CONSUMPTION PATTERN OF GREEN LEAFY VEGETABLES AMONG DIFFERENT INCOME GROUPS IN GUTUR TOWN, ANDHRA PRADESH

BY

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DECLARATION

I, Ms. **K. Sri Sai Lakshmi,** hereby declare that the thesis entitled **"Consumption pattern of Green Leafy Vegetables among different income groups in Guntur Town, Andhra Pradesh"** submitted to the **Acharya N. G. Ranga Agricultural University for the degree of Master of Science in Home Science** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

(K. SRI SAI LAKSHMI)

I.D. No. GHM/2017-07

Place : Guntur

Date :

CERTIFICATE

Ms. **K. Sri Sai Lakshmi** has satisfactory prosecuted the course of research and that thesis entitled **“Consumption pattern of Green Leafy Vegetables among different income groups in Guntur Town, Andhra Pradesh”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

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Date:

CERTIFICATE

This is to certify that the thesis entitled **"Consumption pattern of Green Leafy Vegetables among different income groups in Guntur Town, Andhra Pradesh"** submitted in partial fulfillment of the requirement for the degree of Master of Science in Home Science of the Acharya N.G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by Ms. **K. Sri Sai Lakshmi** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of investigations have been duly acknowledged by the author of the thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Percentage
/	:	Or
<	:	Less than sign
=	:	Equal to symbol
>	:	Greater than sign
±	:	Plus – Minus symbol
°C	:	Degree Celsius
µg/100g	:	Microgram per 100 gram
ANOVA	:	Analysis of variance
AOAC	:	Association of Official Analytical Chemists
AP	:	Andhra Pradesh
C.D	:	Critical Deviation
Ca	:	Calcium
CI	:	Confidence Interval
db	:	Decibel
DPPH	:	2,2- diphenyl-1-picrylhydrazyl
DV	:	Daily Value
et al.	:	And other people
Fe	:	Iron
g	:	Gram
g/100g	:	Gram per 100 gram
g/dl	:	Gram per decilitre
GAE/g	:	Gallic Acid Equivalent per gram
GLVs	:	Green Leafy Vegetables
GRAS	:	Generally Recognized as Safe
HIG	:	High Income Group
ICAR	:	Indian Council for Agricultural Research
ICMR	:	Indian Counsel of Medical Research
IDF	:	Insoluble Dietary Fiber
ILVs	:	Indigenous Leafy Vegetables
K	:	Potassium
LBW	:	Low Birth Weight
LIG	:	Little Income Group

MC	:	Moisture content
Meq/kg	:	Milliequvalent per litre
mg	:	Milligram
Mg	:	Magnesium
mg/100g	:	Milligram per 100 gram
mg/kg	:	Milligram/kilogram
MIG	:	Middle Income Group
min	:	Minute
ml	:	millilitre
ml	:	Milliliter
Ml/g	:	Milliliter per gram
mm	:	millimeter
mm2	:	Square millimeter
Na	:	Sodium
RDA	:	Recommended Daily Allowance
SDF	:	Soluble Dietary Fiber
TAC	:	Total Anti-oxidant Capacity
TDF	:	Total Dietary Fiber
TRAP	:	Total Radical-trapping Anti-oxidant Parameter
Viz	:	Namely
w/v	:	Weight per volume
w/w	:	Weight per weight
WHO	:	World Health Organization
µg	:	Microgram
µmol	:	Micro mole

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ABSTRACT

Green Leafy Vegetables (GLVs) are the most commonly consumed vegetables which are found ubiquitously in Indian cuisine. They also add variety to the diet. GLVs are consumed raw in the form of salad, or used as seasonings. Sometimes the GLVs are subjected to processing method such as cooking and dehydration prior to consumption. They are mainly consumed for their nutrients such as high dietary fiber, low lipids, and rich folic acid, ascorbic acid, vitamin K, Magnesium and Potassium. They also contains plenty of phytochemicals such as β-carotene, flavonoids and poly phenolic compounds.

The present study was designed to know the consumption pattern of GLVs in Guntur Town, Andhra Pradesh. The study is based on primary data collected from sample of 150 respondents belonging to the High Income Group, Middle Income Group and Low Income Group 50 from each group. In accordance with the objectives set for the study, data was collected on the consumption pattern of GLVs, the commonly consumed GLVs were subjected to few processing techniques and the retention of nutrients after processing were studied.

The information on consumption pattern of GLVs was collected with the help of a structured interview schedule and the data was analyzed through inferential statistics and ANOVA. From the collected data the most commonly consumed GLVs were found to be Amaranth, Spinach, Gogu, Fenugreek leaves, Rumex leaves, Basella leaves, Ponnanganni, Tamarind leaves, Drumstick leaves, Mint, Coriander and Curry leaves. Coriander and curry leaves are used by the people to prepare Chutney (*Roti pacchadi*), for garnishing salads and curries and for seasoning. Out of 150 respondents majority (92%) were consuming GLVs twice in a week followed by Alternate days (42%). GLVs are also consumed in the form of value added powders. Fifty five percent of the respondents were consuming value added GLVs powders. Among all the GLV

powders, curry leaf powder consumption was found to be high. GLVs are processed to make dhal by adding red gram dhal to it along with other ingredients, curry and *pulusu* are prepared by simmering the GLVs along with other ingredients. They are also consumed after frying in fat along with seasonings. All the respondents were consuming GLVs dhal. Most of the respondents were known the benefits of GLVs. Most of the respondents are with the knowledge of β carotene content in GLVs. Forty four percent of the respondents were storing GLVs prior to consumption.

From the collected data the GLVs consumed by the majority of the subjects were found to be Amaranth, Spinach and Gogu. Hence they were chosen for further determination of nutrient availability after subjecting them to the commonly practiced cooking methods such as pressure cooking, sauteing and simmering. The processed GLVs were analysed to understand the retention of Total Carotenoids, β Carotene, Vitamin C, Calcium, Iron and Total Dietary fiber content.

Total Carotenoids of GLVs showed significant decrease from 72 to 35% on pressure cooking, 80 to 72% on sauteing, 83 to 59% on simmering. β Carotene levels of GLVs showed significant decrease from 76 to 48% on pressure cooking, 76 to 68% on sauteing, 56 to 79% on simmering. Upon processing, the retention of Total Carotenoids β Carotene was being better in sautéing followed by simmering and pressure cooking. Processing resulted in decrease in the Ascorbic Acid content to extreme. Ascorbic Acid showed significant decrease from 4 to 2% on pressure cooking, 14 to 18% on sauteing, 28 to 15% on simmering. Calcium content increased up to 2.3% and 5% on processing in Amaranth and Spinach respectively. With processing the calcium content was increased slightly due the cell wall breakage which results in increased availability of calcium. Iron content of the Amaranth and Gogu did not show any significant difference up on processing. But there was significant difference in iron content of Spinach after simmering. Total Dietary Fiber content of all GLVs showed slight increase on processing. Pressure cooking increased Total Dietary Fiber content from 138 to 118%, sauteing from 117 to 114% and simmering from 108 to 106%.The results of the present study showed that Amaranth, Spinach and Gogu are the GLVs consumed by most of the respondents and the processing/cooking methods used for the GLVs resulted in good retention of the nutrients except for Ascorbic acid.

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Chapter I

INTRODUCTION

Green Leafy Vegetables (GLVs) occupy an important place in the diets of millions of people in India. India is endowed with a wide range of GLVs suited for tropical, sub-tropical and temperate climates. They are grown all-round the year. Consumption of leaves is dated back to the human race itself. GLVs represent a good constituent of the regular diet in the tropical and temperate countries. GLVs add variety to the menu, have good appearance and flavor and above all contain several protective nutrients. In remote rural areas where vegetable cultivation is not practiced and market supplies are not organized, local inhabitants depend on indigenous vegetables, both cultivated in kitchen gardens and wild, for enriching the diversity of food (Mirsa *et al*., 2008). There are about ten major GLVs grown in India. The common ones among them are amaranth (*Amaranthus spp*.), agathi (*Sesbania grandifloa*), beet greens (*Beta vulgaris*), mustard greens (*Brassica spp*.), chekkur manis (*Sourophus androgynous*), drumstick leaves (*Moringa oleifera*), fenugreek leaves (*Trigonella foenum graecum*) and Indian Spinach (*Basella spp*.). Among these GLVs amaranth, spinach, fenugreek and mustard leaves are cultivated on large scale in India.

GLVs are the affordable sources of several phytochemicals such as Dietary fiber, β carotene, Ascorbic Acid, folic acid and minerals like iron, calcium, phosphorus, sodium and potassium (Tiwari *et al*., 2013). β-Carotene which is also known as pro-vitamin A helps and maintain healthy teeth, skeletal, soft tissue, mucus membranes and skin. Vitamin C, phenolics and flavonoids are phytochemical compounds responsible for the antioxidant activity. Calcium and phosphorus are associated with formation and functioning of bones, muscles and tooth. Iron plays important role in prevention of anemia. Consumption of higher levels of vegetable fiber reduces the risk of cardiovascular diseases and colon cancer (Jenkins *et al*., 2001). Phenolics and flavonoids reduce the risk of cardiovascular, chronic and neurodegenerative diseases and certain types of cancer (Das *et al*., 2012; Velderrain-Rodriguez *et al*., 2014; Randhawa *et al*., 2015).

GLVs are pigment-rich and nutritionally relevant functional food with unique phytochemical constituents that include carotenoids which protect cells from oxidation and cellular damage. GLVs are widely designated as “protective foods” in our daily diet due to their valid health benefits attributing to rich vitamins, essential fatty acids, minerals, amino acids and dietary fiber (Shukla *et al*., 2016). These include health-promoting plant secondary metabolites composed of antioxidants and phenolic compounds. It is well acknowledged that ICMR (2011) has recommended to consume 50 g of GLVs per day whereas for pregnant women it is 100 g per day. According to the 2015 Dietary Guidelines for Americans, it is recommended that five servings of vegetables be consumed per day, based on a 2000 calorie intake. Additionally, one of the five subgroups of vegetables recommended is the group of GLVs (HHS & USDA, 2015).

The presence of phytochemicals such as tannins, flavonoids, alkaloids, saponins, terpenoids, cardiac glycosides and phlobatannins contribute to therapeutic properties., The usage of GLVs in daily diets is a common practice since times immorial as they are dense sources of different nutrients and also they are having anti-microbial property. However certain GLVs can produce acute and chronic toxic effects, which makes it compulsory to process and store GLVs properly (Venu *et al*., 2019).

The good nutrition profile of GLVs is beneficial in lowering the risk of cardiovascular diseases and cancer. GLVs are also valued for individuals with type II diabetes as they are high in Mg content which plays a significant role in carbohydrate metabolism, high fiber content which slows down the absorption of glucose and low glycemic index. These contain appreciate amounts of poly phenolic compounds and antioxidants, which makes them unique for therapeutic values. They also possess antimicrobial activity and can be used in different food products to extend storage life. The burden over synthetic chemicals can be reduced by encouraging the use of GLVs in food and food products (Randhawa *et al*., 2015).

However, anti-nutritional constituents present in GLVs such as oxalate can reduce the bioavailability of some minerals, especially calcium (Radek and Savage, 2008). Depending on the species, oxalate can occur as salts of potassium and sodium (soluble oxalates) and as insoluble salts of calcium, magnesium and iron (insoluble oxalates) or as a combination of these two forms (Noonan and Savage, 1999). Soluble oxalate affects the human body because it can bind with calcium and other minerals. It forms strong chelates with dietary calcium, rendering the complex unavailable for absorption and assimilation. Insoluble oxalate in plant tissues is excreted in the faeces while free oxalate and the soluble oxalate are absorbed by the body, which must be eliminated as they have no metabolic use (Albihn and Savage, 2000).

GLVs are generally cooked/processed prior to the consumption. Cooking and other factors such as light, temperature and variation in the moisture content promotes either isomerization (trans to cis form) or oxidative degradation of carotenoids to epoxides. The presence of anti-nutritional factors such as nitrates, oxalates, phytates, cyanogenic glycosides and tannins in GLVs which can affects the absorption of micronutrients and thus, making them unavailable. Thermal processing of leafy vegetables through boiling, cooking and blanching before consumption help in reducing the level of anti-nutrients (Natesh *et al.*, 2017).

