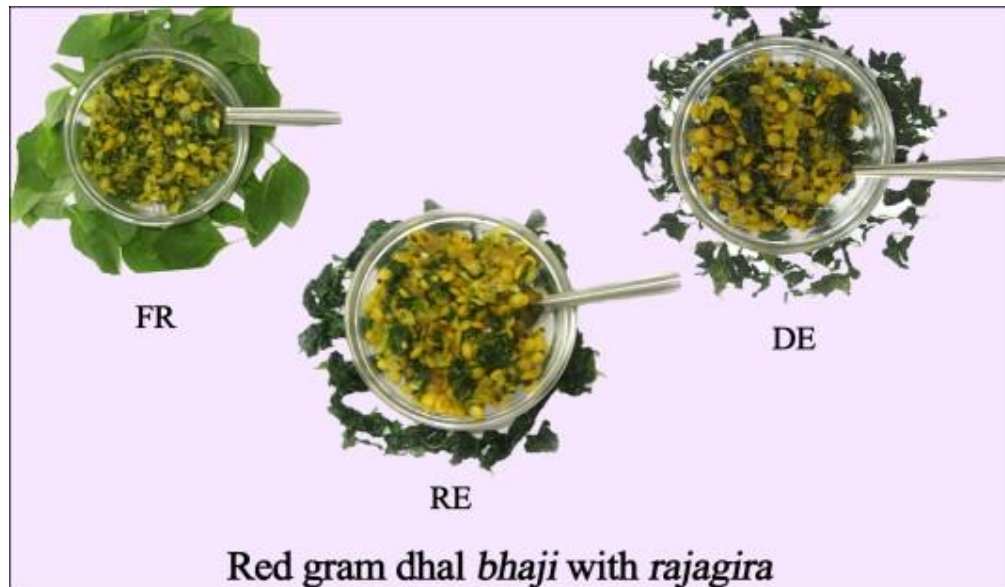
Fig. 13. Acceptability of bhaji – II with rajagira

Table 10. Ranks of the value added products based on sensory scores

Sl. No.	Products	Unsauteed	Sauteed	Dehydrated	Rehydrated
1	<i>Chapathi</i>	–	I (40.7)	III (36.9)	II (40.2)
2	<i>Poori</i>	–	III (35.6)	II (38.6)	I (41.3)
3	<i>Thalipattu</i>	III (38.7)	I (40.0)	III (38.7)	II (39.8)
4	<i>Bhaji-I</i>	II (38.1)	–	III (34.0)	I (38.4)
5	<i>Bhaji-II</i>	II (38.7)	–	III (37.3)	I (41.3)
6	<i>Bhaji-III</i>	II (38.4)	–	III (37.0)	I (41.6)

Figures in parenthesis indicate total scores.





FR – Fresh SA – Sauted, DE – Dehydrated, RE – Rehydrated

Plate 2. Pulse based value added products with rajagira

in the Fig. 13. *Bhaji-II* and *III* with rehydrated *rajagira* recorded highest scores for all the sensory parameters, ranging between extremely good (8) and excellent (9). However, the form of *rajagira* whether fresh, dehydrated or rehydrated did not significantly influence the scores for texture and aroma of *bhaji-II* though rehydrated form received higher scores. Incorporation of dehydrated leafy vegetable in *bhaji* resulted in lower level of acceptability with regard to all the sensory parameters studied, compared to fresh and rehydrated. However, all the three forms were scored above the acceptable level. *Bhaji-III* with fresh *rajagira* ranged from very good (7) to extremely good (8), *bhaji-III* with dehydrated *rajagira* received lowest scores ranging from 7.1 (colour and appearance) to 7.6 (aroma and overall acceptability) for all the sensory parameters.

Table 10 indicates the ranks of the value added products based on sensory scores. The *rajagira* incorporated in the rehydrated form in *poori* and *bhaji* with green gram dhal, red gram dhal and whole green gram were ranked I with highest scores of 41.3, 38.4, 41.3, and 41.6 respectively. *Chapathi* and *thalipattu* with sauted *rajagira* were ranked I with highest scores of 40.7 and 40.0 respectively. It was obvious that fresh vegetable when incorporated in

products like *thalipattu* and *bhaji* with different pulses were not accepted in line with rehydrated GLV and hence were ranked III and II. Dehydrated leafy vegetable when incorporated in different products were ranked third with lower sensory scores ranging from 34.0 to 38.7 except *poori* which was ranked second.

#### 4.3.2.2 Acceptability at consumer level

*Chapathi* and *rajagira bhaji* with green gram dhal were evaluated by 300 adolescent girls to indicate their acceptability (Fig. 14). Among 300 consumers majority of them liked *chapathi* (90.33%) and *bhaji* (84.33%). Around 8.34 and 12.67 per cent of the consumers neither liked nor disliked the products viz., *chapathi* and *bhaji* respectively. Very few consumers (1.33 and 3.00 %) did not like *chapathi* and *bhaji* with rehydrated *rajagira* respectively.

#### 4.3.4 The composition of blood forming nutrients in VAPs

The composition of blood forming nutrients (by analysis) of VAPs (incorporating with rehydrated *rajagira*) and its per cent adequacy (per serving) for adolescent girls is given in Table 11.

Moisture content of *rajagira bhaji* (with green gram dhal) was significantly higher (65.26 g) followed by *rajagira thalipattu* (31.98 g), *poori* (28.76 g) and *chapathi* (27.61 g). *Thalipattu* contained significantly higher amounts of protein (17.97 g), iron (14.90 g) and  $\beta$ -carotene (3462 $\mu$ g) per serving compared to other value added products viz., *chapathi*, *poori*, *bhaji*. Obviously, *thalipattu* could meet higher requirements of these blood forming nutrients (28, 53 and 144% respectively) than other VAPs. *Bhaji* with green gram provided significantly lower amounts of protein (8.44 g / serving), iron (10.59 mg / serving) and  $\beta$ -carotene (1937  $\mu$ g / serving) meeting 13, 38 and 81 per cent of the recommendations of adolescent girls. Value added *chapathi* and *poori* did not differ significantly with regard to the quantity of iron present in them. *Poori* recorded significantly lower amounts of protein (9.35 g) and  $\beta$ -carotene (2300  $\mu$ g) compared to *chapathi* (10.46 g and 2490  $\mu$ g respectively).

Figure 15 indicate blood forming nutrient composition of the VAPs and percent increase by incorporation of *rajagira* in the product. Among all the value added products *thalipattu* was highest with respect to all the nutrients followed by *chapathi* and *poori*. The nutrients present in different variations of *bhaji* were more or less similar but lesser as compared to other products.

The energy content of *chapathi* and *poori* was 328 and 233 Kcal respectively which was augmented by 11.18 (*chapathi*) and 16.50 per cent (*poori*) over the traditional non incorporated product. The protein content was increased by 39.72 per cent in *chapathi* (10.2 g) and 47.52 per cent in *poori* (9.0 g). There was a tremendous increase in iron and total carotene contents in all the value added products. The presence of minerals like iron and zinc was to an extent of 14.1 and 1.4 mg in *chapathi* and 13.6 and 1.2 mg in *poori* which were enhanced by 386.20 and 7.69 per cent in *chapathi* and 444.00 and 9.09 per cent in *poori*. The total carotene content was increased by 41735.29 per cent and 47300.00 per cent in *chapathi* and *poori* containing 7112 and 7110  $\mu$ g per serving respectively.

The energy (456 Kcal) and protein (16.5 g) content of *thalipattu* was increased by 8.05 and 22.22 per cent whereas iron (16.0 mg) and zinc (1.9 mg) contents were augmented by 233.33 and 5.55 per cent. The total carotene and total folic acid content of *thalipattu* was 7167 and 137.3  $\mu$ g which was augmented to 9854.16 and 118.63 per cent.

*Rajagira bhaji* with variation of pulses did not show much variation in energy and protein content (193 kcal and 6.8 g in green gram dhal based, 191 kcal and 6.8 g in red gram dhal based, 191 and 7.1 g in whole green gram based which was increased by 21.38 per cent (green gram dhal based) to 21.65 (whole green gram and red gram dhal based) and 69.04 (green gram dhal based) to 78.94 per cent (red gram dhal based) respectively. The iron content was enhanced many fold in *bhaji* prepared using *rajagira* leaves (925.00% in *bhaji* with whole green gram to 1233.33% in that with red gram dhal based respectively) compared to unincorporated pulse *bhajis* (12.3 and 12.0 mg respectively). *Bhaji* with red gram dhal showed lesser content (0.4 mg) of zinc than other variations (0.7 mg) which was enhanced by 28380.00 per cent. While the actual content of the total carotene and total folic acid ranged from 7108 (green gram dhal based) to 7120  $\mu$ g (red gram dhal based) and 76.3 (whole green

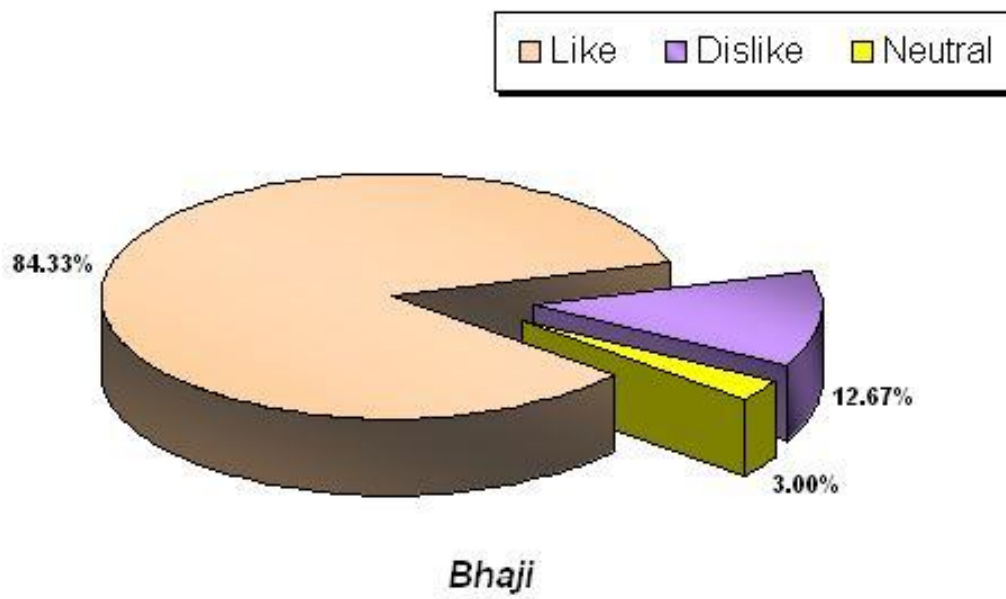
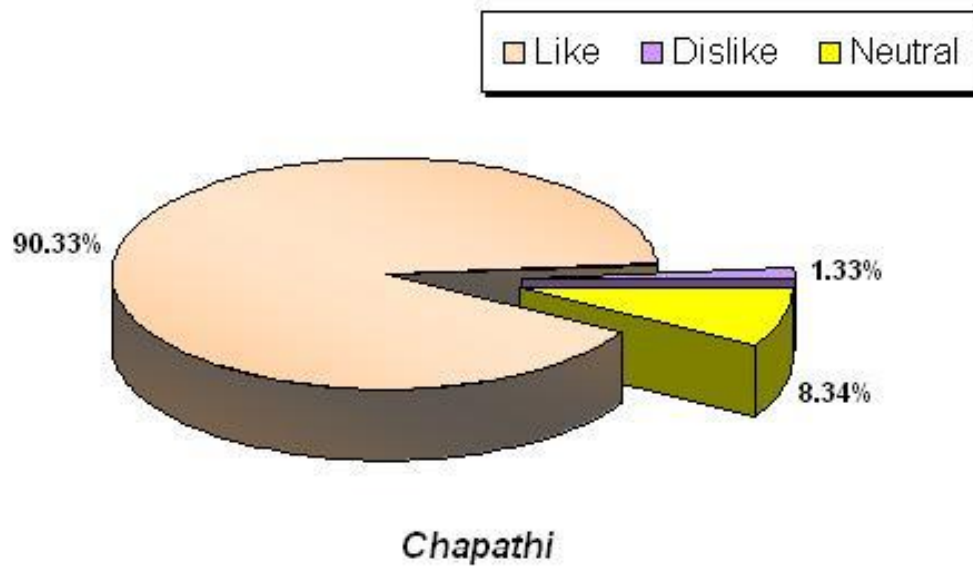


Fig. 14. Consumer acceptability of chapathi and bhaji with rehydrated rajagira

Table 11. Composition <sup>§</sup>and adequacy (%) of blood forming nutrients in VAPs (per serving)

Sl. No.	Products	Moisture (g)	Protein		Iron		β-carotene	
			(g)	Adequacy (%)	(mg)	Adequacy (%)	(μg)	Adequacy (%)
1	<i>Chapathi</i>	27.61	10.46	16.15	12.70	45.35	2490	103.75
2	<i>Poori</i>	28.76	9.35	14.38	12.25	43.75	2300	95.83
3	<i>Thalipattu</i>	31.98	17.97	27.64	14.90	53.21	3462	144.25
4	<i>Bhaji</i>	65.26	8.43	12.98	10.59	37.82	1937	80.70
Mean		38.40	11.55		12.61		2547.25	
SEm□		0.52	0.01		0.46		0.41	
CD at 1 %		2.25	0.04		1.97		1.76	
'F' value		1198.92**	227578.7**		15.10**		2547165.5**	

Each value represents average of 4 determinations

\*\*Significant at 1 % level

<sup>§</sup> By analysis

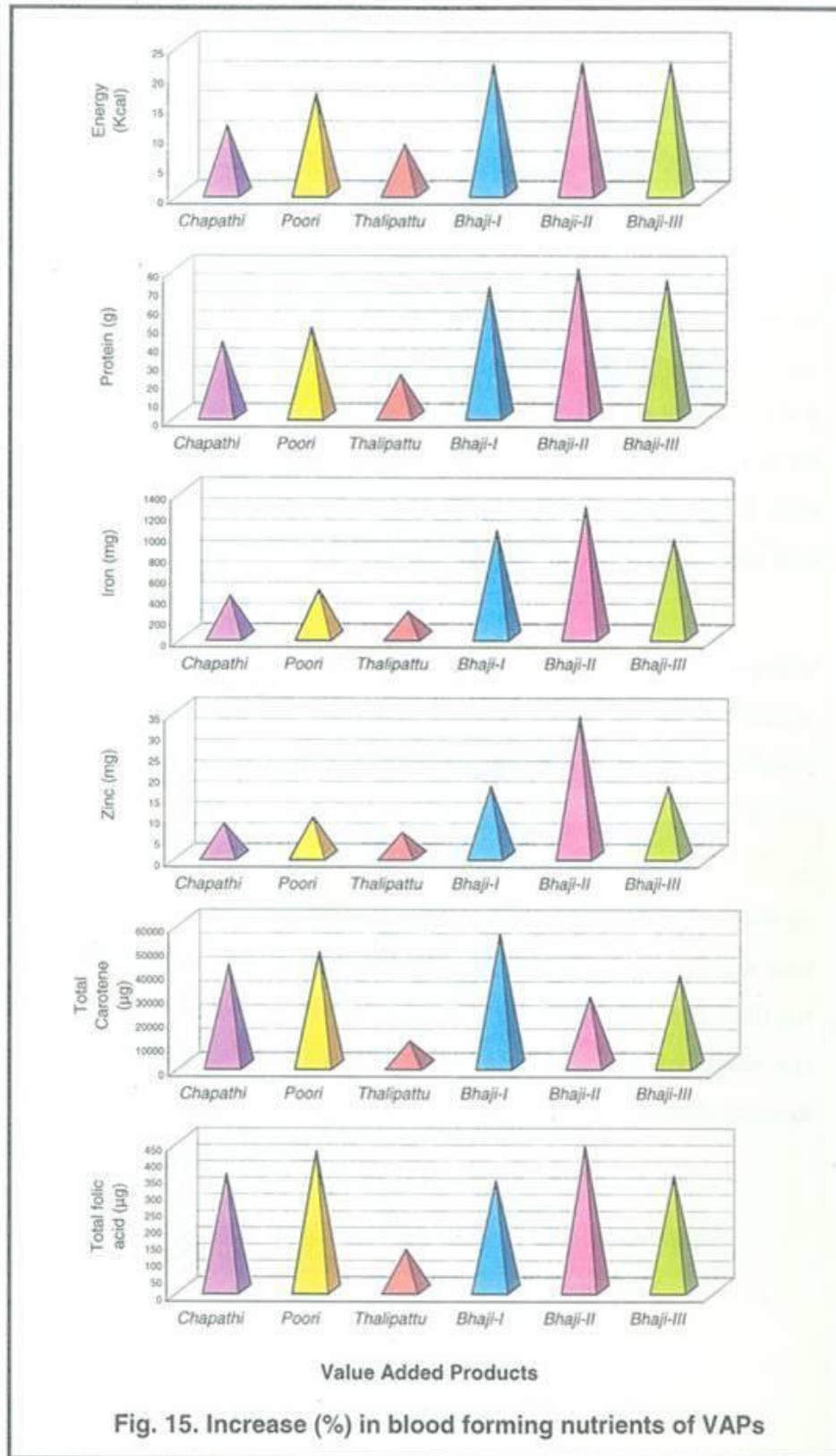


Fig. 15. Increase (%) blood forming nutrients of VAPs

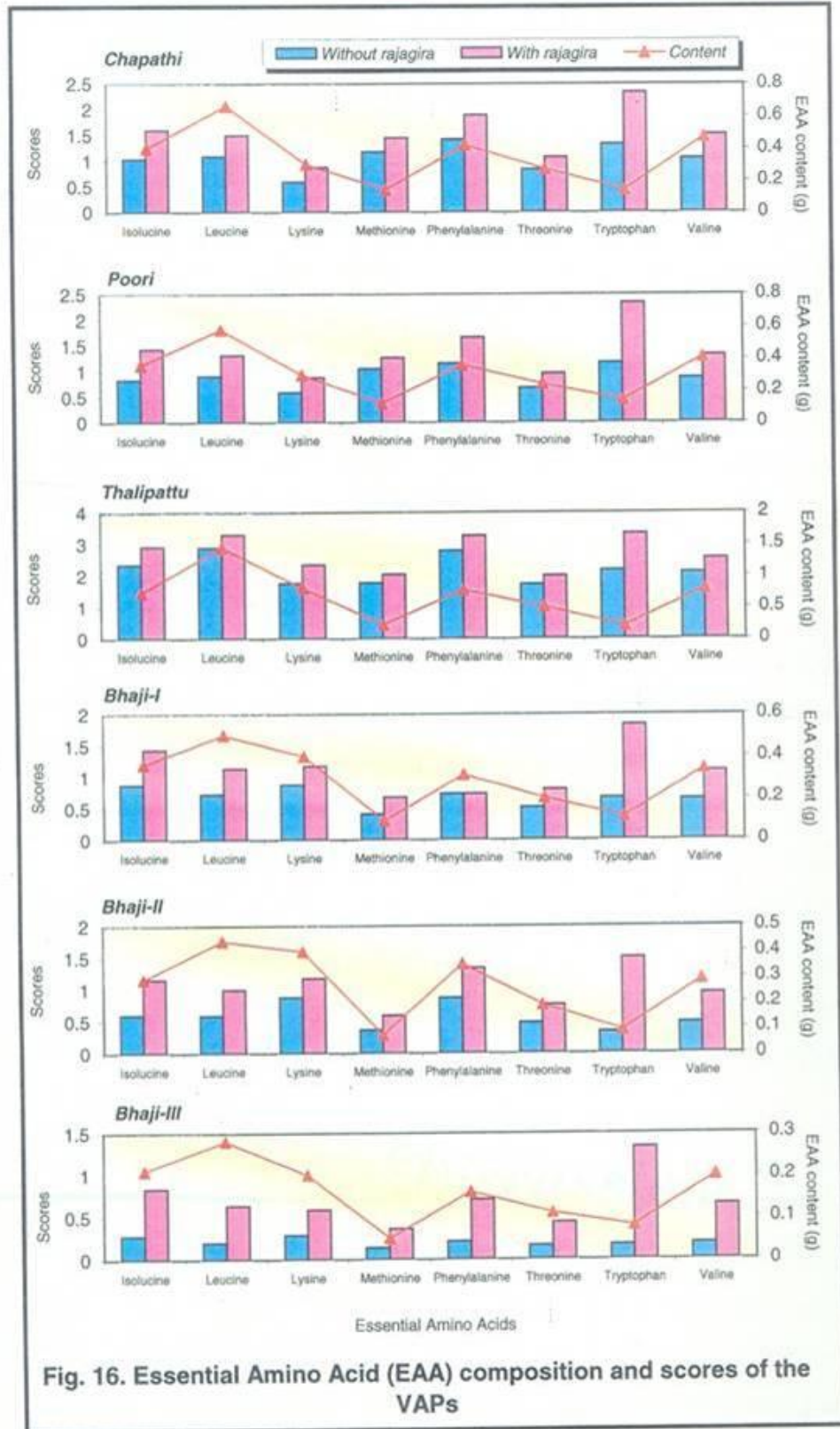


Fig. 16. Essential Amino Acid (EAA) composition and scores of the VAPs

Fig. 16. Essential Amino Acid (EAA) composition and scores of the VAPs

gram based) to 97.3 µg (green gram dhal based) respectively in all the variations of *bhaji*, this increased by 54576.92 and 28380.00 per cent and 4138.88 to 326.75 per cent.