GLVs are almost used every day by the people due their inexpensive and easy availability all-round the year which can be used along with spices and condiments and also for garnishing. The consumption of GLVs depends on factors such as availability, time required for cooking, taste, knowledge on their nutritive composition and subsequent health benefits. They are consumed more often after converting them into value added products like curry leaf powder, drum stick leaf powder, mint leaf powder or processed form after incorporating in various recipes along with other ingredients. GLVs can be stored at refrigerated temperature by placing in poly ethylene covers. Availability of nutrients from GLVs depends mostly on the method of processing employed.

The present study was planned to know the consumption pattern of Green Leafy Vegetables of the people belonging to Upper, Middle and Lower income groups living in Guntur town of Andhra Pradesh. This study also aimed to understand the different processing methods commonly practiced for the GLVs and the retention of nutrients. The objectives of the study are:

- To develop a standard schedule to elicit information on consumption pattern of green leafy vegetables among different income groups in Guntur Town.
- To collect information on different cooking methods of Green Leafy Vegetables used by the consumers.
- To determine the availability of selected nutrients such as β carotene, Vitamin C, Iron, Calcium and fibre in commonly consumed green leafy vegetables both in raw and cooked form.

CHAPTER II

REVIEW OF THE LITERATURE

Green Leafy vegetables (GLVs) are grown all-round the year in tropical, sub-tropical and temperate climates. They are most inexpensive components of habitual diet ubiquitously present in Indian cuisines. They are the good sources of dietary fiber, β Carotene, Vitamin C, folic acid and minerals like iron, calcium, phosphorous, sodium and potassium. They are also rich in phenolic compounds which are non-nutritive health promoting factors. Green Leafy Vegetables play a major role in contributing to eye health and organs lining the epithelial tissue. Therefore the present study is planned to examine the consumption pattern of the GLVs in people residing in Guntur town and nutrients available to the people consuming GLVs after commonly practiced processing methods. So far, not much work has been done on the consumption pattern of GLVs and nutrients availability after processing. The available literature on the consumption of GLVs, factors affecting consumption of GLVs, effect of processing on nutritive value of GLVs are presented under the following subheadings.

2.1 Nutrient content of GLVs

2.2 Non Nutritive Components of GLVs

2.3 Antioxidants in GLVs

2.4 Consumption of GLVs

2.5 Effect of Processing on the Nutritive Value of GLVs

2.6 Retention of Nutrients in GLVs

2.7 Bio availability of Nutrients in GLVs

2.1 Nutrient Content of GLVs

Schonfeldt and Pretorius (2011) conducted a study on nutrient content (proximate composition, vitamin B2, β-carotene, iron, zinc, magnesium, calcium and phosphorus) of 5 traditional dark green leafy vegetables, traditionally consumed by rural inhabitants of South Africa. The moisture, protein, ash and fat content in the raw leaves per 100 g ranged from 81.0 to 89.9 g/100 g, 3.49 to 5.68 g/100 g, 1.42 to 3.23 g/100 g and 0.12 to 0.36 g/100 g respectively. There was an increase in moisture content in the cooked leaves, while the protein, fat and ash decreased during the cooking process. Raw misbredie (*Amaranthus tricolor*), pumpkin leaves (*Curcubita maxima*) and cat's whiskers (*Cleome gynandra*) had a high iron content compared to cowpea leaves (*Vigna unguiculata*) and wild jute (*Corchorus olitorius*). The zinc content ranged from 0.5 to 1.0 mg/100 g, while the magnesium ranged from 54.7 mg to 146 mg/100 g. As expected, the minerals decreased during cooking. Cowpea leaves was the poorest source of minerals compared to the other leafy vegetables but had a good index of nutritional quality for protein. Raw and cooked pumpkin leaves had the highest index of nutritional quality for protein. Both raw and cooked leafy vegetables contained high levels of beta-carotene (with total beta-carotene levels in the range of 796–6134 μg/100 g) but low levels of vitamin B2 (0.01–0.12 mg/100 g).

Kumar *et al.* (2013) reported that green leafy vegetables are of great medical importance due to the health benefits produced. Green Leafy Vegetables contain several chemical constituents which are pharmacologically important as they are been proved to be beneficial in many specific diseases like cancer, diabetes, hepatotoxicity, nephrotoxicity and many microbial attacks.

Tiwari *et al.* (2013) reported in their study that all the leafy vegetables juice displayed potent free radicals scavenging activities. Amaranthus leaves juice potently mitigated glucose-induced postprandial glycemic load and also reduced hemoglobin glycation induced by glucose *in vitro*.

Lewu and Kambizi (2014) had done a comparative study on the nutritional compositions of leaves of the vegetable species such as *Brassica oleracea L. var acephala* (leaf cabbage) commonly known as Chomoullier and *Brassica napus L.* (leaf rape) which are traditional leafy vegetables widely grown in Kenya (East Africa) and Zimbabwe (southern Africa). Urtica urens on the other hand, is a wild leafy vegetable consumed in rural communities of South Africa. The three species investigated were high in moisture. The Brassica species had significantly higher moisture content (85.19% and 84.72% for "Choumollier" and "Rape" respectively) compared with *U. urens* (83.70%). *B. napus, B. oleracea L. var. acephala* and *U. urens* are good sources of many nutrients like protein, crude fibre, Ca, P, Fe, Mn, Zn and Cu. The levels of ash, crude protein and crude fiber in *U. urens* were consistently higher than those of the two Brassica species. The ash content is an index of the nutritionally important mineral contents present in the food material. Considering the substantial amount of minerals in these vegetables and most especially high level of micronutrients in *U. urens*, these plants may be considered valuable and important contributors to the diets.

Randhawa *et al.* (2015) reported that the low caloric value of leafy vegetables makes them ideal for weight management. GLVs are a rich source of nutrients, high in dietary fiber, low in lipids, and rich in folate, ascorbic acid, vitamin K, Mg, and K. They also carry plenty of phytochemicals such as β-carotene and flavonoids. The good nutrition profile of GLV is beneficial in lowering the risk of cardiovascular diseases and cancer. GLVs are also valued for individuals with type 2 diabetes due to their high Mg content, high fiber content and low glycemic index.

Jimenez-Aguila *et al*. (2017) conducted a study to evaluate mineral, vitamin C, phenolic and flavonoid concentrations and antioxidant activity levels in 15 leafy Amaranthus species. Across species, the concentration ranges of Ca, K, Mg, P and phenolics, and activity ranges of antioxidants in amaranth leaves were 1.5-3.5mg/g, 5.5-8.8 mg/g, 1.8-4.5 mg/g, 0.5-0.9 mg/g, 3.2-5.5 mg gallic acid equivalents/g, and 38-90 μmol Trolox equivalents/g (all values on a fresh weight basis), respectively. *Amaranthus acanthochiton* had the highest concentrations of Ca, Mg, Ni, Zn, and *A. deflexus* and *A. viridis* had the highest concentrations of Fe .One serving of any of the Amaranthus leaves (1 cup; 30 g of fresh weight) would contribute from 13 to 34% of the daily value (DV) of Mg (DV = 400 mg; as established by the US Food and Drug Administration), and up to 68% of the DV of vitamin C (DV = 60 mg). *A. acanthochiton* can be considered a good source of Ca, Mn and Mo (10%-19% of the DV), and an excellent source of Mg and vitamin C (20% or more of the DV).

Morris *et al*. (2018) conducted a study on nutrients and bioactives in green leafy vegetablesb and cognitive decline to increase understanding of the biological mechanisms underlying the association between cognitive decline to the primary nutrients and bioactives in green leafy vegetables, including vitamin K (phylloquinone), lutein, β-carotene, nitrate, folate, kaempferol, and α-tocopherol. 960 participants of the Memory and Aging Project, ages 58–99 years, who completed a food frequency questionnaire and had ≥2 cognitive assessments over a mean 4.7 years were chosen for the study. Results had shown that higher intakes of each of the nutrients and bioactives except β-carotene were individually associated with slower cognitive decline. Consumption of approximately 1 serving per day of green leafy vegetables and foods rich in phylloquinone, lutein, nitrate, folate, α-tocopherol, and kaempferol may help to slow cognitive decline with aging.

2.2 Non nutrients in GLVs

Radek and Savage (2008) conducted a study on oxalates in some Indian green leafy vegetables and determined the soluble and total oxalate contents of 11 leafy vegetables grown in India. Spinach, purple and green amaranth and colocasia contained high levels of total oxalates, which ranged from 5,138.0937.6 mg/100 g dry matter up to 12,576.19107.9 mg/100 g dry matter. Seven other leafy vegetables (curry, drumstick, shepu, fenugreek, coriander, radish and onion stalks) contained only insoluble oxalate, which ranged from 209.095.0 mg/100 g dry matter to 2,774.9918.4 mg/100 g dry matter. In vitro digestion of the samples showed that the gastric available oxalate was 10% lower than the values obtained from acid extraction and that intestinal available oxalate was 20% lower than the values obtained following hot water extraction. The percentage calcium bound in the insoluble oxalate fraction of the dried leafy vegetables ranged from 3.3% to 86.7% of the total calcium. Addition of four different sources of calcium (low fat milk, whole milk, calcium carbonate and calcium sulphate) resulted in a range of 32100% reductions of intestinal available oxalate in the mixture.

Khanam *et al.* (2012) conducted a study on phenolic compounds and total antioxidant capacity of eight leafy vegetables, namely Komatsuna, Mizuna, Pok choi, Mitsuba, Salad spinach, Lettuce, Red amaranth and Green amaranth were determined. The phenolic compounds were characterized as hydroxybenzoic acids, hydroxycinnamic acids and flavonoids. Salicylic acid was the most common hydroxybenzoic acid, ranging from 4.40 to 117.36 μg/g fresh frozen weight (ffw). Vanilic acid, gallic acid, caffeic acid, chlorogenic acid, *p*-coumaric acid, ferulic acid and *m*-coumaric acid were commonly found in all of these vegetables. Isoquercetin and rutin, the most common flavonoids, ranged from 3.70 to 19.26 and 1.60 to 7.89 μg/g ffw, respectively, and hyperoside was highest (38.72 μg/g ffw) in Mizuna. Total antioxidant capacity values varied widely between $ABTS^{\cdot +}$ and DPPH assay methods, with values reported as equivalents to trolox, quercetin and ascorbic acid. Among these vegetables, total antioxidant capacity was found in the following order: Pokchoi > Komatsuna > Mizuna > Mitsuba > Redamaranth > Lettuce > Greenamaranth > Salad spinach.

Mibei *et al.* (2012) investigated the phytochemical composition and relative antioxidant activity of selected African indigenous leafy vegetables (ILVs). *Corchorus olitorius* (Jute mallow), *Crotalaria ochroleuca* (Slender leaf), *Solanum scabrum* (Black nightshade) and *Cleome gynandra* (Spider plant). The crude extracts were prepared by methanol extraction. The study revealed the presence of a wide array of phytochemicals including alkaloids, flavonoids, tannins, saponins, steroids and phenols whereas terpenoids, steroids and anthraquinones were absent in most ILVs. The antioxidant activity was achieved by screening the leaf extracts for their free radical scavenging properties using diphenyl picryl hydrazyl (DPPH) and ascorbic acid as standard antioxidant.The ability of the extracts to scavenge DPPH radicals was determined spectrophotometrically at 517nm. The four ILV extracts had significant radical scavenging effects and almost all reported a significantly higher percentage of DPPH inhibition than ascorbic acid ($P < 0.05$). The extracts of *C. olitorius* and *C. gynandra* were most effective since they had higher percentages of radical scavenging activity and lower IC50 values (concentration which scavenged 50% of the DPPH radicals). The results therefore indicated that these vegetables are phytochemical rich and natural antioxidants with potent antioxidative activities.