The quantity of essential amino acids and chemical scores in the value added products is indicated in Fig. 16. In all the VAPs methionine and tryptophan were the limiting amino acid followed by threonine. Lysine was the limiting amino acid with lowest score of 0.59 in both *chapathi* and *poori* which increased to 0.88 with the addition of *rajagira* leaves. Tryptophan was 1.4 g in *rajagira chapathi* and *poori* which was increased from scores of 1.33 to 2.33 (*chapathi* without *rajagira*) and from 1.17 to 2.33 (*poori* without *rajagira*).

All essential amino acids were found to be higher in *thalipattu* with *rajagira* and there was no limiting amino acid observed in *thalipattu* with or without *rajagira*. Tryptophan (0.20 g) was lowest among all essential amino acids content in *thalipattu* with *rajagira* though had highest scores of 3.33 whereas leucine content (1.45 g) was highest which had 3.30 scores.

Methionine content was least in *rajagira bhaji* with green gram dhal (0.09 g), red gram dhal (0.07) and whole green gram (0.05 g). The scores for methionine were shifted from 0.41 to 0.68 (green gram dhal based). 0.36 to 0.59 (red gram dhal) and 0.14 to 0.36 (whole green gram based) in *bhaji* by adding *rajagira*. Tryptophan was the limiting amino acid in the red gram dhal *bhaji* without *rajagira* with scores of 0.33 which was shifted to 1.50 scores.

## 5. DISCUSSION

Anaemia is a major public health problem among the population of reproductive age in general and adolescent girls in particular. Despite the fact that Anaemia Prophylaxis Programme is launched in 1970 by Government of India to allay this disorder, the problem still exists in the country with higher magnitude, due to less comply for pharmaceutical approach by population.

At this juncture, it is essential to look for sustainable, culturally acceptable, cost effective strategy with multiple benefits. Pharmaceutical approach with iron-folic acid tablets provides sole nutrients with low compliance rate. As Dr. Gopalan puts it, food based approach is excellent strategy to combat malnutrition since it provides a packet of nutrients and satisfaction, is culturally acceptable and sustainable in addition to being cost effective.

India is bestowed with a number of iron rich foods including cereals, pulses, oilseeds, nuts, vegetables and dry fruits. Wide array of GLVs are available in the country, many of them flooding the market during season and are sold at throw away prices. However, during off season prices soar to sky.

Owing to the perishability of these vegetables huge amount goes as waste, which calls for processing and preservation for extension of shelf life. Dehydration is a simple user friendly, traditional technology which converts the vegetables in to crisp form, reducing in size to facilitate the utility throughout the year. Another added advantage of this method is that the vegetable can be rehydrated easily before incorporation in to the products.

Incorporation of GLVs in various products brings in value addition for nutrition security, if practiced for routine products can turn out to be a sustainable strategy. Hence, the present study was undertaken to assess the consumption pattern, health and nutrition related knowledge of adolescent girls and to fabricate green leafy vegetable based designer foods to provide sufficient quantity of iron using GLVs in the form of fresh, dehydrated and rehydrated. The results of the experimentation are discussed in this chapter.

### 5.1 CONSUMPTION PATTERN OF GLVs AMONG ADOLESCENT GIRLS

Adolescent girls are rigid in their food habits and make choices for themselves (Udipi, 2003). Often dietary habits of adolescents differ from those of children and adults. Adolescents indulge in skipping breakfast; eat more snacks and fast foods as they are more conscious of the figure and weight watchers. At the same time this group is influenced by their peer. The girls are concerned with the prestige and status. Since GLVs are considered as poor man's food, it is a status symbol to exclude GLV from diet. Many urbanites, despite having knowledge of its importance do not purchase / consume GLVs specially iron rich ones like amaranth. Only leafy vegetable included in diet may be spinach or fenugreek. Hence, majority of subjects knew the preparations of fenugreek and spinach (Table 2).

Less familiarity of GLVs undoubtedly affects the consumption of vegetables. The underutilized GLVs viz., *goli*, *honagone*, *vandelaga*, *chekkurmani* and drumstick leaves were known and consumed by lower percent of the subjects. Many of the parents of adolescent girls especially mothers were engaged in field activities as laborer (Table 1) and belonged to low income category with less than Rs. 5000 a month, which necessitates the picking and gathering of vegetables specially GLVs grown as weeds. This might have facilitated the familiarity of underutilized leafy vegetables by adolescent girls and thus consumption.

The present study indicated that though large percentage of the adolescents were familiar with GLVs like fenugreek, spinach, *rajagira*, shepu, *kiraksali*, curry leaves and coriander leaves, all of them were not consuming these vegetables (Figure 2) as the sensory qualities like taste, aroma, colour and flavour were not liked (Figure 3). The subjects experienced the grassy taste in many of GLVs, bitter or astringent taste and fibrous rough texture of curry leaves were quoted as the reasons for lower intake of these leafy vegetables. Akkamahadevi (1996) also reported disliking taste as the reason for depreciation in consumption of GLVs. Further pronounced dissipating flavour of certain GLVs like shepu and drumstick leaves; astringency of colocasia which was spelt out as "itching in mouth" were the reasons for lowered consumption. In addition, very sight of unhygienic washing the vegetable

in market, presence of worms, infested leaves, and dirt leads to unhygienic appearance and leading to hatredness feeling towards GLVs.

Surprisingly, many of the subjects reported the preparation of a varied number of products from spinach and fenugreek (Table 2). These are the two commercially exploited GLVs and were much familiar to the urban girls. Special preparations from fenugreek find a place in the market shelf as *kasuri methi* and hence are considered as prestige foods. Subjects with income of more than 30,000 rupees per month and working mothers (Table 1) tend to purchase such products either from food shoppers or eating outlets. Similarly it is intended that *rajagira* leaf powder can find a place in the market shelf as iron rich leaf powder.

The utilization of GLVs as major, secondary, seasoning or garnishing ingredient depicts indirectly the quantity of consumption. It is obvious that major and secondary ingredients are consumed in higher quantities and many a times seasoning ingredient curry leaves are not consumed at all. The garnishing ingredients or slight sauteing prior to consumption of *rajagira*, spinach and *hakkarakki* is considered as the raw consumption by many of the subjects (Figure 4).

Urban girls are exposed to number of resources including television, radio, print media etc. Further, the textbooks of school do have few topics on food and nutrition which might have permitted them to have knowledge about the health benefits of GLV like good for 'prevention of anaemia', 'good for eyes' and 'prevents constipation'.

## 5.2 DEHYDRATION PROTOCOL OF GLVs

The GLVs, which were available in most of the seasons, commonly known and consumed by majority of the adolescent girls (Figure 2) were selected to study dehydration protocol. Among five selected GLVs (fenugreek, spinach, *rajagira*, *kiraksali* and shepu), the highest edible part per bundle (Table 6) was obtained from spinach (59.24 %) followed by *kiraksali* (53.94 %) and *rajagira* (51.65 %) while, the large trimming loss of 59.46 per cent was observed in shepu followed by fenugreek (54.44 %). Singh *et al.* (2006) reported a trimming loss of 21.3 per cent in drumstick leaves, 17.8 per cent in *methi* leaves and 17.2 per cent in amaranth. This difference probably is due to the variations in size of the bundle, so also the method of harvesting and preparation which affects the trimming loss.

*Rajagira*, *kiraksali* and shepu had similar cost of 1.50 rupees per bundle while, fenugreek and spinach were available at slightly higher cost of 2.00 rupees per bundle. When the cost of vegetable per 100g of edible part was considered, among all GLVs *rajagira* was available at cheaper rate of about 1.75 rupees owing to its higher edible part per bundle. The cost of *kiraksali* and spinach was about 2.40 and 2.70 rupees per 100g edible part respectively. The fenugreek was the costliest with rupees 4.45 per 100g of edible part. Among the selected GLVs, *rajagira* had more edible part per bundle hence, was cheaper and was found to be reasonable and affordable even for lower socioeconomic population.

Vegetables flood the market during glut and excess gets spoilt owing to their perishability. Further, the consumption of leafy vegetables is restricted during rainy season due to lowered temperature, high humidity and gastrointestinal problems (Deepa 2002). In order to minimize wastage and utilize during off season it is necessary to process and preserve the vegetables by simple traditional methods like sun drying, salting, smoking, pickling and advanced methods like canning, dehydration, freezing and freeze drying. Among the various types of processing dehydration is considered to be the best as it is inexpensive, and imparts properties that are unmatched by other preservation technologies (Laxmi and Radhapiya, 2005).

Drying is one of the simplest methods of preservation requiring little outlay of special equipments. Drying of vegetable implies removal of free water to such a low level (water activity of 0.7) that the microbial activity and biochemical reactions are hindered, thus the effective edible span of the product is enhanced (Gould, 1989). This facilitates the utilization of the dried leaves in other parts of the country or world where this vegetable is unavailable in plenty.

Among the traditional drying methods, drying under sun and shade are the cheapest methods commonly practiced in places of plenty of sunshine and dry atmosphere (low relative humidity). But the limitation is, it cannot be practiced at all places, during all the seasons of

the year, takes longer time for drying and hygiene can not be ensured. Dehydration of vegetables by using modern equipments like electric drier is a popular and commercially adopted drying technique. Uniform quality product can be obtained when dried under controlled conditions of an electric tray drier in hot air oven or microwave oven as compared to the product dried in open sun or under shade. Drying method is not the sole criterion for dehydration period and obtaining higher recovery and good quality of dried product but the pre-treatments given to the vegetables prior to drying are also known to profusely influence the quality. Pre-treatment prior to drying is also essential to maintain quality and prevent spoilage during drying process (Gupta *et al.*, 1999). The suitability of a particular drying method and pre-treatment has been worked out for specific GLVs, in the present study, in order to get a product of high quality with consumer acceptability. In the present investigation the dehydration protocol was standardized for commonly consumed GLVs (Figure 2) namely *rajagira*, *kiraksali*, spinach, fenugreek and shepu, which were prepared in to many products (Table 2), using different pre-treatments and modes of drying.

The time taken for dehydration of GLVs to attain crispness and removal of moisture was found to be more in shade drying irrespective of pre-treatments, followed by hot air oven and sun drying (Table 7). This is obvious by the fact that drying carried out during rainy season when glut of vegetable arrived in market and when the temperature of drying room was 24.5 to 25°C with high humidity. All GLVs dried under sun took significantly lesser time than hot air oven dried GLVs probably because the GLVs were exposed to direct sunlight of summer at 38 to 42°C. The results are in line with Bhosale and Arya (2004) who inferred that cabinet tray drying was faster drying mode and required less time for drying the vegetables (cabbage, fenugreek and spinach) than shade drying which required maximum time for drying. Similar findings were also reported by Madalgi *et al.* (1996) for curry leaf; Singh *et al.* (1997) for fenugreek leaves, mustard leaves, *bathu* and spinach; Lakshmi and Vimala (2000) for amaranth, curry leaves, *gogu*, mint; and Kowsalya and Vidhya (2004) for *aria keerai*, *mulla keerai*, *paruppu keerai* and drumstick leaves. The unequal time taken by different vegetables may be because of differences in the initial moisture content, surface area exposed and thickness of individual leaves (Bhosale and Arya, 2004). Normally vegetables are dried in hot air driers where heat transfer is by way of convection either with natural air circulation or forced air circulation (Walde *et al.*, 1992). Sun drying and oven drying are conventional methods where transfer of thermal energy from product surfaces towards their centre is slow compared to microwave, as the Magnetron generates microwaves which penetrate the food and agitate the moisture molecules present in food and drives them out. Microwave processing results in shorter processing time, higher yields and better quality than conventional drying (Decareau, 1984). In the present study, irrespective of the pre-treatments, all GLVs took significantly lesser time in microwave drying where the duration was just 2.00-3.42 minutes. Shepu required minimum time of two minutes (Table 7) whereas spinach required maximum time of 3.42 irrespective of pre-treatments. Untreated GLVs could be dried in lesser time compared blanched with and without sulphitation. Karthika, (2006) also reported that underutilized cucurbits can be dried in significantly lower time in microwave oven.