Ahmed *et al.* (2013) revealed the phytochemical characters of *Amaranthus viridis* in both leaves and seeds. Alkaloids, tannins, saponins and glycosides were present in both leaf and seed. Leaves contained the highest percentage crude yield of alkaloids, tannins, saponins and cardiac glycosides. *Amaranthus viridis* extract possessed the ability to be effective, under physiological conditions, in reducing the transition state of iron and consequently, the rate at which super oxide and hydroperoxyl radicals are generated from the metal. The extract yields from the leaves and seeds ranged 5.5 - 6.1 and 2.42% - 3.72% w/w, respectively. Phytochemical investigation of this plant determines that tanins (6.07% - 5.96%), saponins (53% - 32%), alkaloids (13.14% - 11.42%), protiens (16.76% - 24.51%) and glycosides (63.2% - 32.3%) were rich in leaves. The extracts also contained appreciable levels of total phenolic contents (2.81 - 3.61 GAE, g/100 g), total flavanoid contents (18.4 - 5.42 QE, g/100 g) and DPPH free radical scavenging activity, showing IC50 (83.45 - 75.95 µg/mL) along with reducing power. The MIC of extracts ranged 178 - 645 µg/mL.

2.3 Antioxidants in GLVs

Gacche *et al*. (2010) conducted a study on eleven different fruits and leaves of commonly used vegetables in diet of Asian subcontinent. They have been evaluated for antioxidative constituents and free radical scavenging activities. Fifty per cent ethanolic extracts of *Abelmoschus esculentus* (Linn.) Moench (fruits), *Trigonella foenum-graecum* Linn. (leaves), *Spinacia oleracea* Linn. (leaves), *Brassica oleracea* Linn. var. *capitata* and *B. oleracea* var. *botrytis* (leaves, inflorescence and young stems), *Coriandrum sativum* Linn. (seeds and leaves), *Capsicum annuum* Linn. var. *grossum* (Willd.) Sendt. (fruits), *Cucurbita maxima* Duch. (fruits), *Cyamopsis tetragonoloba* Linn. (fruits), *Anethum graveolens* Linn. (fruits and seeds), *Solanum melongena* Linn. (fruits) were tested for the determination of free radical scavenging potentials and quantification of antioxidant agents such as ascorbic acid and phenolic compounds. Amongst the vegetables the sample of *B. oleracea* var. *botrytis* has shown (67.2%) the highest 1, 1-Diphenyl-2-picryl hydrazine (DPPH radical) scavenging potential while *B. oleracea* var. *capitata* was found to be the most effective (58.4%) inhibitor of lipid peroxidation. The extract of *S. oleracea* (43.9%) and *S. melongena* (32.8%) were found to be effective in ferrous ion chelating abilities. The maximum amount (25.60mg/100g) of vitamin-C was found in *A. esculentus* while the amount of total phenolics was noted maximum (13.30 mg/g) in *C. maxima*.

Gopi *et al.* (2011) studied the antioxidant activities of the leafy vegetables of Cuddalore district. The antioxidant activity were measured in different systems of assay like DPPH assay, superoxide radical-scavenging assay, hydroxyl radical scavenging assay and lipid peroxidation assay. Taking 0% inhibition in the mixture without plant extract, regression equations were prepared from the concentrations of the extracts and percentage inhibitions of free radical formation. The extracts were found to have different levels of antioxidant activity in different systems tested. Highest anti-oxidant activity was found in *Moringa pterygosperma* (MP) followed by *Solanum nigrum* (SN), *Alternanthera sessilis* (AS), *Chenopodium album* (CA) and the lowest activity was found in *Amaranthus polygamus* (AP). SN and MP had the highest activity. Then the poorest activity was noted in AP. MPs has strongest superoxide radical-scavenging activity others showed very less activity only, among them CA showed poorest activity. MP has the strongest DPPH radical scavenging activity. The least activity was absorbed in AS, followed by CA, AP, SN. The total antioxidant capacity (FAA and SAA) was highest in MPs and lowest in CA. Of all the leafy vegetables CA has poorest activity and MP has good activity.

Jacob and Shenbagaraman (2011) evaluated antioxidant and antimicrobial activities of the selected green leafy vegetables such as *Amaranthus tricolor L., Centella asiatica L., Hibiscus sabdariffa L., Moringa oleifera Lam., Sesbania grandiflora (L.) Poir* and *Solanum trilobatum L.* Phytochemical screening of the plant extracts revealed some difference between them. *S.trilobatum, C.asiatica* and *S.grandiflora* extracts showed positive results for all the classes of chemicals. Greater inhibition of free radicals in *H. sabdariffa, C.asiatica* and *M.olifera* may be due to the presence of high amount of alkaloids and flavonoids. The presence of flavonoids and tannins in all the plants are likely to be responsible for the free radical scavenging effects observed which are the phenolic compounds and plant phenolics are a major group of compounds that act as a primary antioxidant or free radical scavenger. The lack of antimicrobial activity in aqueous extracts and some ethanolic extracts may be due to the absence of antimicrobial components in these extracts. Leaf extracts contain less antimicrobial activity compared to stem and other parts, due to the interference of pigments and phenolics with the antimicrobial activity of these extracts. The lack of antimicrobial activity in these extracts may be due to the presence of pigments like carotene and phenolics in these plants. Since the selected leafy vegetable samples are rich in carotene and varying levels of antioxidants.

Kim *et al*. (2013) investigated antioxidant and antimicrobial activities of leafy green vegetable extracts and their applications to meat product preservation. Fresh leaves of butterbur (*Petasites japonicus Maxim*), chamnamul (Pimpinella brachycarpa (Kom.) Nakai), bok choy (*Brassica campestris L. ssp. chinensis*), Chinese chives (*Allium tuberosum Rottler ex Spreng*), crown daisy (*Chrysanthemum coronarium L.),* fatsia (*Aralia elata Seem*), pumpkin (*Curcubita moschata Duch*), sesame (*Perilla frutescens var. japonica Hara*), stonecrop (*Sedum sarmentosum Bunge*), and flowering head of broccoli (*Brassia oleracea L. var. italica Plenk*) were purchased from local farms during the harvest season in April - June in Suwon, South Korea. Although broccoli is not a GLV, it was used as a positive control due to its reported antioxidant activity. The extracts of GLV when evaluated for their antibacterial and antioxidant abilities Chamnamul and fatsia extracts showed better antibacterial and antioxidant activity than other GLV. These natural extracts contain a large amount of essential oil compounds, as well as phenolic acids, that can help control foodborne pathogens and inhibit lipid oxidation. And when applied to raw beef patties natural antioxidants from chamnamul and fatsia appear to reduce the final microbial load and retard lipid oxidation during refrigerated storage. These GLV naturally contain green-colored pigment, which has a negative impact on patty color. The addition of fatsia extract was as effective against microbial growth and oxidative reactions as synthetic additives. GLVs are considered GRAS, more acceptable to consumers, and also potentially good for human health.

Sahu *et al.* (2013) investigated phytochemical screening of phenolic content and antioxidant activity of six leafy vegetables used by tribals of Koraput district in odisha in different extracts. Amoung the different leafy vegetables Olax psittacorum has the highest antioxidant activity which is very close to leucas aspera. Other four leafy vegetables like Ipomoea Cairica, Commelina benghalensis, Cassia tora and Bauhinia purpurea are also equally potent. The ethanolic extract possesses more antioxidant activity than methanol and hexane extract. The phytochemical analysis of leafy vegetables indicates the presence of phenolic contents in different degrees and the positive correlation between antioxidant activity and total polyphenols (r=0.993) suggests that phenolic compounds are the major antioxidant components in the leafy vegetables. Rich phenolics of the leafy vegetables and its high antioxidant activity may be responsible for providing dietary antioxidants.

Routray *et al.* (2013) conducted a study on seven edible widely used leafy vegetables of Odisha namely *Amaranthus tricolor, Amaranthus viridis, Brassica oleracea, Brassica campestris, Basella alba, Cucurbita maxima, Cicer arietinum.* They have been analyzed for their DPPH radical scavenging activity, using methanol, ethanol, petroleum ether as solvent. Their total phenolic content was measured by Folin-ciocalteu reagent. The plant extracts were found to have different levels of antioxidant properties . A positive correlation between the phenolic contents and the in vitro free radical scavenging activity of the plant extracts. In all the species methanolic and ethanolic extract gave maximum yield of crude extract, phenol content as well as antioxidant activity. Highest antioxidant activity was demonstrated in Brassica campestris followed by *Amaranthus tricolor* and *Cucurbita maxima*. Accordingly minimum IC50 values were obtained in the concentration of maximum antioxidant activity. These values are comparable with ascorbic acid as standard. The rich phytochemical contents especially phenolics of the leafy vegetables and good antioxidant activity may be responsible for its wide and popular use in any balanced diet.

Amornrit and Santiyanont (2016) investigated the antioxidant properties of Amaranthus extracts and their effect on the nervous system. The leaves of *Amaranthus lividus* and *Amaranthus tricolor* were extracted using petroleum ether, dichloromethane, and methanol. Results indicated that antioxidant activities were the highest in methanol extracts from both kinds of Amaranthus leaves. Oxidative stress was induced in human neuroblastoma cell lines (SH-SY5Y) by using H_2O_2. Intracellular oxidative stress, cytotoxicity, and gene expression of RAGE were then determined. In vitro results demonstrated that pretreatment with *A. lividus* and *A. tricolor* extracts can significantly decrease cell toxicity and intracellular ROS production in SH-SY5Y cells. The extracts also significantly downregulated the expression of oxidative stress genes such as HMOX-1, RAGE, and RelA/ NF-κB. Amaranthus leaves may be useful for reducing oxidative stress and may be beneficial for age-related diseases and neurodegenerative disorders.

Gunathilake and Ranaweera (2016) investigated antioxidative properties of 34 green leafy vegetables. Total phenolics, chlorophyll and carotene contents of 34 leafy vegetables were analysed. The total phenolic content of the methanolic extracts of leafy vegetables was within the range of 0.92.0– 11.03 mg GAE/g dry weight of leaf. Of all the leafy vegetables , *Gymnema lactiferum and Sesbania grandiflora* leaves showed the highest total phenolic contents (11.03 and 10.98 mg GAE/g dry weight of leaf respectively), followed by *Cassia auriculata* leaves (10.70 mg GAE/g dry weight). Chlorophyll content in leafy vegetables ranged from 9.20 to 37.10 g/g dry weight. *Boerhavia diffusa* (9.20 g/g), *Alternanthera sessilis* (9.55 g/g), *Allium cepa* (9.45 g/g) and *Amaranthus caudatus* (11.37 g/g) showed significantly lower chlorophyll content, whereas *Asteracantha longifolia* (37.10 g/g) had the highest chlorophyll content. Carotene content of all the leafy vegetables was within the range of 0.47–4.17 mg/g dry weight. *Passiflora edulis* had the highest carotene content (4.17 mg/g), followed by *Cassia auriculata* (3.45 mg/g), *Solanum nigrum* (3.18 mg/g) and *Syngonium angustatum* (3.13 mg/g). The lowest carotene content was observed in Alternanthera sessilis (0.47 mg/g), *Allium cepa* (0.53 mg/g), *Boerhavia diffusa* (0.67 mg/g), *Osbeckia octandra* (0.79 mg/g) and *Bacopa monnieri* (0.89 mg/g). *Olax zeylanica* and *Ipomoea batatas* show higher DPPH radical scavenging activities compared with other leaf extracts. *Murraya koenigii Spreng, Hemidesmus indicus, Cassia auriculata* and *Sesbania grandiflora* extracts also show higher DPPH radical scavenging activity compared to other leaves. *Asteracantha longifolia, Alternanthera sessilis, Amaranthus lividus, Amaranthus caudatus* and *Syngonium angustatum* displayed significantly lower DPPH radical scavenging activity. It shows that all leafy vegetables have remarkable variations in their antioxidant activities. Among the plant materials screened for their antioxidant properties, *Sesbania grandiflora, Cassia auriculata, Murraya koenigii Spreng, Passiflora edulis, Gymnema lactiferum* and *Olax zeylanica* showed high carotene content, antioxidant activities and polyphenolics compared to other leaf varieties.

2.4 Consumption of GLVs

Prabha *et al.* (2008) conducted studies on consumption pattern of green leafy vegetables among selected urban households in Bangalore, India and reported that green leafy vegetables were consumed twice or thrice a week in majority of the population, irrespective of the occupation. Majority of women (50%) of all the age groups, all the monthly income groups and educational level consumed vegetables twice a week. Percapita consumption of greens ranged between 48-66 g for the adult and adolescents as against a figure of 100 g recommended by ICMR. Family income and education had no impact on their consumption. Important factors affecting nutrient loss in fresh greens between harvest and use on table include duration of time they are stored and also the method of storage.