The yield of dehydrated GLVs showed significant variation due to treatments and methods of drying (Table 8). The highest per cent yield was obtained by drying under shade and the lowest in sun dried GLVs. Shade drying took a very long time indicating slow removal of moisture without damaging the tissues and hence probably the yield was better. Further, Laxmi and Vimala (2000) also reported that sun drying results in more loss of solids during drying. Among all the selected GLVs spinach showed lowest and *kiraksali* showed highest per cent yield irrespective of method of drying and pre-treatments which may be because of differences in moisture in raw form, composition of the vegetable, structure of the cells and anatomical differences in the tissues (Singh *et al.*, 2006).

It is known that pretreatment results in heat application which might damage the tissues, intern leading to leaching out of the tissue components. Thus, in the present study all the GLVs without any treatment showed higher yield (%) while the GLVs treated by blanching with or without sulphitation showed lesser yield. The better results of hot air oven drying were due to high temperature, low relative humidity and fast removal of water. Singh *et al.* (2006) reported that cabinet drier was superior for dehydration of leafy vegetables as it reduced maximum moisture content. Lalitha and Sathya (2003) have also found that the yield of sun dried vegetable powder was less than that of oven dried ones. The temperature, rate of air flow and structural difference of individual vegetables might also be responsible for difference

in per cent yield of GLVs dried by different modes of drying (Bhosale and Arya, 2004). The lower yield in sun dried samples over shade dried vegetables must have been resulted from higher evaporation of moisture from the vegetables due to heat of the sun. Less time and higher per cent yield of GLVs dehydrated in microwave and hot air oven may be due to the controlled temperature and constant flow of hot air which must have evaporated moisture more rapidly from the GLVs at constant temperature without any external disrupting factors (Bhosale and Arya, 2004). It is desirable to dry the GLVs using microwave and hot air oven in order to attain more per cent yield within shorter period of time.

The changes in quality or physico-chemical characteristics such as discolouration and off flavour development in the product are mainly attributed to the enzymes present in vegetable. Therefore, it is necessary to check the undesirable changes that may occur during the drying process. In the present study, the dehydrated *rajagira* with different modes of drying was assessed for its quality with respect to rehydration ratio and chlorophyll content.

The *rajagira* leaves dried in sun and shade showed significantly lower rehydration ratio (Figure 9) while, microwave dried *rajagira* showed higher rehydration ratio followed by hot air oven dried irrespective of treatments given prior to dehydration which indicates the higher efficiency of electric drying. Microwave drying is a well known dehydration technology without damaging and disturbing the anatomy of the leaves, with better retention of most of the components. Thus, it is but natural that rehydration ratio is excellent in this method of drying. Better rehydration ratio of hot air oven dried samples can be attributed to faster removal of water during drying, lesser disturbances to anatomical structure of the leaves (Singh *et al.*, 2006) and better integration of components of dried materials. The longer time needed for drying, poor RH maintenance and fluctuation in air flow and loss of texture (Singh *et al.*, 2006) were the main reasons for the poor rehydration ratio in case of shade and sun dried products. The rehydration ratio was higher in blanched samples with or without sulphitation as compared to the untreated, indicating that the treatments had a positive effect in enhancing the reabsorption capacity of dried leaves. The results are in concurrence with those of Singh *et al.* (2006), who showed higher rehydration ratio in the cabinet dried products compared to low temperature and solar dried.

Maintenance of natural colour of the vegetable during drying determines the acceptability of product by the consumer. Chlorophyll is the main chemical component responsible for the green colour and attractiveness of the vegetable. It is the *chlorophyllase* enzyme which may be responsible for degradation of chlorophyll (Singh *et al.*, 2006). Pretreatments like blanching and blanching with sulphitation results in inactivation of the enzyme *chlorophyllase* and thus help in retention of higher proportion of chlorophyll. Similarly exposure to sulphur in the form of sulphur-di-oxide produced in blanching, water containing Sodium bisulphite results in bleaching of the pigment. Probably when enzyme inactivation is achieved prior to sulphitation, bleaching effect is not observed hence better chlorophyll retention was recorded in blanched + sulphitated samples in the present study (Figure 10). The minimum loss of total chlorophyll content in plain water blanched fenugreek was observed by Bajaj *et al.* (1993) while, higher retention of chlorophyll in blanched GLVs was reported by Lakshmi and Vimala (2000) for amaranth, curry leaves, *gogu* and mint, and Premavalli *et al.* (2001) for *dhantu*, *khirkhire*, *honagone*, *chakota*, *palak*, *kachi* and fenugreek.

Among the drying methods, chlorophyll retention was maximum in microwave dried *rajagira* followed by hot air oven dried samples while, the least retention of chlorophyll content was observed in all samples dried under sun (Singh *et al.*, 1997). This may be due to an inactivation of *chlorophyllase* enzyme by direct exposure to sun and bleaching of pigments due to exposure to ultra violet radiation. Singh *et al.* (1997) also reported the severe deterioration in colour of vegetable produce after sun drying. The increased efficiency of chlorophyll retention in electric drying has also been reported by Lakshmi and Vimala (2000) in GLVs *viz.*, amaranth, mint and curry leaf.

### 5.3 VALUE ADDITION TO TRADITIONAL PRODUCTS WITH RAJAGIRA

It is obvious that each region is endowed with typical traditional food habits which are culture bound highly acceptable to the population because these recipes are transferred from generation to generation with little modification. Hence, enriching the traditional foods with iron rich, nutritious leafy vegetable could pave a way for sustainable utilization in routine diets and to attain nutritional security. Survey of 1000 adolescent girls indicated that *chapathi*, *poori*, *thalipattu* and *bhaji* were routinely consumed cereal based staple foods. *Rajagira* leaves being cheapest (Rs.1.75 per 100g of edible portion) available in all seasons (Table 4) and rich in iron content (Figure 8) has been selected to provide iron security by incorporating in traditional products.

The different forms of *rajagira* including fresh, dehydrated and rehydrated were used to incorporate in selected products to emerge with suitable form of the GLV on different quality attributes including cooking characteristics as well as sensory attributes. Around 50.0 grams of fresh *rajagira* leaves yielded five grams of dried leaves which was equivalent in iron content and could meet minimum of 1/3<sup>rd</sup> requirement of iron (10 mg) of adolescent girls (Gopalan *et al.*, 2000). Therefore 50 g of fresh or sauted leaves and 5.00 g of dehydrated *rajagira* was added in different products. Equal quantity of dehydrated leaves was rehydrated and incorporated in the products. Among the local population it is customary that pulses like whole green gram, green gram dhal and red gram dhal are used in several preparations like *bhaji*. While GLV contributes iron and  $\beta$ -carotene as blood forming nutrients pulses provide protein, another blood forming nutrient. The cooking characteristics always contributed directly or indirectly for the acceptability of the products. The products with rehydrated *rajagira* showed better characteristics than with dehydrated and fresh *rajagira* with respect to water uptake, rollability, puffability and also for cooking or baking time. It was natural that water uptake in the preparation of products using rehydrated *rajagira* was lesser because presence of more water content in the tissues of leaves while, dehydrated leaves required plenty of water for cooking. The rehydration process was done in boiling water for five minutes hence, the cooking time and water uptake of the products using rehydrated *rajagira* leaves was found to be less than that of products with fresh and dehydrated leaves.

Very easy rollability observed in rehydrated *rajagira* products like *chapatti*, *poori* and *thalipattu* might be due to blendability of rehydrated leaves to obtain soft and homogenous dough. Further rehydration results in high temperature treatment which might soften the tissues and enable easy blending with dough. There was disruption in rolling of the dehydrated *rajagira* products because of the presence of broken particles of dry leaves and absorption of moisture by dry leaves might be reasons for difficult rollability.

*Poori* with dehydrated and rehydrated *rajagira* was fully puffed while, that with fresh was partial puffed in the present study. This probably is due to the presence of solid particles of leaves the veins and fibers present in the fresh form.

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. Hence, the developed products were evaluated by panel of judges at laboratory level and young adult women and adolescent girls at the consumer level. All the products prepared by incorporating *rajagira* in different forms were acceptable with scores of above 6.0 ranging from moderately good (6.4) to excellent (8.6) on nine point hedonic scale (Figure 11-13).

The fat used for sautéing the *rajagira* leaves might have contributed to the palatability, in addition to enhancing the availability of fat soluble  $\beta$ -carotene, a blood forming nutrient. Advantageously, the products with rehydrated *rajagira* received highest scores and were ranked first except *chapathi* and *thalipattu* (Table 10). Freshly sauted *rajagira* contributed for greater acceptability of the *chapathi* and *thalipattu* with respect to all the sensory parameters.

The sensory parameters were affected in all the products prepared out of dehydrated *rajagira* which was responsible for significantly lower scores. However, the form of *rajagira* whether sauted, dehydrated or rehydrated did not significantly influence the scores for colour and appearance and aroma of *chapathi*; aroma of *poori*; colour and appearance, taste and aroma in *thalipattu*. *Rajagira* contributed pleasant aroma in all the savoury products. The

texture of the rehydrated *rajagira* products were found to be superior which can be attributed to higher moisture (Table 11). Also cooking characteristics like easy rollability and complete puffability of *poories* which might have contributed to the textural improvement thus, making products soft, pliable and to be cut between three fingers. The results are in concurrence with those of Lakshmi and Vimala, (2000) for amaranth *pesarattu*; Kaur and Kochar, (2005) for *prantha* with radish and cauliflower greens and Shah, (2005) for bengal gram leaf powder incorporated stuffed *paratha*, *puri*, *dhapate* and *thalipeeth*.