Nkafamiya *et al*. (2010) carried out a study 14 non-conventional leafy vegetables consumed by rural populace in Michika Local Government Area of Adamawa State Nigeria. They were assessed for vitamins and effect of blanching on their nutrients and anti-nutrients content. Before blanching Ficus asperifolia has the highest level of vitamins followed by Adansonia digitata. These values are higher compared to those of some common Nigerian vegetables. Proximate composition showed that the leaves have high carbohydrate, crude protein and crude fiber. The anti-nutritional factors were analyzed; oxalate, hydrogen cyanide (HCN), tannin, alkanoids and phytate, in the vegetables were lower than the range of values reported for most vegetables. After blanching the vitamin content, nutrient composition and antinutrients decrease. Though the anti-nutrients decrease as a result of blanching, the leaves are best used in diet preparation before blanching as the anti-nutrient content of the leaves before the blanching are below the established toxic level.

Pandey and Neerubala (2013) conducted a cross – sectional descriptive survey on food consumption patterns of adult population in rural and urban area of Faizabad District. Total 400 respondents aged above 18 years were selected by simple random sampling. They were interviewed with a modified version of WHO stepwise questionnaires to obtain information on demographic and socioeconomic characteristics as well as food consumption patterns. The mean age of the respondents was 35 years. Majority of urban populations (28.5%) were businessman, while the participants from rural areas were predominantly farmers (47.5). 78.5% and 60% of both rural and urban respondents were belonging to vegetarian category respectively. Cereals consumption in rural and urban areas was quite similar in a month, it included mainly wheat and rice only, While the consumption of coarse grains was very low (2-3 days in a month). Consumption of pulses included red gram and green gram dhal had taking by rural population by 15-20 days in a month, while in urban population it was 10-15 days in a month. Only seasonal and low cost fruits were consumed by rural population while all type of fruits was consumed by urban population, but it was below 5 serving in a day. Consumption of leafy vegetables was 5-10 days in a month for both urban and rural population. The study revealed that low cost, easily available and staple foods was frequently consumed by rural population. Mustard oil was the commonest type of oil used in cooking food in rural area, while refined oil and soybean oil was frequently consumed by urban population. On other hand consumption of foods considered as less healthy such as fast foods/pastries, sweets, chocolates, soft-drinks were frequently consumed by urban population.

Joglekar *et al*. (2014) explored the factors responsible for the knowledge towards green leafy vegetables among women from Raipur city. This study was conducted on 100 women between ages group of 15 to above 45 years. 14 GLVs were selected for the study based on their availability. It is concluded that the Palak (*Spinancia oleravea*) and Methi (*Trigonella foenum graecum*) has the highest awareness among with 100% and 98% which is followed by Dhaniya (*Coriander Satimum*), Mithi Neem (*Murraya Koenigii*) and Pudina (*Mentha Spicata*). Very few people have awareness about Kusum (*Carthamus Tinctorius*) (6%), Chana (*Cicer Arietinum*) (12%) and Pyaj (*Allium Cepa*) (14%). That in a week 28% of women consume GLVs at least three times whereas 22% of women consume GLV once in a week, 24% of the women consume GLV twice in the week, whereas 8% of women have respondent they consume GLV 4 times in a week and 18% of women have said that they won't cosume GLV. Women normally consume most of the GLVs during the dinner as 60% of women reported this, and further 40% of the respondents says they would prefer to consume GLVs during the breakfast, 26 % of the women says they take GLV during the lunch and 10% of GLV consuming women have said that they consume GLV at evening. Totally 82% women said that they consume Green Leafy Vegetables. 27% of women consumed GLVs since they were cost effective, 25% of women consumed the GLV's due to perceived nutritional value 21% for their easy availability and only 7% of women have reported their consumption is due to medical recommendation.

Mathiventhan (2014) conducted a study on identification, market availability and consumption of green leafy vegetables in Batticaloa, Sri Lanka and found that fifty nine species of Green Leafy vegetables (GLVs) were identified, which were consumed for food and medicinal purposes. Among the identified species, 29 were supplied by the markets in the Batticaloa district and the others from home gardens and forest lands. Thirty one species were consumed commonly and their average consumption was 59%. Twenty eight species were consumed rarely and their average consumption was 2%. Availability of GLVs depends on size of the markets, seasonality, and easy access of supply area to markets and attitude of people. GLVs were consumed both in cooked and uncooked states. Lactuca sativa was the only GLV consumed in uncooked form for food purpose and *Coleus amboinicus*, *Momordica charantia*, *Ocimum tenuiflorum* and *Tribulus terrestris* were the only GLVs consumed in uncooked form for medicinal purpose. Average consumption of commonly consumed leafy vegetables was 31% and 28% on weekly and monthly basis respectively. But rarely consumed leafy vegetables were consumed less than 2% on weekly as well as on monthly basis. Eighty eight percent of the study subjects consumed GLVs immediately and 12% of study subjects consumed after 2–3 days of purchasing/harvesting. Excess GLVs were stored mainly at room temperature (30±2 ºC) and at 4ºC for a maximum of 4 days. Sixty five percent of study subjects preferred to store at 4ºC and 23% at room temperature.

Shukla *et al*. (2018) conducted a cross sectional study on 336 school going adolescent girls to study the eating habits among school going adolescent girls in Barabanki District, Uttar Pradesh. The adolescent girls were interviewed using self-administered questionnaire on their dietary pattern, food habits and preferences and were thus assessed. Most of them had consumed regular food items like chapatti, rice and dal (more than 80%). Nearly half of them had consumed green leafy vegetable and snacks in between meals like papads, pickles, bakery products and fast food like chowmein/burger etc. The consumption of deep fried snacks/namkeens/potato chips was also reported in four- fifth of the cases. The consumption of milk as such was found in 32.7% of cases. Similar pattern was seen with respect to consumption of chocolate/pastries/sweets. Also the eating of egg and meat products was reported in 30.4% and 32.7% subjects respectively. Regarding regularities in meals, about one-fourth (22.6%) of the girls stated they never take breakfast before coming to school. But none of the girls reported any missing with respect to lunch and dinner. Daily intake of breakfast was found in 16.9% of the subjects. 43.0% of the girls stated about frequent missing of meals.

Zerfu *et al*. (2018) conducted a study on consumption of dairy, fruits and dark green leafy vegetables is associated with lower risk of adverse pregnancy outcomes (APO): a prospective cohort study in rural Ethiopia. The study employed a prospective cohort follow-up study design enrolling 374 pregnant women from their initial antenatal care (ANC). All mothers were then followed monthly (for a total of four visits) from enrollment to delivery. The results showed that, out of the 374 pregnant women who completed the study, one in five [74 (19.8%)] experienced at least one of the APO: 34 (9.1%) gave birth to LBW babies, 51(13.6%) had PTB and 17 (4.5%) experienced stillbirth. Poor or inconsistent consumption of dark green leafy vegetables (adjusted odds ratio (AOR) = 2.01; 95% confidence interval (CI): 1.04–3.87), dairy products (AOR = 2.64; 95% CI: 1.11–6.30), and fruits and vegetables (AOR = 2.92; 95% CI: 1.49–5.67) were independently associated with higher APO risks. Whereas, being non-anemic at term (AOR = 0.24; 95% CI: 0.12–0.48) was independently associated with lower APO risks.

2.5 Effect of Processing on the Nutritive Value of GLVs

Miglio *et al.* (2008) evaluated the effect of three common cooking practices (i.e., boiling, steaming, and frying) on phytochemical contents (i.e., polyphenols, carotenoids, glucosinolates, and ascorbic acid), total antioxidant capacities (TAC), as measured by three different analytical assays [Trolox equivalent antioxidant capacity (TEAC), total radical-trapping antioxidant parameter (TRAP), ferric reducing antioxidant power (FRAP)] and physicochemical parameters of three vegetables (carrots, courgettes, and broccoli). Water-cooking treatments better preserved the antioxidant compounds, particularly carotenoids, in all vegetables analyzed and ascorbic acid in carrots and courgettes. Steamed vegetables maintained a better texture quality than boiled ones, whereas boiled vegetables showed limited discoloration. Fried vegetables showed the lowest degree of softening but antioxidant compounds were less retained. An overall increase of TEAC, FRAP, and TRAP values was observed in all cooked vegetables, probably because of matrix softening and increased extractability of compounds, which could be partially converted into more antioxidant chemical species.

Chang *et al*. (2012) conducted a study on carotenoids retention in leafy vegetables based on cooking methods. The vegetables selected were Chinese cabbage (*Brassica Pekinensis var. cephalata*), swamp cabbage (*Ipomoea aquatica*), spinach (*Spinacia oleracea*), Ceylon spinach (Basella rubra), red spinach (Amaranthus gangeticus), white spinach (*Amaranthus viridis*) and tapioca shoots (*Manihot utilissima*). Results showed that stir-frying had reduced lutein content for all vegetables ranging from 8-89% while the effect of boiling for lutein varied (0-428%) with different vegetables at both cooking durations of 4 and 8 min. Boiling for 8 min increased retention of β-carotene in all vegetables ranging from 18-380% except for Chinese cabbage and spinach compared with 4 min, while stir-frying generally increased the retention of β-carotene for all vegetables 2-3 times except for spinach. Cooked vegetables have variations in carotenoids composition brought by varying cooking conditions (time and temperature), type of vegetables and the interaction between cooking methods and type of vegetables.

Ilelaboye *et al*. (2013) studied effect of cooking methods on mineral and anti-nutrient composition of some green leafy vegetables. Seven tropical leafy vegetable species (*Talium triangulae, Amaranthus hydrides, Colocaisa esculenta, Telfairia occidentials, Solanum nigrum, Crassocephalum crepidiodes* and *cindosculus aconitifolis*) that are used as soup condiments in Nigeria either in the processed or unprocessed forms, were subjected to two cooking methods (cooking without blanching and cooking after blanching). There is varietal influence on the mineral and anti nutritional contents of the vegetables. All the mineral elements; Calcium, Phosphorus, Potassium, Magnesium, Iron, Manganese, Copper and Zinc, except Sodium (155.14mg/Kg to 4759.80mg/Kg) were reduced by the cooking methods. There was 45.96% to 69.33%, 39.22% to 64.42%, 76.71% to 87.88%, 68.10% to 98.33% and 78.78% to 88.02% reduction in phytate, oxalate, saponin, tannin and cyanide contents of the vegetables respectively due to cooking methods.

Oulai *et al.* (2014) conducted a study on impact of cooking on nutritive and antioxidant characteristics of leafy vegetables consumed in northern côte d'ivoire. Five leafy vegetable species (*Amaranthus hybridus, Andasonia digitata, Ceiba patendra, Hibiscus sabdariffa* and *Vigna unguiculata*) that are used as soup condiments in Northern Côte d'Ivoire were subjected to cooking in order to evaluate the effect of this processing method on their nutritive value and antioxidant properties. The result of the study revealed that longer time of cooking (higher than 15 min) caused negative impact by reducing nutritive value but positive impact by reducing anti-nutrients such as oxalates and phytates. The registered losses at 15 min were as follow: ash (9.41 – 62.87 %), proteins (11.33 - 36.24 %), vitamin C (33.33 – 82.14 %), carotenoids (69.17 - 100%), oxalates (27.23 – 59.10%) and phytates (40.29 – 91.03%).The average reduction at 15 min of cooking was 31.30 – 56.02% for polyphenols content. Contrary to these reductions, a slight increase of fiber content was observed in the studied cooked leafy vegetables. Furthermore after 15 min, the residual contents of minerals were: calcium (139.10 – 314.46 mg/100g), magnesium (40.55 – 344.57 mg/100g), phosphorus (120.46 – 248.93 mg/100g), potassium (177.65 – 747.28 mg/100g), iron (18.62 – 34.31 mg/100g) and zinc (7.33 – 26.33 mg/100g). All these results suggest that the recommended time of domestic cooking must be less than 15 min for the studied leafy vegetables in order to contribute efficiently to the nutritional requirement and to the food security of Ivorian population.

Singh and Harshel (2016) studied effects of cooking on content of Vitamin C in Green Leafy Vegetables namely, Spinach (*Spinacia oleracea*), Methi (*Trigonella foenum-graecum*), Lal maath (*Amaranthus cruentus*), Chauli (*Thotakur avepudu*) and Bhathua (Chenopodium album). Processing methods employed were boiling, blanching and microwave heating the vegetables for particular time interval. The vegetable extracts were subjected to 0.01% N-Bromosuccinimide titration to estimate their Vitamin C content before and after the treatment. Results revealed that maximum reduction in Vitamin C activity of vegetable samples were observed with microwave heating followed by boiling and blanching. Vitamin C content of microwave heated samples resulted into 50-75% reduction, boiled vegetable samples showed 40-50% reduction in their vitamin C activity, and blanching lead to minimum reduction i.e. 20-35% as compared to unprocessed vegetable samples. Vitamin C is easily destroyed by excessive heat and water as well as exposure to air. For retention of Vitamin C in cooked foods, it is recommended that foods containing Vitamin C be cooked as fast as possible with less heat and small amount of water.

Saranya *et al*. (2017) carried out a study out to identify a suitable blanching temperature, time and chemical media for the green leafy vegetables namely, *Alternanthera sessilis, Cardiospermum helicacabum* and *Celosia argentea* that ensures enzyme inactivation and maximum nutrient retention. The leaves were processed by the following methods (i) Blanched at 80°C, 90°C and 100°C for 5 min in distilled water (ii) Blanched in water containing chemical media (potassium metabisulphite (KMS), sodium bicarbonate and sodium chloride) at 80°C for the 1 min, 2 min and 4 min respectively. All of the three leafy vegetables *Alternanthera sessilis*, *Cardiospermum helicacabum* and *Celosia argentea* have been found Vitamin C was sensitive to heat and oxidation during blanching. Among the plants selected, *Alternanthera sessilis* had a better retention of Vitamin C followed by *Cardiospermum helicacabum* and *Celosia argentea*. Potassium metabisulphite showed better retention of vitamin C followed by sodium bicarbonate and sodium chloride. Blanching at 80°C for 1 min ensured peroxidase inactivation in all greens. The losses of nutritional content protein, moisture, fiber and iron were marginal. But Vitamin C which is a major antioxidant known for proper functioning of the human body had a better retention during blanching. Blanching at 80°C for 1 min in Potassium meta-bisulphite are the most ideal for blanching greens.

Eriksen *et al*. (2017) investigated the effects of mechanical and thermal processing as well as fat addition and fat type on lutein and b-carotene liberation and in vitro accessibility from spinach. Lutein liberation and in vitro accessibility were three-fold higher from spinach puree compared to whole leaves. For b-carotene liberation also it was similar, whereas that of β-carotene accessibility was only about two-fold. Steaming had no or a negative effect on carotenoid liberation. Fat addition increased bcarotene liberation from raw and steamed puree, but reduced lutein liberation from steamed leaves and raw puree. Fat types affected β-carotene differently. Butter addition led to a 2.5 fold increased liberation from raw spinach puree, while the effect of olive and peanut oil was significantly lower, but only minor effects were observed for lutein.

Gunathilake *et al.* (2018) evaluated the effect of cooking (boiling, steaming, and frying) on anti-inflammation associated properties in vitro of six popularly consumed green leafy vegetables in Sri Lanka, namely *Centella asiatica, Cassia auriculata, Gymnema lactiferum, Olax zeylanica, Sesbania grnadiflora,* and *Passiflora edulis*. The in vitro anti-inflammatory associated biological activities of green leafy vegetables are modified, increased or decreased, by boiling, steaming, and frying process, depending upon the vegetable species. Among the cooking methods, the frying of all leafy vegetables has reduced the inhibition abilities of protein denaturation, hemolysis, proteinase, and lipoxygenase activities when compared with other cooking methods that were studied. Steaming significantly increased the protein denaturation and hemolysis inhibition in O. zeylanica and P. edulis. Boiling of leaves increased the inhibitory activity of protein denaturation in C. asiatica and P. edulis; hemolysis in C. asiatica, C. auriculata, and S. grandiflora; lipoxygenase inhibition ability in O. zeylanica, P. edulis, C. asiatica and C. auriculata leaves; proteinase inhibition in C. auriculata when compared with that of raw and their other cooked leaves.

2.6 Retention of Nutrients in GLVs

Uadal and Sagar (2008) had studied Influence of packaging and storage temperature on the quality of dehydrated selected leafy vegetables and reported that dehydrated amaranth, fenugreek and spinach retained higher β-carotene and ascorbic acid when stored in high density polyethylene at low temperature.Vitamins are more prone to destruction on dehydration, while there seems to be little effect on the other proximate constituent.

Vimala *et al*. (2011) conducted a study on retention of carotenoids in orange fleshed sweet potato during processing and reported in their study that highest retention of total carotenoids (90%–91%) β-carotene (89%–96%) was observed in the oven drying which is not the common method of processing for human consumption followed by boiling (85%– 90% and 84%–90%). In the frying method, the retention of total carotenoid was 77%–85% and β-carotene was 72%–86%. Least retention of total carotenoids (63%–73%) β-carotene (63%–73%) was recorded in the sun-drying process. The reduction of carotenoids in the sun-drying process may be due to the detrimental effect of the sun-light on the stability of carotenoid pigment.

Gupta *et al.* (2013) studied on retention of nutrients in green leafy vegetables on dehydration on nutrient composition of Amaranth leaves (*Amaranthus gangeticus*), Brahmi (*Centella asiatica*), Bathua leaves (*Chenopodium album*) Kilkeerae (*Amaranthus tricolor*) and Fenugreek leaves (*Trigonella foenum graecum*). The green leafy vegetables (GLV) were steam blanched for 5 min after pretreatment and dried in an oven at 60 °C for 10–12 h. The fresh and dehydrated samples were analyzed for selected proximate constituents, vitamins, minerals, antinutrients and dialyzable minerals. Dehydration seems to have little effect on the proximate, mineral and antinutrient content of the GLV. Among the vitamins, retention of ascorbic acid was 1–14%, thiamine 22–71%, total carotene 49–73% and β— carotene 20–69% respectively, of their initial content. Dialyzable iron and calcium in the fresh vegetables ranged between 0.21–3.5 mg and 15.36–81.33 mg/100 g respectively, which reduced to 0.05–0.53 mg and 6.94–58.15 mg/ 100 g on dehydration. Dehydration seems to be the simplest convenient technology for preserving these sources of micronutrients, especially when they are abundantly available. Irrespective of the losses of vitamins that take place during dehydration, dehydrated GLV are a concentrated natural source of micronutrients and they can be used in product formulations. Dehydration seems to have little effect on the proximate, mineral and antinutrient content of the GLV. Among the vitamins, retention of ascorbic acid was 1– 14%, thiamine 22–71%, total carotene 49–73% and β— carotene 20–69% respectively, of their initial content. Dialyzable iron and calcium in the fresh vegetables ranged between 0.21–3.5 mg and 15.36–81.33

mg/100 g respectively, which reduced to 0.05–0.53 mg and 6.94–58.15 mg/ 100 g on dehydration.

Rao and Bhaskarachary (2014) conducted a study on retention based bio accessibility of carotenoids in green leafy vegetables: effect of different Indian culinary practices. GLV such as amaranth (*Amaranthus gangeticus*), spinach (*Spinacia oleracea*) and curry leaves(*Murraya koenigii*) were selected for the study and subjected to domestic cooking methods of microwave cooking, sautéing, pressure cooking, steaming and deep frying in oil, for a time duration of 8 and 12 minutes, either with lid closed or open. In Spinach, the retention concentration of total carotenoids was found to be maximum in uncooked form. Among various cooking methods followed, maximum retention of 77.4µg/g was observed in spinach cooked by sautéing. Microwave cooking and sautéing of spinach also showed maximum bio accessibilities of 27.9 and 27.7 µg/g among various cooking methods adopted. Cooking without lid was found to cause least retention and bio accessibility of 52.9 and 23.9 µg/g of total carotenoids. β-carotene bio accessibilities were similar among steaming and microwaving as well as among sautéing and deep frying. In Amaranth, among various cooking methods, maximum retention concentration of 169.2 µg/g total carotenoids was observed by steaming while maximum bio accessibility concentration of 61.2 µg/g was observed in sautéed form. With respect to β-carotene, among various cooking methods, maximum retention concentration of 61.3 µg/g and bio accessibility concentration of 23.4 µg/g were both observed in sautéed forms. Maximum retention and bio accessibilities of 219.6 and 109.2 µg/g of total carotenoids was found in fresh form while with respect to β-carotene maximum retention and bio accessibilities of 83.3 and 40.7 µg/g were also noted in fresh forms. Among various methods of cooking studied, the method of cooking without lid caused least retention and bio accessibility of total carotenoids with values of 134.6 and 55.2 µg/g respectively and that of β-carotene with values of 51.2 and 20.3 µg/g respectively. Curry leaves in similar to other GLVs, the fresh samples contained maximum retention and bio accessibility concentrations of 218.5 and 100.3 µg/g of total carotenoids. Among the various cooking methods, sautéing yielded maximum retention and bio accessibility concentrations of total carotenoids. Maximum beta carotene retention of 55.8 µg/g was noted with steaming while the maximum bio accessibility values of 23.4 µg/g was observed in sautéed form. Cooking of curry leaves without lid yielded least retention and bio accessibilities of total carotenoids and β-carotene. Total carotenoid retentions did not vary significantly among microwave and deep frying while bio accessibilities of total carotenoids were similar among cooking without and with lid as well as among steaming, microwaving, sautéing and deep frying.

2.7 Bio availability of Nutrients in GLVs

Gibson *et al*. (2006) conducted a study on improving the bioavailability of nutrients in plant foods at the household level. Diet-related factors in plant foods that affect bioavailability include: the chemical form of the nutrient in food and/or nature of the food matrix; interactions between nutrients and other organic components (e.g. phytate, polyphenols, dietary fibre, oxalic acid, protein, fat, ascorbic acid); pretreatment of food as a result of processing and/or preparation practices. Bioavailability of protein in leafy vegetables is typically influenced by thermal processing, which inactivates heat-labile anti-nutritional factors such as protease inhibitors, lectins, thiaminases and goitrogens but enhances digestibility of proteins and starch.

Sotelo *et al*. (2010) conducted a study on role of oxate, phytate, tannins and cooking on iron bioavailability from foods commonly consumed in Mexico. The samples selected for the present study were grouped into leafy vegetables [chard (Beta vulgaris), watercress (*Nasturtium nasturtium-aquaticum*), spinach (*Spinacia oleracea*), purslane (Portulaca oleracea L.)], cereals [maize (Zea mays), sorghum (*Sorghum vulgare*)], legumes [black beans ‘Jamapa’ (*Phaseolus vulgaris L.*), lentil (*Lens culinaris*), chickpea (*Cicer arietinum L.*), tubers [salad radish (*Raphanus sativus L.*)] and animal products (beef liver, chicken liver, beef, chicken, fish) which were widely consumed in Mexico and have significant iron content. Insoluble iron complexes cannot be absorbed into the small intestine, therefore these compounds inhibit iron absorption. They found no difference in iron bioavailability between raw and boiled spinach even though boiling decreased the oxalate and tannin content of spinach. Boiling significantly decreased the content of these anti-nutritional compounds in almost all green leafy vegetables with the exception of the content of phytates in spinach and tannins in chard. Since phytate is heat-stable, significant reduction during cooking or any conventional heat-processing method is not expected unless the cooking water is discarded, given that some nutrients will be dissolved in the cooking water. Discarding cooking water will also result in a certain loss of nutrients at the same time; therefore, this method may not be effective in maintaining their nutritional value and in improving the bioavailability of minerals.