*Bhajis* with all three pulses namely red gram dhal, green gram either whole or split were acceptable with scores ranging between very good and extremely good. *Bhajis* with rehydrated *rajagira* were highly acceptable compared to other two probably because of bright colour of the leaves, well cooked, soft fibers and good blendability with pulses. The rehydration process enhances the softness of fibers in addition augmenting colour. Though, all three forms of *rajagira* differed significantly with regard to sensory parameters, they were acceptable at the laboratory level by panel of judges. The results are in accordance with those of Kowsalya and Mohandas, (1999) for acceptability of cauliflower leaves *poriyal* and *kootu*; Lakshmi and Vimala, (2000) for amaranth soup and *dhal*; Lalitha and Sathya, (2003) for curry leaves, drumstick leaves and coriander leaves powder incorporated *bajji* mix and *vadai* mix; Shah, (2005) for bengal gram leaves incorporated pulse based recipes like plain *dal*, *mung dal*, *masoor dal* and moth bean *usal* and Nambiar *et al.* (2007) for drumstick leaves added *mung*, *Kabuli chana* and *desi chana* based recipes.

When 300 adolescent girls and young adult women were provided one serving of the commonly consumed traditional products, namely *rajagira* leaves *chapathi* and red gram dhal based *bhaji*, 90.33 and 84.33 per cent of them liked the products. It was interesting observation that *rajagira bhaji* prepared at home or in the hostels was not liked by the girls due to the mushy texture and dull appearance of fresh leaves used. Dehydration and rehydration though additional processing operation improved the acceptability of the products.

Among all the products *thalipattu* contributed for higher per cent adequacy of all analyzed nutrients to fulfill the daily requirements by adolescent girls which may be due to the large serving size and combination of variety of ingredients specially cereals and pulses, in proportion of 2:1 and with the addition of GLV, the composition improved further.

The value addition enriched the nutritive value of traditional recipes appreciably (Fig. 15). There was a substantial increase in the nutritional value of all the products enriched by *rajagira* leaves alone. The increment was substantial with respect to energy from 8.03 to 21.65 per cent, protein from 22.22 to 78.94 per cent, zinc from 5.55 to 33.33 per cent, among all VAPs. Considerable enhancement of nutrients in the products was also achieved with regard to iron (233.33 to 1009.09%) and total carotene (9854.16 to 54576.92%) after incorporating *rajagira*. The total folic acid enhanced to an extent of 119 to 430 per cent. Similarly, there was substantial increment in nutrients was observed in the products after addition of GLVs by Vijayalakshmi and coworkers (1994) in *vadai* mix and *bhaji* mix with coriander and curry leaves; Nalwade and others (2002) in colocasia and *chana* leaves curries, *Methi-mung* dhal curry, Colocasia curry and Shepu-mung dhal curry; (Anon, 2003) in *Dosa*, *idli* and *upma* enriched with *anne* greens and knolkhol leaves.

Protein is said to be complete when it provides all the essential amino acids in required proportion, chemical and biological methods are good indicators for protein quality evaluation but computation of amino acid score is one of the feasible methods to evaluate the quality of protein. When the essential amino acid scores of the VAPs in the present study were computed, methionine was found to be the most limiting amino acids (Fig. 16) which ranged from 0.05 to 0.22 followed by tryptophan (0.08 to 0.20).

The essential amino acid scores of the products with and without addition of *rajagira* when compared showed that lysine was the limiting amino acid with lowest score of 0.59 in *chapathi* and *poori* without *rajagira* which was augmented to 0.88 after addition of *rajagira* leaves. The product *thalipattu* without *rajagira* had the scores of more than one for all the essential amino acids. This further improved beyond two with addition of *rajagira*. Green gram dhal and whole green gram based *bhaji* showed lowest scores for methionine which was increased from 0.41 to 0.68 and 0.14 to 0.36 respectively by adding *rajagira* leaves into it. While, tryptophan score enhanced from 0.33 to 1.50 in red gram dhal based *bhaji* of *rajagira*.

## FUTURE LINE OF WORK

- *In vivo* and *in vitro* studies on bioavailability of blood forming nutrients of the value added products in anaemic adolescent girls
- A longitudinal study on impact of nutrition education on consumption of GLVs
- *Rajagira* based convenience snack foods can be developed and popularized through appropriate media and commercialization

## 6. SUMMARY AND CONCLUSIONS

Anemia is a major public health problem among the population in general and among adolescent girls in particular. Green leafy vegetables being the treasure trove of micronutrients finds a place in combating the menace of nutritional anemia. Hence, an investigation was undertaken to fabricate green leafy vegetable based designer foods for iron security of adolescent girls during the year 2006-08 in the department with the objective to assess the consumption pattern of green leafy vegetables among urban adolescent girls, standardize the dehydration protocol of green leafy vegetables and finally to develop and standardize value added products from green leafy vegetables for iron security along with determination of blood forming nutrients in value added products.

A total of 100 school going adolescent girls of 12 to 16 years were randomly selected from all 10 schools of Dharwad city totaling to 1000 for the study. Basic information, demographic details and specific information including GLVs known and consumed, reasons for not consuming GLVs, commonly prepared recipes using GLVs, seasonal availability of GLVs, was collected by structural pre-tested questionnaire using personal interview method.

The five commonly consumed GLVs like *rajagira*, *kiraksali*, fenugreek, spinach and shepu, were selected for standardization of dehydration protocol. Different pretreatments (blanching, sulphitation and blanching + sulphitation) were applied prior to dehydration in sun, shade, hot air oven and microwave oven drying. Untreated GLVs dried similarly served as control. Quality of dehydrated GLV was evaluated in terms of time taken for drying, per cent yield and iron content. Rehydration ratio and chlorophyll content of *rajagira* leaves, used for product development, was estimated. The value addition was done to the products viz., *chapathi*, *poori*, *thalipattu* and *bhaji* with different pulses. The sensory and nutritional quality of VAPs was assessed. Trained panel of judges at laboratory level and adolescent girls and young adult women at consumer level evaluated the organoleptic quality. The nutrient content of all value added products was computed using Annapurna software and certain blood forming nutrients like protein, iron and  $\beta$ -carotene were analyzed. The quality of the protein of all the VAPs was also evaluated using chemical score method.

The findings of present investigation are summarized below.

- Majority of the adolescent subjects selected for the study were belonging to 14- 15 years age group (55.6 %).
- Around 71 per cent of the girls belonged to nuclear family with family size of 4-6 members.
- The monthly income of 61.8 per cent families of adolescent girls was below Rs. 5000.
- Only around 3.6 to 11.7 per cent of the parents were found to be educated up to degree level while, 36 per cent of fathers and 42.2 per cent of mothers were educated up to secondary school. The illiteracy was more among the mothers (17 %) as compared to fathers (13.5 %) of the adolescent girls.
- Only 3.7 per cent of fathers and majority of mothers (78.2 %) were not involved in gainful employment.
- Among all the reported leafy vegetables, fenugreek was known and consumed by higher per cent (87.4 and 76.9 %) of the adolescent girls followed by spinach, *rajagira*, shepu and *kiraksali*.
- The taste of GLV (24 %) followed by aroma (12.6 %) was the reason for not consuming this group of foods. Around 5.6 to 9.4 per cent of the girls were not consuming as they were not brought at home, less available in market or lack of information about its preparations. Reasons like skin allergy, vomiting, stomach pain, digestion problem and itching in mouth were also quoted by 2 to 12 per cent of the subjects for not consuming GLVs.
- Spinach (13) and fenugreek (11) were the most commonly used GLVs to prepare maximum number of the recipes.

- All the GLVs were reported to be used for preparation of *bhaji* except curry leaves, mint and coriander leaves.
- The cereal based recipes such as *chapathi*, *poori*, *paratha*, *thalipattu*, rice and pulse based recipes like *bhaji*, *sambar*, *chakali*, *pakoda*, *vada* by adding different GLVs were reported by the adolescent girls.
- Around 24 and 15 GLVs were reported to be used as major ingredient and secondary ingredient respectively in different preparations while, only curry leaves was used for seasoning and coriander and mint as a garnishing ingredient.
- The GLVs consumed in the raw form by higher percent of the adolescent girls were coriander, (68 %), fenugreek (62 %) and radish leaves (52.5 %).
- Majority of the subjects reported that fenugreek (52.8 %), *rajagira* (41.2 %) and *kiraksali* (31.9 %) were available in all seasons in the local market of Dharwad city.
- Some of the underutilized leafy vegetables like *chakota*, *chekkuramani*, drumstick leaves, *goli soppu*, mustard leaves, pea leaves, *colocasia* leaves, *hunchik* and *vandelaga* were not available in the market.
- There are more number of the subjects reported sorting of GLVs by leaves with tender stalk (400) and only leaves (376).
- Around one third of the adolescent subjects reported cleaning of GLVs using plain water.
- The preliminary processing like cutting of GLVs after washing was reported by 55.8 per cent subjects while, washing after cut it was reported by 44.2 per cent of the subjects.
- The health benefits of GLVs reported by the adolescent girls included 'Good for eyes' (33.5 %) 'Helps in blood formation' (32.7 %), 'Good for diabetes' (15.1 %) and 'Prevents constipation' (10.0 %).
- Higher per cent of the adolescent girls reported that GLVs contain fat soluble vitamins (320), water soluble vitamin (295) and proteins (104).
- Text book (31.5 %) was the most popular source for the adolescent subjects for having health and nutrition knowledge of GLVs followed by general books (20.6 %), teachers (20.4 %) and relatives (18 %).
- The adolescent girls felt that the consumption of GLV could be recommended to overcome from anemia, diabetes, heart disease, hypertension, obesity, constipation, eye, skin and kidney disorders, tuberculosis, jaundice, cholera, piles, diarrhea, round worm infection, stomachache and vomiting and also in the conditions like pregnancy.
- In general, untreated GLVs took more time for dehydration compared to treated GLVs, irrespective of the method of drying except in microwave oven wherein reverse trend was observed with untreated sample taking less time than treated.
- The mean time taken for dehydration and the yield (%) of dried GLVs was found to be higher in shade dried samples irrespective of treatments.
- Microwave drying took significantly lesser time of 2.24 (shepu) to 2.86 minutes (spinach) compared to all other methods of drying and the yield obtained was ranged from 4.47 (spinach) to 11.12 g/100g (*kiraksali*) respectively.
- Among all selected GLVs *rajagira* showed highest iron content 222.52 mg/100g followed by *kiraksali* (54.59 mg/100g) while, the least iron content was found in fenugreek (26.19 mg/100g).
- The rehydration ratio ranged from 5.29 (untreated) to 6.29 (blanching + sulphitation) and chlorophyll content from 12.04 (untreated) to 12.86 mg/g (blanching + sulphitation) in microwave oven dried *rajagira* samples.
- The *rajagira* samples dried under sun showed poor rehydration ratio (4.55) as well as amount of chlorophyll content (6.85 mg/g).

- Around 50.00 g of fresh *rajagira* leaves was equivalent to 5.00 g of dried *rajagira* leaves in iron content.
- The water uptake, rollability, puffability and cooking/ baking time of all rehydrated *rajagira* products was better compared to the products with fresh and dehydrated *rajagira*.
- *Bhajis* and *pooris* with rehydrated *rajagira* were scored highest (38.4 to 41.6), and hence were ranked first. *Chapathi* and *thalipattu* with sauted *rajagira* received highest total scores with the range of 40.0 to 40.7 and were ranked first.
- There was no significant difference in aroma of all cereal based products and also in *bhaji* with red gram after addition of *rajagira* in the different forms.
- The colour, appearance and taste of *thalipattu* and only colour and appearance of *chapathi* with different forms of *rajagira* were not differed significantly.
- Among all the *bhajis*, whole green gram based *bhaji* with rehydrated *rajagira* recorded highest total score of 41.6.
- Red gram dhal based *bhaji* with different forms of *rajagira* was scored similarly with regard to texture and aroma.
- Colour, appearance and texture were the major parameters affecting the acceptability of the products.
- All the products with dehydrated *rajagira* registered lower scores except *poori*.
- *Chapathi* and *bhaji* with rehydrated *rajagira* was liked by 90.33 and 84.33 per cent of the adolescent girls and young adult women at consumer level.
- Among all VAPs *bhaji* had highest moisture content of 65.26 per cent.
- The analyzed protein, iron and  $\beta$ -carotene content in all the VAPs ranged from 8.43 to 17.97 g, 10.59 to 14.90 mg and 1937 to 3462  $\mu$ g per serving.
- The products were able to meet 12.98 to 27.64, 37.82 to 53.21 and 80.70 to 144.25 per cent RDA of protein, iron and  $\beta$ -carotene respectively for the adolescent girls.
- All the nutrients were substantially increased in the products with addition of *rajagira* leaves (energy from 8.03 to 21.65 %, protein from 22.22 to 78.94 %, iron from 233.33 to 1009.09 %, zinc from 5.55 to 33.33 %, total carotene from 9854.16 to 54576.92 %, total folic acid from 118.63 to 4138.88 %).
- Methionine was the limiting amino acid in all the VAPs except *thalipattu* wherein, there was no limiting amino acid.
- After addition of *rajagira* leaves there was an increase observed in all the essential amino acids.

Thus it can be concluded from the study that there are number of GLVs known to the adolescent girls among which fenugreek, spinach, *rajagira*, *kiraksali* and shepu were commonly consumed and locally available in most of the seasons. Taste and aroma of the GLVs were the major factors for reduced consumption among urban adolescent girls though the hygiene, unavailability and unknown preparations were also the reasons for non consumption. The nutrition education is required for girls of adolescent age to improve the knowledge regarding health and nutritional importance of GLVs. Microwave oven drying showed better qualitative results followed by hot air oven drying. While blanching with or without sulphitation was the most desirable pretreatment in terms of quality characteristics like rehydration ratio and chlorophyll content. While, all the products prepared using *rajagira* in different forms were scored between moderately good to excellent the products with rehydrated *rajagira* were highly acceptable at both laboratory and consumer level. There was substantial increase in the nutrient content after incorporation of *rajagira* in to the products. All the VAPs could meet around 13 (Protein) to 144 ( $\beta$ -carotene) per cent of blood forming nutrients required by the adolescent girls. Hence, the consumption of VAPs with *rajagira* might help in combating anemia and to improve health.

## REFERENCES

- Akkamahadevi, K. H., 1996, Dietary iron intake and prevalence of anemia in urban and rural adolescent girls of Dharwad taluk. *M.H.Sc. Thesis*, Uni. Agri. Sci., Dharwad.
- Angadi, A.C., 1990, impact of integrated child development service on nutritional status of pregnant and lactating mothers. *M.H.Sc. Thesis*, Uni. Agri. Sci., Dharwad.
- Anonymous, 1951, Methods of Vitamin Assay of the Association of Vitamin Chemists, *Inter Science Publishers, Inc.*, New York.
- Anonymous, 1990, Official methods of analysis of the association of official analytical chemists. 20<sup>th</sup> Edn., AOAC, Washington, D.C.
- Anonymous, 2003, Gender perspective in farm & home management & utilization of underutilized foods towards household nutrition security, PSR-62, NATP.
- Anonymous, 2006, Report of population research centre, Dharwad.
- Bajaj, M., Aggarwal, P., Minhas, K.S. and Sidhu, J. S., 1993, Effect of blanching treatments on the quality characteristics of dehydrated fenugreek leaves. *J. Food Sci. Tech.*, **30** (3): 196-198.
- Bhosle, B. S. and Arya, A. B., 2004, Effect of different modes of drying time of selected vegetables. *The Indian J. Nutr. Diet.*, **41**(7): 293-298.
- Birar, R. M., Ferande, V. R. and Unde, P. A., 2001, Effect of pretreatments on quality of dehydrated fenugreek (*methi*). *Beverage and Food World*, **28**(12): 23-24.
- Chacko, M. and Khyrunissa B., 2007, Eating behavior and nutrient intake among adolescent girls from middle income families. *The Indian J. Nutr. Diet.*, **44**(7): 367-373.
- Chandrashekhar, U., Kowsalya, S. and Eapen, D., 2000, Retention of beta carotene from selected greens and absorption of beta carotene from pumpkin leaves in adults. *The Indian J. Nutr. Diet.*, **37**: 233-239.
- Chauhan, S. K., Sharma, C. R., 1993, Development of instant dehydrated saag. *Beverage and Food World*, **20** (4): 25-26.
- Decareau, R. V., 1984, Microwave in food processing. *Food tech. in Australia*, **36** (2): 81-86.
- Deepa, K. S., 2002, Nutritional and health profile during menarche and seasonal variations in iron status. *M. H.Sc. Thesis*, Uni. Agri. Sci., Dharwad.
- Gopalan, C., Rama Sastri, B.V., Balasubramanian, S. C., 2004, Nutritive value of Indian foods. National Institute of Nutrition, ICMR, Hyderabad.
- Gould, G. W., 1989, Drying raised osmotic pressure and low water activity. In: Mechanisms of Action of food preservation procedures. Ed. Gould, G. W., Elsevier science publishers limited, Netherlands, PP. 97-106.
- Gupta, D. K., Baburao, N. and Jayaraman, K. S., 1999, Improvement in rehydration and shelf life stability of hot air dried and sun dried cabbage by pre-drying treatment. *Indian Food Packer*, **53**(6): 51-60.
- Gupta, S., Jyothi, L. A., 2003, Compositional changes in green leafy vegetables on dehydration. *Proceedings of International Food Conference*, VG-28: 213-214.
- Hanagi, C., 2001, Nutritional effect of protein concentrate in rural anaemic adolescent girls of Dharwad taluk. *M.H.Sc. Thesis*, Uni. of Agri. Sci., Dharwad.
- Jemima, B. M., Bhavani, k., 2004, The efficacy of cauliflower greens preparation in improving blood hemoglobin in selected adolescent girls. *Indian J. Nutr. Diet.*, **41**: 63 – 66.
- Karthika, B., 2006, Physical characters and glycemic response of fresh and dehydrated underutilized cucurbits. *M.H.Sc. Thesis*, Uni. Agri. Sci., Dharwad.
- Kasturiba, B., 1999, Promotion of vitamin A status through horticulture intervention. *Ph.D. Thesis*, Uni. Agri. Sci., Dharwad.
- Kasturiba, B., Naik, R. K. and Basarkar P.W., 2007, Impact of synthetic vitamin A and horticulture intervention on vitamin A status & iron status of rural school children. *J. Human Ecology*, **22**(3): 251 – 254.
- Kaur, J., and Bajwa, U., 2003, Effect of pre-treatments of green leafy vegetables on the quality attributes of vegetable impregnated *paneer*. *Indian J. Nutr. Diet.*, **40**(6): 632-637.
- Kaur, T. J., and Kochar, G. K., 2005, Organoleptic evaluation and retention of vitamin C in commonly consumed food preparations using underexploited greens. *Indian J. Nutr. Diet.*, **42**: 425-431.

- Kowsalya, S., and Mohandas, S., 1999, Acceptability nutrient profile of cauliflower leaves. *The Indian J. Nutr. Diet.*, **36**: 332-338.
- Kowsalya, S., and Vidhya, M. R., 2004, Nutritive value of selected dehydrated green leafy vegetables. *The Indian J. Nutr. Diet.*, **41**: 279-286.
- Kulkarni, L. R., 2003, Documentation, valuearization and promotion of underutilized foods for nutrition security of school children. *Ph.D. Thesis.*, Uni. Agri. Sci., Dharwad.
- Lakshmi, B. and Vimala, V., 2000, Nutritive value of dehydrated green leafy vegetable powders. *J. Food Sci. Tech.*, **37** (5): 465-471.
- Lalitha, R., and Sathya, K., 2003, Enrichment of instant food mixes with  $\beta$ -carotene through green leafy vegetables: acceptability characteristics. *Proceedings of International Food Conference*, SS-02: 75
- Laxmi and Radhapriya, 2005, Incorporation of dehydrated plantain and drumstick flowers in recipes and their acceptability. *Indian J. Nutri. Dietet.*, **42**: 300-306.
- Lindsay, W. L. and Norwell, W. A., 1978, Development of DTPA soil test for Zn, Fe, Cu and M. E. No. *J. American Soc. Soil Sci.*, **42**: 421-428.
- Mackinney, G., 1941, Absorption of light by chlorophyll a and b from algae using dimethyl sulfoxide. *Limnol. Oceanogr*, **21**: 926-928.
- Madalageri, B.B., Mahadev and Hiremath, S. M., 1996, Dehydration methods, Oil extraction and flavor components. Detection in curry leaf (*Murraya Koenigii Spreng*) and detection of flavor components. *Karnataka J. Agric. Sci.*, **9** (2): 284-288.
- Nalwade, V. M., Reddy, N. S. and Kokil, V. N., 2002, Proximate composition of calcium, iron and  $\beta$ -carotene contents of vegetable preparations. *The Indian J. Nutr. Diet.*, **39** (2): 81-84.
- Nalwade, V., Manu, M., Kokil, V. and Zanvar V., 2005, Nutritional intervention for iron and vitamin A deficient school children. *The Indian J. Nutr. Diet.*, **42**(10): 465-474.
- Nambiar, V. S. and Parnami, S., 2007, Standardization and organoleptic evaluation of drumstick (*Moringa oleifera*) leaves incorporated into traditional Indian recipes. *Trees for Life Journal*, **3**: 2.
- Nande, P., Dudhmogre, S. and Vali, S. A., 2007, Evaluation of nutritive value and acceptability of recipes prepared from spinach and betel leaves. *The Indian J. Nutr. Diet.*, **44**: 476-483.
- Narasinga Rao, B. S., Deosthale, Y. G., Pant, K.C., 1989, Nutritive Value of Indian Foods. National Institute of Nutrition. Indian Council of Medical Research, Hyderabad, India.
- Negi, P. and Subramanyan, S., 1972, Studies on nutrient contents of spinach beet. *Indian Hortic.*, pp.17-23.
- Negi, P. S. and Roy, S. K., 2001, Effect of drying conditions on quality of green leaves during long term storage. *Food Res. International*, **34**: 283-287.
- Pande, V. K., Sonune, A. V. and Philip, S. K., 2000, Solar drying of coriander and methi. *J. Food Sci. Tech.*, **37**(2): 110-113.
- Patil, V. R., Kulkarni, D. N., Kulkarni, K. and Ingle, U.M., 1978, Effect of blanching factors on quality and durability of sun dried and dehydrated fenugreek (*methi*). *Indian Food Packer*, **32**(1): 43-49.
- Pellett, P. L., Young, V. R., 1980, Nutritional Evaluation of Protein Foods. The United Nations University, WHTR-3/ UNUP-129.
- Prameela, Y., Chittemma Rao, K. and Sarojini, G., 1995, A comparative study on the nutritional status of rural adolescent girls and boys (11-18 years) in Andhra Pradesh. *The Indian J. Nutr. Diet.*, **32**: 175-179.
- Premavalli, K. S., Jamudar, T. K. and Madhura, 2001, Processing effect on color and vitamins of green leafy vegetables. *J. Food Sci. Tech.*, **38**(1): 79-81.
- Punia, D., Yadav, S., Gupta, M., and Khetar, N. P., 2004, Nutrient composition of amaranth (*amaranthus tricolor*) and *Kondhara* (*Digeria arvensis*) leaves and their products. *J. Food Sci. Tech.*, **41**(5): 563-566.
- Saroj-Dahia., 2002, Nutritional status assessment of pregnant women from Hisar city of Haryana. *Nutrition and Health*, **16**(3): 239-247.
- Seema, A. S., 1997, Effect of processing and storage on  $\beta$ -carotene content of selected fruits and vegetables. *M.H.Sc. Thesis*, Uni. Agri. Sci., Dharwad.
- Shah, B. A., 2005, Value addition of traditional diets for iron with bengal gram leaves. *M.Sc. Thesis*, Marathwada Agriculture University, Parbhani.