Antonio (2012) conducted a study on mineral composition of boiled, green leafy vegetables found in hawai and iron bioavailability using the in-vitro digestion/caco-2 cell method. Moringa and chrysanthemum had equal iron efficiency to spinach, while amaranth and bitter melon leaf were less iron efficient than spinach, even though they had higher iron content. Although there were differences in iron efficiency among green leafy vegetables, when the dry matter was re expressed to a cooked weight serving, iron bioavailability of green leafy vegetables was approximately equal. In the second experiment, 0.5 grams of DM food were used in each digest. The iron efficiency of moringa was equal to spinach, but amaranth was significantly lower in iron efficiency to spinach. Reexpressed per RA, the same relationship as found. Iron bioavailability of moringa was equal to spinach but amaranth was significantly lower than spinach. We also discovered that comparing iron bioavailability using 0.5 gram food DM in each digest is preferable to 67 μM Fe in each digest as evidenced by the beef control and ferritin formation past baseline. More experiments are needed to confirm our findings. Enhancing iron bioavailability of green leafy vegetables with ascorbic acid and/or meat may help to elucidate differences in iron bioavailability among green leafy vegetables.

Amalraj and Pius (2015) conducted a study on bioavailability of calcium and its absorption inhibitors in raw and cooked 20 green leafy vegetables commonly consumed in India like *Acalypha indica, Allmania nodiflora, Alternanthera dentate, Alternanthera lehmannii, Alternanthera philoxeroides, Alternanthera sessilis, Amaranthus blitum, Amaranthus dubius, Amaranthus polygonoides, Amaranthus spinosus, Basella alba, Centella asiatica, Chenopodium album, Hibiscus sabdariffa (Linn), Marsilea villosa, Moringa oleifera, Pisonia alba, Sesbania grandiflora, Solanum nigrum and Trigonella foenum-graecum*. The calcium content of the GLV varied widely, ranging from 453.2 mg/100 g in *Alternanthera lehmannii* to 1083.7 215 mg/100 g in *Amaranthus polygonoides*. Boiling significantly decreased the oxalate content. Cooking did not significantly change the phytate content, tannin content of any selected GLVs. The cooking process did not affect invitro calcium bioavailability in any of the selected GLVs.The contents of IDF in the GLV were found to be in the range of 26.1 g/100g in *Amaranthus spinosus* to 69.6 g/100g in *Pisonia alba*. *Basella alba* and *Sesbabnia grandiflora* had SDF content of 6.4 and 7.9 g/100g respectively, while in the rest of the GLVs it varied from 10.6 to 28.0 g/100g. Significant differences were found between TDF and IDF content among the GLVs ($P < 0.01$). *Amaranthus spinosus* had a low TDF content of 26.1 g/100g and *Pisonia alba* had high TDF content of 69.6 g/100 g. Amounts of SDF, IDF and TDF amount increased significantly ($p < 0.01$) in the cooked GLVs compared to the raw leaves. Cooking caused a significant ($p < 0.01$) increase in the TDF content of almost all GLVs, probably due to hydration or polymerization of its fractions. SDF content increased significantly ($p < 0.01$) in cooked

GLVs compared to raw samples (0.8 to 18.4%).

Several research work have been carried out on GLVs. From the review of the literature it can be concluded that GLVs are the part of Indian daily diet which play a role in meeting RDA. They are not only rich in vitamins and minerals but also good amounts of poly phenolic compounds. They possess anti-oxidant and anti-microbial activity. GLV is beneficial in lowering the risk of cardiovascular diseases and cancer. GLVs are also valued for individuals with type 2 diabetes due to their high Mg content, high fiber content, and low glycemic index. Various GLVs are consumed in different parts of the world. Being inexpensive and easy availability they are consumed by all the socio economic group. They are mostly consumed either in raw or cooked forms. Cooking increase the palatability and declines the anti-nutritional factors present in GLVs. Cooking the increase the bio availability of certain nutrients present in the food.

CHAPTER III

MATERIAL AND METHODS

The present study titled "Consumption pattern of Green Leafy Vegetables among different income groups in Guntur Town, Andhra Pradesh" was carried out to know the consumption pattern of Green Leafy Vegetables among different income groups. This chapter gives the details of study area, sampling procedure, variables and their empirical measurement, methods used for collection of data, analytical procedures and statistical tests followed for interpretation of the data. The contents of this chapter are discussed under the following sub-headings.

3.1 Description of Study Area

- 3.1.1 Location
- 3.1.2 Area and Population

3.2 Sampling Procedure

- 3.2.1 Study Area
- 3.2.2 Size of the Sample
- 3.2.3 Selection of the Respondents

3.3 Tools for the Collection of Data

- 3.4 Tools for Analysis of Data

3.5 Selection of Green Leafy Vegetables

- 3.5.1 Identification of Commonly Practiced Cooking Method for GLVs

3.6 Processing of GLVs

- 3.6.1 Pressure Cooking
- 3.6.2 Sauteing
- 3.6.3 Simmering

3.7 Statistical Analysis

- 3.6.1 Percentage
- 3.6.2 Inferential Statistics
- 3.6.3 ANOVA

3.1Description of Study Area

3.1.1 Location: Guntur city (Municipal Corporation) is an administrative district in the Andhra Pradesh region which is nearby State Capital City Amaravati (25 km away from Guntur city). Guntur city became a municipal corporation in the year 1994 which

consists of 52 election wards. Guntur is one of the biggest cities in terms of area and population. It has a coastline of approximately 100 km and is situated on the right bank of River Krishna, which separates from Krishna district and extends till it empties into the Bay of Bengal. It is bounded on South by Prakasam district and on the West by the state of Telangana.

3.1.2 Area and Population: As per 1866 census the population of Guntur is about 25,000. As per 1902 the region extends over an area of 11.68 square miles and its population increased to 30,183. By the 1961 census, Guntur had population of 187,122. As of the 2001 India census, Guntur had a population of 514,707. Males constitute 50% of the population and females 50%. Guntur has an average literacy rate of 68%, which is higher than that of the national average literacy rate of 59.5%. As per 2011 census, it has an area of 11,391 kilometer^2 (4,398 square miles) and is the second most populous district in the state, with a population of 4,889,230. It is also a major center for agriculture, education and learning. It has grown about six times in its size during these 60 years. Currently the city of Guntur is estimated to have population of around 800,000 with an urban agglomeration of approximately 1,028,667 (National Informatics Centre, 2010).

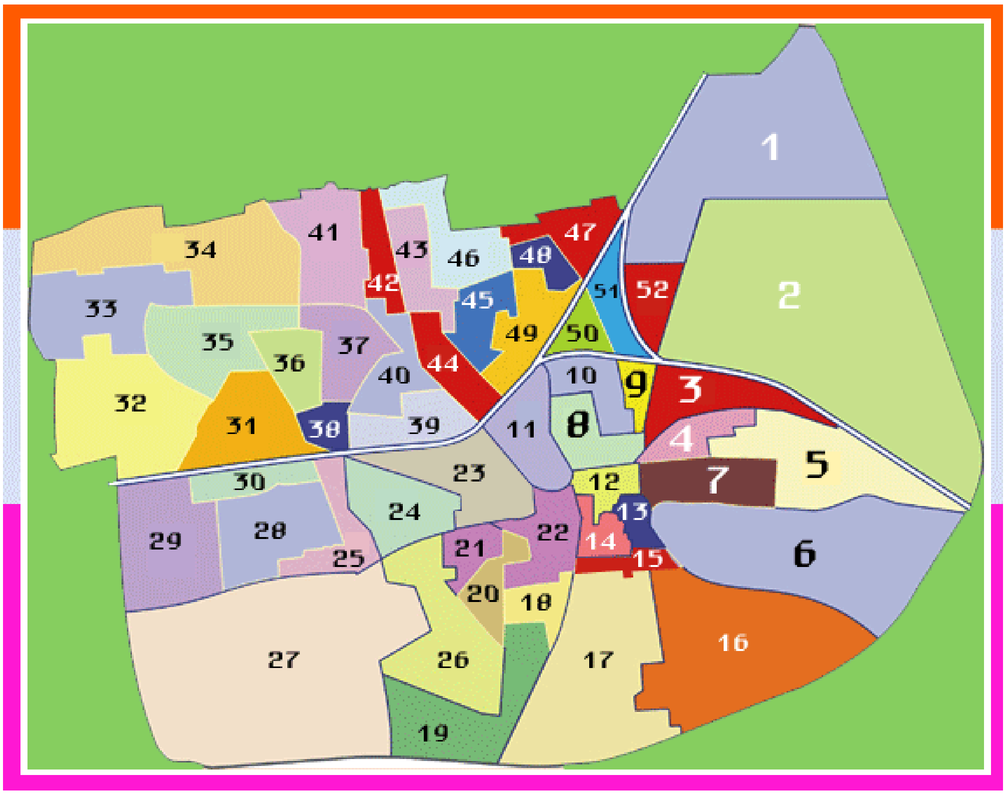

Figure 3.1. Guntur city map showing 52 wards.

Table 3.1 Areas under different wards in Guntur City

Ward Number	Areas
1	Auto nagar, Ganeshnagar, Gaddipadu, Maddirala colony, Vasavi nagar
2	Tarakarama nagar, Shop employees colony, Raghava nagar, Israispet, RTC Colony, Gandhi nagar
3	Vinoba Jakeer Hussian nagar
4	L.B.Nagar, Old Guntur
5	Balaji nagar
6	Anandapet, Golusukondala Rao nagar, Vijayashanthi nagar
7	Siva temple, Stadium, GMC complex
8	Potturi varithota, Guntur varithota
9	Ramireddy thota
10	Kothapet
11	Sambasivapet, Railpet, Govt.Women's college
12	Lalapet, Ahmed nagar, Chinna nagar
13	NIL
14	Chowtra road, Govt.girls high school-1, Cloth bazar
15	A.E.I School
16	Balaji nagar, Saibaba colony, Sabha Husain nagar, Chandrababu naidu colony, Indra priyadarshini colony
17	Lakshmi raju ramaya colony, Gandhi nagar, Sangadagunta
18	Nalla cheruvu, Workers colony
19	NIL
20	Ramalayam, Ayyapa swami temple, Sampath nagar, Indira Colony
21	Srinivasrao thota
22	R. Agraharam road
23	Nagarampalem road
24	Ankammanagar
25	A.T. Agraharam, Hanumannagar, Akulavarithota
26	Kondavenkatapayya colony, Krishna babu colony
27	Subhareddy nagar, Adarsha nagar, Sainagar, Lakshmi nagar, Rehabilitation colony, Nethaji nagar, Joseph nagar
28	Ramireddy nagar, Chaitanya nagar, A.T. Agraharam
29	Nallakunta, Housingboard colony, NGO colony, Seethamma Colony
30	Fathima nagar, SBI nagar
31	Pattabhipuram, Krishna nagar
32	Syamala nagar, Stambalaguruvu
33	Krishna babu nagar, Gujjanagundla, Maruthi nagar
34	SVN colony, NGO colony, Vikas junior college, Donbosco I.T.I college, Goutham college, Vikas mahila junior college, J.K.C road
35	Rajendra nagar, Women polytechnic college to employees provident fund organisation, Brundavan gardens, Chandramouli nagar
36	PG-NTR stadium, ESI Hospital
37	Cobaldpet, Ashok nagar, Lakshmipuram
38	Devapuram

Table 3.1 (cont.)

39	Brodipet
40	Mandal college, Majeti guravaiah junior college, L.E.M School
41	Hanumaiah nagar, Koritipadu
42	Sanjay gandhi nagar, Anjaneyapeta, Sakethapuram
43	Bharatpet, Postalcolony, Hindu PG college, Velangini nagar
44	Arundalpet, P.S.Nagar
45	Municipal school, Srinagar
46	Sarada colony
47	Vengala rao nagar, Rajive Gandhi nagar
48	Sanjeevaiah nagar
49	Shanthi nagar
50	Nehru nagar
51	Nehru nagar
52	Seetha nagar, Ambedkar nagar, Mangaldas nagar

3.2 Sampling Procedure

3.2.1 Study Area: The study was undertaken in Guntur city, Andhra Pradesh and the data with regard to consumption pattern of green leafy vegetables was collected from households.

3.2.2 Size of the Sample: The total households considered for the study were 150 based on their income level, fifty each from Low income group, Middle income group and High income groups.

3.2.3 Selection of the Respondents: Selection of the respondents was done by Random sampling method. The random sampling method was used for selection of 10 wards out of 52 wards in Guntur city, Andhra Pradesh. Quota sampling procedure was followed to select 5 households each from Low income group (LIG), Middle income group (MIG) and High income group (HIG) from each ward.

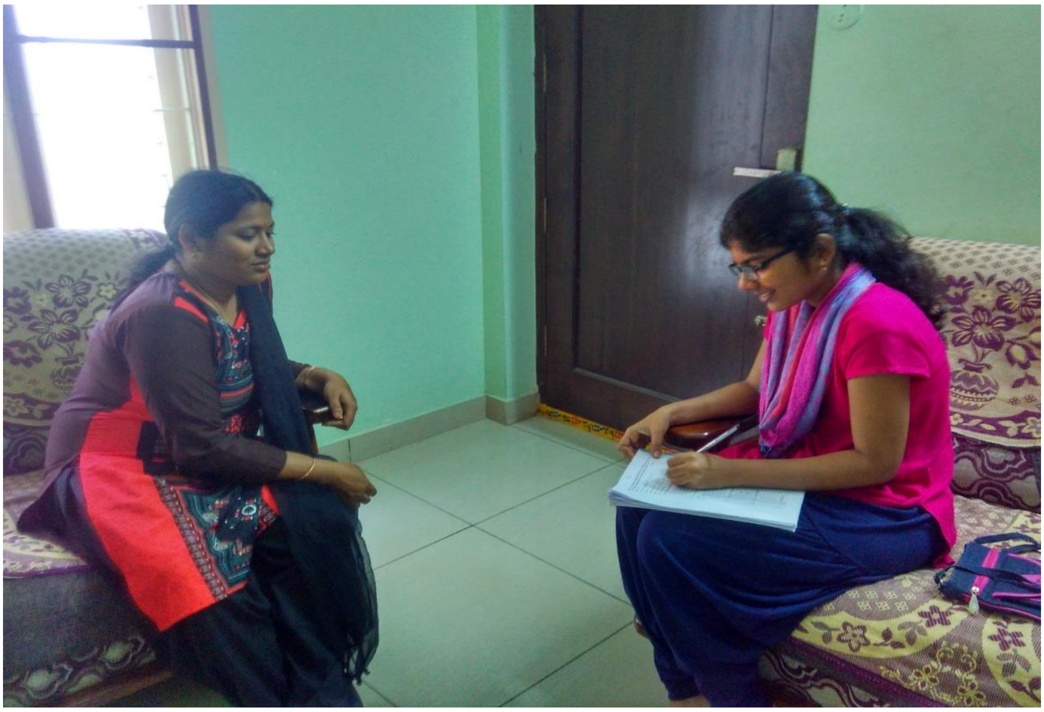

Plate 3.1. Data Collection from HIG Household.

Plate 3.3 Data Collection from MIG Household

Plate 3.4. Data Collection from LIG Households

3.3 Tools for the Collection of Data

The data was collected with the help of a structured interview schedule developed based on the objectives of the study. The schedule was pretested by administering on a sample of 30 households, necessary modifications were done in this schedule and was used for further collection of the data. The interview schedule is given in Appendix A.

3.4 Tools for Analysis of Data

The collected data was coded, analyzed and it was presented in the form of tables to draw valid conclusions. From the collected data most commonly used green leafy vegetables were subjected to the most commonly practiced cooking methods and was analyzed for the availability of selected nutrients such as Total Carotenoids & β carotene, vitamin C, Iron, Calcium and fiber. A comparison was made between the availability of the selected nutrients in raw form and cooked form.

3.5 Selection of Green Leafy Vegetables

The most commonly/frequently consumed three Green Leafy Vegetables by the people of the Guntur Town were selected based on the results of the survey carried out as a part of the present study. Among all the GLVs available Amaranth (85.33%) was the first most commonly consumed Green Leafy Vegetables followed by Spinach (73.33%) and Gogu (63.33%).

3.5.1 Identification of commonly practiced cooking method for GLVs: The most commonly practiced cooking method for GLVs was identified based on the data obtained through the survey conducted as a part of the present study. The most commonly practiced cooking methods for GLVs were thus found to be sauteing (100%) simmering (100%) and pressure cooking (79%).

3.6 Processing of Green Leafy Vegetables

Fresh bundles of Amaranth, Spinach and Gogu were procured from the local market of Guntur Town. They were cut and washed. 100g of each raw/fresh amaranth, spinach and gogu was kept aside to check the availability of Total Carotenoids & β Carotene, (Appendix B), Vitamin C (Appendix C), Iron and Calcium (Appendix D), fiber (Appendix E). The remaining GLVs were subjected to most commonly practiced cooking methods like pressure cooking, simmering and sauteing.

3.6.1 Pressure Cooking: It works on a principle that a relatively small increase in temperature can drastically reduce cooking time. In pressure cooking, escaping steam is trapped and kept under pressure so that the temperature of the boiling water and steam can be raised above 100° C and reduce cooking time.

In the present study pressure cooking was done in domestic pressure cooker. 50 g of Amaranth/Spinach/Gogu was placed in the pressure cooker with no water and was pressure cooked in medium flame for 5 min. The cooked samples were allowed to cool and then homogenized. The homogenized sample was collected in an air tight container and stored at -20° C to determine the retention of Total Carotenoids & β Carotene (Appendix B), Vitamin C (Appendix C), Iron & Calcium (Appendix D) and Total Dietary Fiber (Appendix E).

3.6.2 Simmering: The process in which the food is cooked in a pan with a well- fitting lid at temperature just below the boiling point 82- 99°C of the liquid in which they are immersed the process is known as simmering. It is a useful method when food has to be cooked for longer time to make it tender/soft.

50 g of raw Amaranth/Spinach/Gogu was placed in an aluminum container by adding 100g of water and was cooked in medium flame for 10 min. The cooked samples were allowed to cool and then homogenized. The homogenized sample was collected in an air tight container and stored at -20° C to determine the retention of Total Carotenoids & β Carotene (Appendix B), Vitamin C (Appendix C), Iron and Calcium (Appendix D) and Total Dietary Fiber (Appendix E).

3.6.3 Sauteing: The method involves cooking in just enough of oil to cover the base of the pan (greasing the pan). The food is tossed occasionally or turned over with the spatula to enable all the pieces to come in contact with the oil and get cooked evenly. It can be covered with lid, reducing the flame and allowing the food to be cooked tender in its own steam.

A pan was heated. 50 g of raw Amaranth/Spinach/Gogu was added to 10g of hot oil and cooked in medium flame for 10 min. The cooked sample was allowed to cool and then homogenized. The homogenized sample was collected in a air tight containers and stored at -20° C to determine the retention of Total Carotenoids & β Carotene (Appendix B), Vitamin C (Appendix C), Iron & Calcium (Appendix D) and Total Dietary Fiber (Appendix E).

3.7 Statistical Analysis

The data collected through household survey nutrient analysis were subjected to statistical tests such as Percentages, Inferential statistics and ANOVA for making valid interpretation of the data.

3.7.1 Percentage: Some part of the data is subjected to percentages and is used to know the distribution of the respondents according to the selected variables. Percentage is used for the standardization of size by computing the number of individuals that would be in the given category, if the total number of cases hundred.

3.7.2 Inferential Statistics: Some of the data is subjected to inferential statistics to make inferences from the data and to generalize the population from the sample data.

3.7.3 ANOVA: One way ANOVA is used to understand the significant differences among the GLVs upon cooking which is depicted in Appendix – F.

Chapter 1V

RESULTS AND DISCUSSION

This chapter deals with the description and presentation of the results that were emerged from the research work on consumption pattern of Green Leafy Vegetables among different income groups in Guntur Town in accordance with the pre-determined objectives. Suitable analytical techniques were used to interpret the data which are presented under the following sub headings.

4.1 General Characteristics of the Sample Respondents

- 4.1.1 Type of the Family
- 4.1.2 Family Composition
- 4.1.3 Education of Head of the Family
- 4.1.4 Occupation of Head of the Family
- 4.1.5 Income of Head of the Family
- 4.1.6 Socio Economic Status

4.2 Consumption Pattern of Green Leafy Vegetables (GLVs)

- 4.2.1 Consumption of GLVs
- 4.2.2 Frequency of Consumption of GLVs
- 4.2.3 Preference GLVs powders
- 4.2.4 Pre processing operations of GLVs
- 4.2.5 Processing of GLVs
- 4.2.6 Different Forms of Consumption of GLVs
- 4.2.7 Reasons Behind the Consumption of GLVs
- 4.2.8 Storage of GLVs
- 4.2.9 Method of Storage of GLVs

4.3 Determination of Nutrient Availability in Most Commonly Consumed GLVs

- 4.3.1 Total Carotenoids Content of GLVs in Fresh and Cooked Form
- 4.3.2 β carotene Content of GLVs in Fresh and Cooked Form
- 4.3.3 Total Ascorbic Acid Content of GLVs in Fresh and Cooked Form
- 4.3.4 Calcium Content of GLVs in Fresh and Cooked Form
- 4.3.5 Iron Content of GLVs in Fresh and Cooked Form
- 4.3.6 Total Dietary Fiber Content of GLVs in Fresh and Cooked Form
- 4.3.7 Retention of nutrients in green leafy vegetables on different methods of cooking

4.1 General Characteristics of the Respondents

4.1.1 Type of Family: Distribution of the subjects according to type of family is presented in the table 4.1.

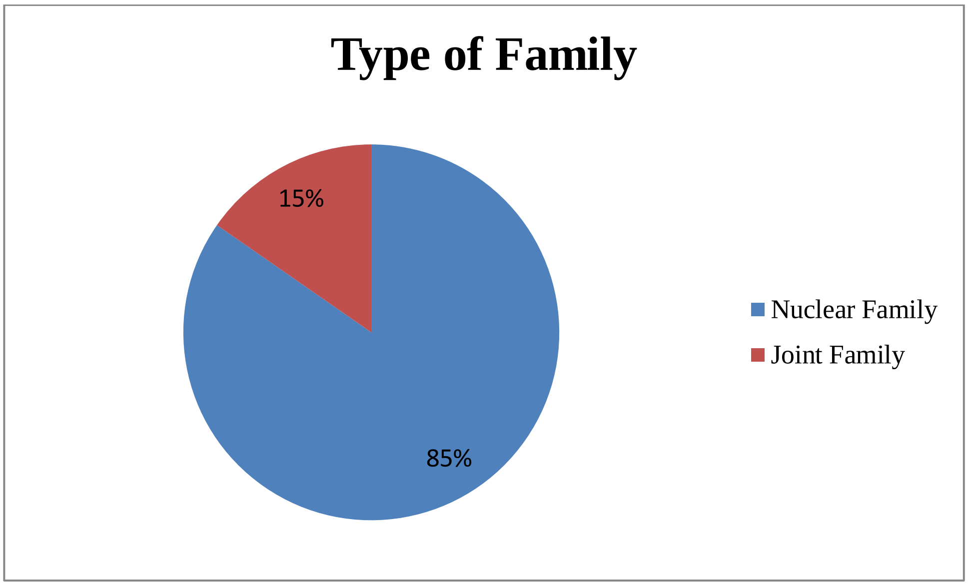

Figure 4.1. Subjects distribution (%) according to the type of family (n = 150).

From the data it is revealed that the average size of the family is 4-6 members comprising of parents and children. Out of 150 respondents 85% of the respondents belonged to nuclear family and 15% belonged to joint family. The eating behaviour was intensely influenced by family members and type of the family, because consumption behaviour of food generally have genetic influence (Scaglioni *et al*., 2008).

4.1.2 Family Composition: There were men, women and children in all the families. In majority of the families there were one or two men or women with one or two children. The consumption pattern of food is always influenced by family members, the consumption of food in children is always influenced by parents (Scaglioni *et al*., 2008).