- Singh, G., Kawatra, A. and Sehgal, S., 2004, Nutritional evaluation of products developed from dried spinach leaves (*spinach oleracea*). *Indian Food Packer*, **58**(1): 68-72.
- Singh, G., Kawatra, A. and Sehgal, S., 2005, Development and nutritional evaluation of products prepared from dried powder of cauliflower leaves. *J. Food Sci. Tech.*, **42**(2): 137-139.
- Singh, H., Bawa, A. S. and Ahmed, J., 1997, Dehydration characteristics of some green leafy vegetables. *Indian Food Packer*, **51**(2): 5-13.
- Singh, P., and Awasthi, P., 2003, Sensory and nutritional quality evaluation of green leafy vegetable (GLV) powder incorporated food products. *Proceedings of International Food Conference*, SS-07: 77.
- Singh, U., and Sagar V. R., 2008, Influence of Packaging and storage temperature on the quality of dehydrated selected leafy vegetables. *J. Food Sci. Tech.*, **45** (5): 450-453.
- Singh, U., Sagar V. R., Behera, T. K., Suresh Kumar P., 2006, Effect of drying conditions on the quality of dehydrated selected leafy vegetables. *J. Food Sci. Tech.*, **43** (6): 579-582.
- Srikantia. S. G., 1989, Nutritional implication of foods. *In trends in food sciences and technology – Proceedings of International Food Conference – 88*. Ed. Raghavendararao, M. R., Chandrasekharan, N. and Ranganath, K. A., Association of Food Scientist and Technologists, Mysore, India, pp.189-196.
- Sukanya, M.H., Rao, S. and Naik, R., 1995-96, Practices of sun drying and storage of different vegetables for domestic purpose. *Karnataka J. Agric. Sci.*, **8**(4): 433-436.
- Udipi, J., 2003, Nutrition. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, April 2003 (ISSN0550-404 X), 3-4.
- Unde, P.A., Padian, S.M. and Chaudhari, R. S., 2000, Osmotic dehydration of leafy vegetables. *Beverage and Food World*, **26**(1): 26-27.
- Vijayalakshmi, P. and Devadas, R. P., 1994, Enhancing the nutritive value of convenience foods by incorporating green leafy vegetables. *The Indian J. Nutr. Diet.*, 31: 333-338.
- Vijayaraghavan, K., 2006, Iron deficiency anaemia in India and its control. *The Indian J. Nutr. Diet.*, 44: 107-114.
- Walde, S. G., Math, R. G., Chakravarthi, A. and Rao, D. G., 1992, Preservation of carrots (*Davour carota* L.) by dehydration techniques – A review. *Indian Food Packer*, **46** (1): 37 -38.

# APPENDIX I

Questionnaire for studying the utility of green leafy vegetables among urban adolescent girls

## 1 part: General information

1. Name :
2. Age :
3. Class :
4. Name of the school :
5. Phone no. / Address :
6. Total monthly income of the family :
7. Family type : 1) Joint  
2) Nuclear  
3) Extended

### 8. Size of the family :

	Male	Female	Total size of the family
Adults			
Children			
Total			

### 9. Family details :

	Education	Occupation	Monthly income
Father			
Mother			

## II Part: Specific information

### 1. Consumption pattern of GLV's

Sl. No.	Enlist the GLV's known to you	GLV's Consumed By you	Give reasons for GLV's not consumed by you	Frequency of consumption			
				Daily	Twice a week	Once a week	Occasionally

### 2. Recipes prepared by using GLV's

Sl. No.	Recipes by using GLV's known to you / prepared at home	Name of GLV's used in preparation		It is used as major / secondary/ garnishing ingredient	Quantity of consumption / serving size T / t / K / C
		Fresh form	Dry form		

### 3. Consumption of GLV's in raw form.

Sl. No.	Name of GLV's Consumed in raw form	Frequency of consumption				Quantity of consumption / serving (T / t / K / C)
		Daily	Twice a week	Once a week	Occasionally	

4. Availability of GLV's in local market

Sl. No.	Name of the GLV's	Seasonal availability			
		All seasons	Summer	Winter	Monsoon

5. Whether you cut vegetables after washing or wash after Cutting?

\_\_\_\_\_

How many times? \_\_\_\_\_

6. What methods you generally follow for cleaning the vegetables?

- a) Plain water
- b) Salt
- c)  $KMnO_4$
- d) Any other \_\_\_\_\_

7. How the sorting / trimming of GLV's are done at your home?

- a. Only Leaves
- b. Leaves with complete stalk
- c) Leaves with tender stalk
- d) Any other \_\_\_\_\_

8. What are the health benefits of eating GLV's?

- 1.
- 2.
- 3.
- 4.

9. Do you know which specific nutrients are present in GLV's?

Yes / No

If yes, enlist those \_\_\_\_\_

10. What is the source of having this knowledge?

General books / Text books / Magazines / News papers / Radio / Television / Friends  
/ Relatives / Teachers /Any other \_\_\_\_\_

11. Any taboos attached to consumption of GLV's?

- 1.
- 2.
- 3.
- 4.

Its impact on consumption

Consumption increased in following conditions	Consumption decreased in following conditions

12. Do you have an idea about any particular GLV recommended for disorder?

Sl. No.	Name of the GLV	Disorder

## APPENDIX II

### List of green leafy vegetables

English name	Local name	Botanical name
Fenugreek	<i>Menthya soppu</i>	<i>Trigonella foenum graecum</i>
Spinach	<i>Palak</i>	<i>Spinacia oleracea</i>
<i>Rajagira</i>	<i>Rajagiri</i>	<i>Amaranthus paniculatus</i>
Shepu	<i>Sabasige</i>	<i>Peucedanum graveolens</i>
Amaranth	<i>Kiraksali</i>	<i>Amaranthus volygonoids</i>
Coriander	<i>Kothambari soppu</i>	<i>Coriandrum sativum</i>
Curry leaves	<i>Karibevu</i>	<i>Murraya koenigii</i>
Radish leaves	<i>Mullangi soppu</i>	<i>Raphanus sativus</i>
Gogu	<i>Pundit</i>	<i>Hibiscus cannabinus</i>
Onion leaves	<i>Eerulli</i>	<i>Allium cepa</i>
Mint	<i>Pudina</i>	<i>Menthe spicata</i>
Lettuce	<i>Hakkaraki</i>	<i>Lactuca sativa</i>
Mayalu	<i>Basale</i>	<i>Basella rubra</i>
Bengal gram leaves	<i>Kadale soppu</i>	<i>Cicer arietinum</i>
Drumstick leaves	<i>Nugge yele</i>	<i>Moringa oleifera</i>
-	<i>Haravi</i>	<i>Amaranthus viridis</i>
Safflower leaves	<i>Kusube yele</i>	<i>Carthamus tinctorius</i>
Ambat Chuka	<i>Hunchik</i>	<i>Rumex vesicarius</i>
Cabbage	<i>Yele kosu</i>	<i>Brassica oleracea var capitata</i>
Paruppu Keerai	<i>Goli</i>	<i>Portulacea oleracea</i>
Pea leaves	<i>Batani soppu</i>	<i>Pisum sativum</i>
Mustard leaves	<i>Sasuve yele</i>	<i>Vigna catjang</i>
Colocasia leaves	<i>Kesina yele</i>	<i>Brassica campestris var sarason</i>
-	<i>Chakota</i>	-
Chekkurmanis	<i>Chakkramuni</i>	<i>Sauropus androgynans</i>
Ponnanganni	<i>Honagone</i>	<i>Alternathera sessilis</i>
Brahmi	<i>vandelaga</i>	<i>Centeella asiatica</i>

## APPENDIX III

Rehydration ratio of dehydrated *rajagira*

Sl. No	Treatments	Methods of Drying				Mean
		Sun	Shade	Hot air oven	Microwave	
1	Control	4.10	4.92	4.98	5.29	4.82
2	Blanching	4.55	4.97	5.32	5.91	5.19
3	Sulphitation	4.66	5.15	5.30	5.53	5.16
4	Blanching + sulphitation	4.88	5.21	5.60	6.29	5.50
Mean		4.55	5.06	5.30	5.76	5.17
		SE±		CD		F' value
Method		0.01		0.04		2854.14**
Treatment		0.01		0.04		853.57**
MxT		0.02		0.07		76.77**

\*\*Significant at 1 % level

## APPENDIX IV

Chlorophyll content (mg/g) in dehydrated *rajagira*

Sl. No	Treatments	Methods of Drying				Mean
		Sun	Shade	Hot air oven	Microwave	
1	Control	6.70	11.85	11.97	12.04	10.64
2	Blanching	7.43	12.70	12.81	12.84	11.44
3	Sulphitation	5.80	11.75	11.89	11.86	10.32
4	Blanching + sulphitation	7.47	12.74	12.85	12.86	11.48
Mean		6.85	12.26	12.38	12.40	10.97
		SE±		CD		F' value
Method		0.07		0.25		1749.26**
Treatment		0.07		0.25		78.0582**
MxT		0.13		NS		1.88132

Each value represents average of 4 determinations

NS: Non significant, \*\*Significant at 1 % level

## APPENDIX V

Details of Value Added Products (per serving)

Level of *rajagira* incorporated

- Fresh leaves – 50 g
- Sauteed – 50 g fresh vegetable
- Dehydrated – 5g
- Rehydrated – 5g dehydrated vegetable

### Value added chapathi with rajagira

Ingredient	Amount (g)
Whole wheat flour	60
Salt	2
Oil	10
<i>Rajagira</i> leaves	as mentioned

Method

- Mix all the ingredients; add water to make soft dough.
- Divide the dough into two equal portions.
- Roll into *chapathi* and bake on a hot griddle smearing oil on both sides.

Nutrients per serving	Quantity
Protein	10.56g
Iron	12.70mg
$\beta$ -carotene	2490 $\mu$ g

### Value added poori with rajagira

Ingredient	Amount (g)
Whole wheat flour	50
Salt	1.5
Oil	3.25
<i>Rajagira</i> leaves	as mentioned

Method

- Mix all the ingredients; add water to make soft dough.
- Divide the dough into four equal portions.
- Roll into *poori* and fry in preheated oil till golden yellow.

Nutrients per serving	Quantity
Protein	9.35g
Iron	12.25mg
$\beta$ -carotene	2300 $\mu$ g

Value added thalipattu with rajagira

Ingredient	Amount (g)
Whole wheat flour	30
Jowar flour	30
Besan flour	30
Salt	3
Oil	10
Onion	10
Green chili paste	2
Turmeric powder	1/8 <sup>th</sup> tea spoon
Cumin seeds	1
<i>Rajagira</i> leaves	as mentioned

Method

- Mix all the ingredients; add water to make soft dough.
- Divide the dough into two equal portions.
- Pat into thalipattu and bake on a hot griddle smearing oil on both sides.

Nutrients per serving	Quantity
Protein	17.97
Iron	14.90
β-carotene	3462

Value added rajagira bhaji with pulse

Ingredient	Amount (g)
Green gram whole or dhal/ red gram dhal	15
Oil	10
Onion	10
Green Chili paste	2
Mustard seeds	1
Turmeric powder	1/8 <sup>th</sup> tea spoon
Salt	3
<i>Rajagira</i> leaves	as mentioned

Method

- Cook the overnight soaked pulse separately.
- Heat the oil, crackle mustard seeds, fry chopped onions till brown, add chilli paste, salt and turmeric.
- Add *rajagira* leaves, mix well and keep covered till leaves are soft. Add water if required and allow to cook.
- Mix cooked pulse thoroughly and cook for two minutes.

Nutrients per serving	Quantity
Protein	8.43
Iron	10.59
β-carotene	1937

## APPENDIX VI

Score card for evaluation of value added products

Name of the product :

Name of the Judge :

Date:

SL. No.	Parameters	Score			
1	COLOUR AND APPEARANCE				
	Excellent				
	Extremely good				
	Very good				
	Moderately good				
	Good				
	Fair				
	Very fair				
	Poor				
	Very poor				
2	TEXTURE/CONSISTENCY				
	Excellent				
	Extremely good				
	Very good				
	Moderately good				
	Good				
	Fair				
	Very fair				
	Poor				
	Very poor				
3	TASTE				
	Excellent				
	Extremely good				
	Very good				
	Moderately good				
	Good				
	Fair				
	Very fair				
	Poor				
	Very poor				
4	AROMA				
	Excellent				
	Extremely good				
	Very good				
	Moderately good				
	Good				
	Fair				
	Very fair				
	Poor				
	Very poor				
5	OVERALL ACCEPTABILITY				
	Excellent				
	Extremely good				
	Very good				
	Moderately good				
	Good				
	Fair				
	Very fair				
	Poor				
	Very poor				

Remarks

Signature

## APPENDIX VII

### Acceptability scores of value added products

#### a) Acceptability scores of *chapathi* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Sauted	8.0	8.1	8.4	8.0	8.2
Dehydrated	7.5	7.1	7.1	8.0	7.2
Rehydrated	8.0	8.1	7.9	8.2	8.0
Mean	7.83	7.7	7.8	8.06	7.8
SEm±	0.20	0.23	0.24	0.19	0.18
CD at 1 %	NS	0.91	0.96	NS	0.70
'F' value	2.14	6.12**	7.16**	0.37	10.90**

(By using nine point hedonic scale)

NS: Non significant, \*\*Significant at 1 % level

#### b) Acceptability scores of *poori* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Sauted	7.0	6.8	7.2	7.7	6.9
Dehydrated	7.5	7.6	7.9	8.0	7.6
Rehydrated	7.9	8.5	8.2	8.4	8.3
Mean	7.46	7.63	7.76	8.03	7.6
SEm±	0.20	0.18	0.23	0.22	0.21
CD at 1 %	0.80	0.70	0.90	NS	0.81
'F' value	5.01**	22.97**	5.04**	2.66	11.60**

(By using nine point hedonic scale)

NS: Non significant, \*\*Significant at 1 % level

#### c) Acceptability scores of *thallipattu* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Fresh	7.6	7.5	7.9	7.9	7.8
Sauted	7.7	7.8	8.0	7.9	8.6
Dehydrated	7.7	7.6	7.8	7.8	7.8
Rehydrated	7.6	8.6	7.8	7.8	8.0
Mean	7.65	7.87	7.87	7.85	8.05
SEm±	0.17	0.16	0.20	0.20	0.18
CD at 1 %	NS	0.60	NS	NS	0.69
'F' value	0.10	10.07**	0.23	0.03	4.44**

(By using nine point hedonic scale)

NS: Non significant, \*\*Significant at 1 % level

d) Acceptability scores of *bhaji-I* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Fresh	7.6	7.6	7.4	7.4	8.1
Dehydrated	6.4	6.7	6.7	6.7	7.5
Rehydrated	7.1	7.7	8.2	7.4	8.0
Mean	7.03	7.33	7.43	7.16	7.86
SEm±	0.17	0.16	0.17	0.16	0.17
CD at 1 %	0.66	0.61	0.68	0.63	0.65
'F' value	12.74**	12.40**	18.77**	6.39**	3.77*

(By using nine point hedonic scale)

\*\*Significant at 1 % level, \*Significant at 5 % level

e) Acceptability scores of *bhaji-II* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Fresh	7.9	7.8	7.5	8.0	7.5
Dehydrated	7.2	7.9	7.3	7.7	7.2
Rehydrated	8.2	8.4	8.1	8.3	8.3
Mean	7.76	8.03	7.63	8.00	7.66
SEm±	0.21	0.18	0.19	0.19	0.15
CD at 1 %	0.83	NS	0.73	NS	0.59
'F' value	5.87**	3.13	4.92*	2.38	14.08**

(By using nine point hedonic scale)

NS: Non significant, \*\*Significant at 1 % level, \*Significant at 5 % level

f) Acceptability scores of *bhaji-III* with *rajagira* in different forms

Form of <i>rajagira</i>	Sensory characteristics				
	Color and appearance	Texture	Taste	Aroma	Overall acceptability
Fresh	7.6	7.5	7.6	7.9	7.8
Dehydrated	7.1	7.3	7.4	7.6	7.6
Rehydrated	8.2	8.3	8.4	8.3	8.4
Mean	7.63	7.70	7.80	7.93	7.93
SEm±	0.20	0.16	0.18	0.19	0.15
CD at 1 %	0.79	0.62	0.72	0.73	0.60
'F' value	7.51**	11.28**	8.21**	3.54*	7.31**

(By using nine point hedonic scale)

\*\*Significant at 1 % level, \*Significant at 5 % level

## APPENDIX VIII

Effect of value addition with *rajagira* on blood forming nutrient composition of products

Products	Energy	Protein	Iron	Zinc	Total carotene	Folic acid
<i>Chapathi without rajagira</i>	295	7.3	2.9	1.3	17.0	21.5
<i>Chapathi with rajagira</i>	328	10.2	14.1	1.4	7112.0	96.0
<i>Poori without rajagira</i>	200	6.1	2.5	1.1	15.0	17.9
<i>Poori with rajagira</i>	233	9.0	13.6	1.2	7110.0	92.4
<i>Thallipattu without rajagira</i>	420	13.4	4.9	1.8	70.0	62.3
<i>Thallipattu with rajagira</i>	456	16.5	16.0	1.9	7167.0	137.3
<i>Bhaji-I without rajagira</i>	153	3.7	1.0	0.3	25.0	16.7
<i>Bhaji-I with rajagira</i>	193	7.1	12.2	0.7	7108.0	97.3
<i>Bhaji-II without rajagira</i>	153	4.0	1.2	0.6	19.0	1.3
<i>Bhaji-II with rajagira</i>	191	6.8	12.0	0.4	7120.0	91.8
<i>Bhaji-III without rajagira</i>	155	4.1	1.2	0.6	13.0	22.3
<i>Bhaji-III with rajagira</i>	191	7.1	12.3	0.7	7114.0	76.3

Note: *Bhaji I, II* and *III* were based on green gram dhal, red gram dhal and whole green gram respectively.

# ENRICHMENT OF TRADITIONAL FOODS WITH GREEN LEAFY VEGETABLES FOR IRON SECURITY OF ADOLESCENT GIRLS

SEEMA L. KARVA

2008

Dr. PUSHPA BHARATI  
MAJOR ADVISOR

## ABSTRACT

Green leafy vegetables constitute the treasure trove of nutrients in addition to being cheap and easily available. Dehydration of GLVs concentrates nutrients thus providing nutrient dense food for nutrient security. Hence, an investigation was undertaken to develop green leafy vegetable based designer foods for iron security of adolescent girls with the objective to utilize dehydrated GLV in traditional products to ensure iron security.

The preliminary survey of 1000 urban adolescent girls revealed that five GLVs viz., *Rajagira*, *Kiraksale*, *Shepu*, Spinach and Fenugreek were commonly consumed, hence selected for dehydration protocol. Among the selected methods of drying microwave drying was found to be efficient with significantly lesser time of drying (2.24 to 2.86 min) and higher yield (4.47 to 11.12 g/100g). The rehydration ratio of microwave oven dried *rajagira* samples ranged from 5.29 (untreated) to 6.29 (blanched and sulphited) and chlorophyll from 12.04 (untreated) to 12.86 mg/g (blanched and sulphited). *Rajagira* showed highest iron content of 222.52 mg/100g among all dehydrated GLVs.

*Bhajis* and *pooris* with rehydrated *rajagira*, *chapathi* and *thalipattu* with sautéed *rajagira* were scored highest with total scores of 38.4, 41.6, 40.0 and 40.7 respectively and hence were ranked first. The analyzed protein, iron and  $\beta$ -carotene content in all the value added products ranged from 8.43 to 17.97 g, 10.59 to 14.90 mg and 1937 to 3462  $\mu$ g per serving respectively and were able to meet 12.98 to 27.64, 37.82 to 53.21 and 80.70 to 144.25 per cent of RDA respectively for the adolescent girls. Essential amino acid content increased substantially with addition of *rajagira*, thus improving the quality of the products. Hence, the consumption of value added products from *rajagira* might serve as a means of combating anemia and to improve the health.