4.1.3 Education of Head of the Family: The education of head of the family is depicted in Figure 4.2.

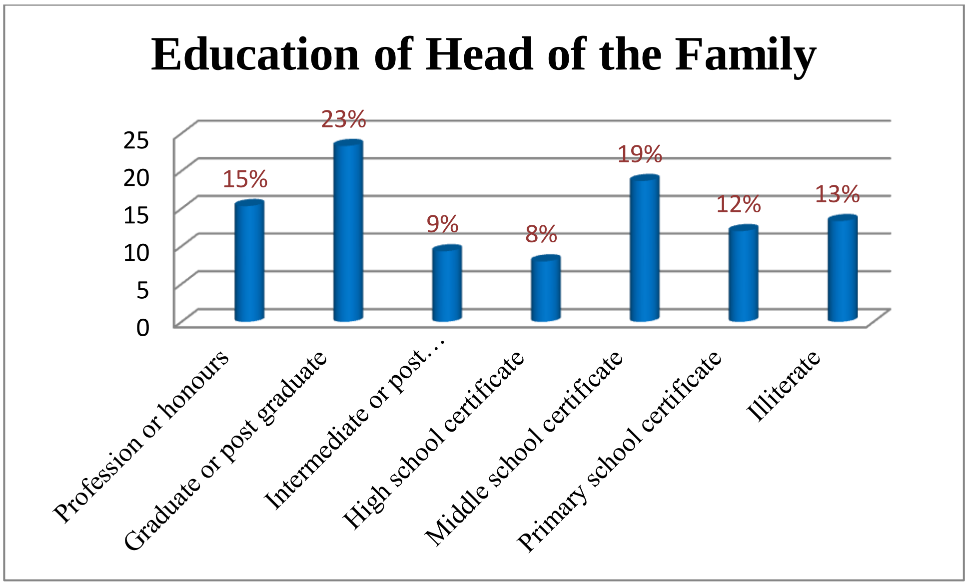

Figure 4.2. Subjects distribution (%) based on education of head of the family.

Among the 150 respondents interviewed, 15% of the subjects were possessing professional or honours degree, 23% were graduates or post graduates, 9% were holding Intermediate or post high school diploma, 8% were high school certificate holders, 19% were Middle school certificate holders, 12% were primary school certificate holders and 13% were illiterates.

4.1.4 Occupation of Head of the Family: Subjects distribution based on their occupation is depicted in the figure 4.3.

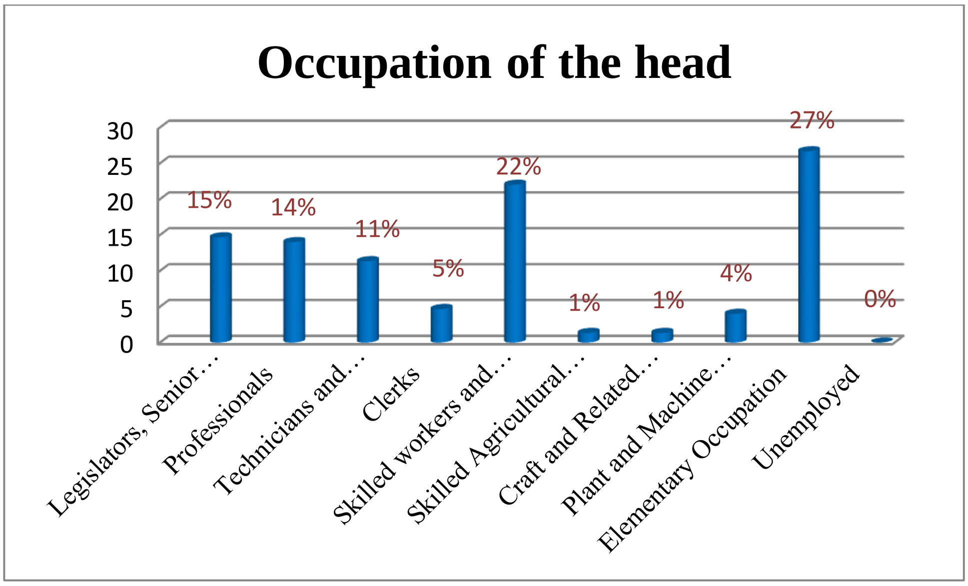

Figure 4.3. Subjects distribution (%) based on their occupation.

Out of 150 subjects, 15% were Legislators, Senior Officials and Managers, 14% were professionals, 11% were Technicians and Associate Professionals, 5% were

Clerks, 22% were Skilled workers and shop and Market sales Workers, 1% were Skilled Agricultural and Fishery workers, 1% were Craft and Related Trade workers, 4% were Plant and Machine Operators and Assemblers, 27% belongs to Elementary Occupation and 0% were Unemployed.

4.1.5 Income of head of the Family: Subjects distribution based on their income is depicted in the Figure 4.4.

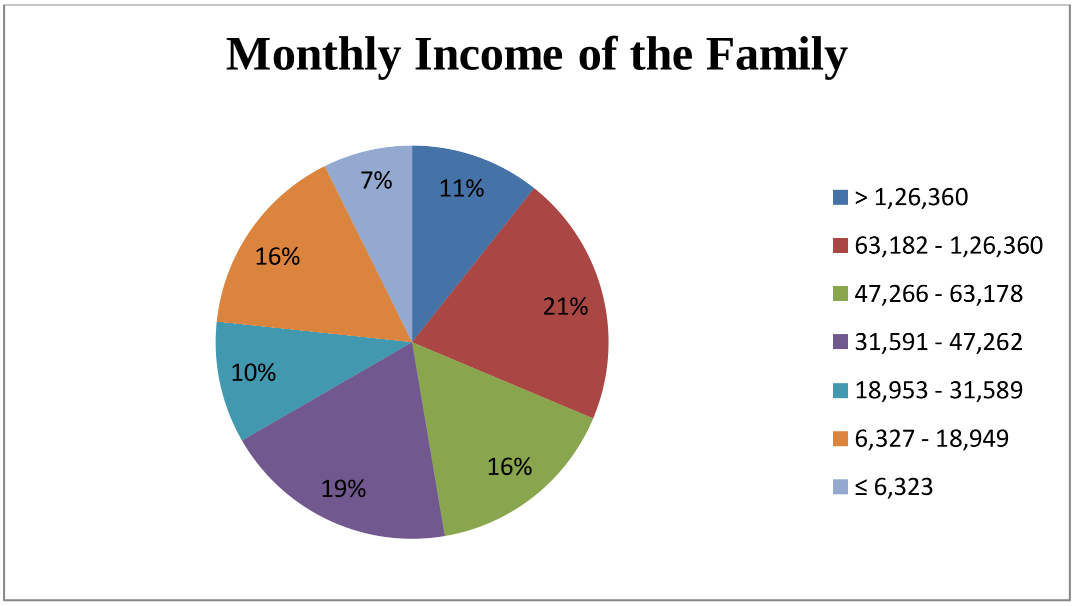

Figure 4.4. Subjects distribution (%) based on their monthly income.

Out of 150 subjects, 11% of the subjects with income > 1,26,360, 21% with 63,182 -1,26,360, 16% with 47,266 – 63,178, 19% with 31,591 – 47, 262, 10% with 18,953 – 31,589, 16 % with 6,327 – 18,949 and 7% with ≤ 6,323 of income.

4.1.6 Socio Economic Status: Socio-economic factor is one of the major variables which might influence the food purchasing behaviour. Socio economic behaviour is unique for each consumer like age, sex, place of domicile, occupation and economic conditions, personality and self-consciousness which plays a vital role on the consumption behaviour of a consumer (Horska and Sparke, 2007). Socioeconomic factor plays a key role in achieving food security all over in the world, particularly among the poor people (Saleh *et al.*, 2013). According to Prabha *et al.* (2008) majority of women (50%) of all the age groups, all the monthly income groups and educational level consumed vegetables twice a week. Family income and education had no impact on their consumption.

The respondents in the current study were classified based on their socio economic status into upper, middle and lower income groups according to the scores obtained for education, income and occupation (Kuppuswamy Scale, 2019) which was mentioned in the interview schedule. Figure 4.5 depicts the subjects distribution based on their socio economic status.

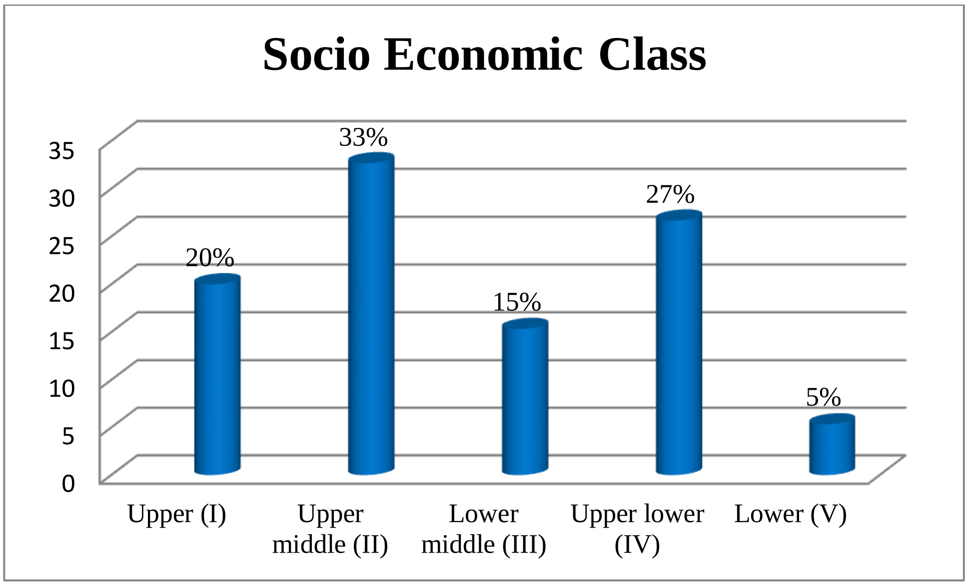

Figure 4.5. Subjects distribution (%) based on their socio economic status.

Figure 4.5 depicts the subjects distribution based on their Socio Economic Status. Out of 150 respondents, 20% of the respondents belongs to Upper class, 33% of the respondents belongs to Upper middle, 15% belongs to Lower middle, 27% belongs to Upper lower and 5% of the respondents belongs to Lower.

4.2 Consumption pattern of Green Leafy Vegetables (GLVs)

4.2.1 Consumption of GLVs: Subjects distribution based on the consumption of different types of GLVs is depicted in the Figure 4.6

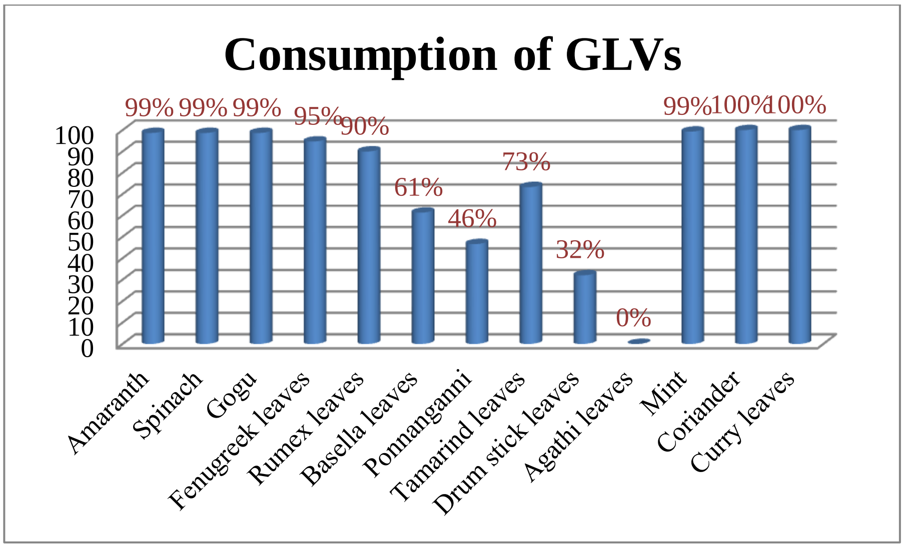

Figure 4.6. Consumption of GLVs.

Out of 150 respondents, all (100%) the respondents were consuming coriander and curry leaves which are widely used as spices and condiments, 99% were consuming Amaranth, Spinach, Gogu and Mint. 95% were consuming Fenugreek leaves, 90% were consuming Rumex leaves (*Chukka kura*), 73% were consuming Tamarind leaves seasonally, 61% were consuming Basella leaves (*Bacchala kura*), 46% were consuming Ponnanganni (*Ponnaganti kura*), 32% were consuming Drumstick leaves and consumption of Agathi leaves were not seen in the study area. ICMR (2011) has recommended that every individual should consume 50 g of GLVs in a day where pregnant women has to consume 100g of Green Leafy vegetables daily in order to meet increased iron and folic acid requirements.

4.2.2 Frequency of consumption of GLVs: Subjects distribution based on frequency of consumption of different types of GLVs is depicted in the Figure 4.7

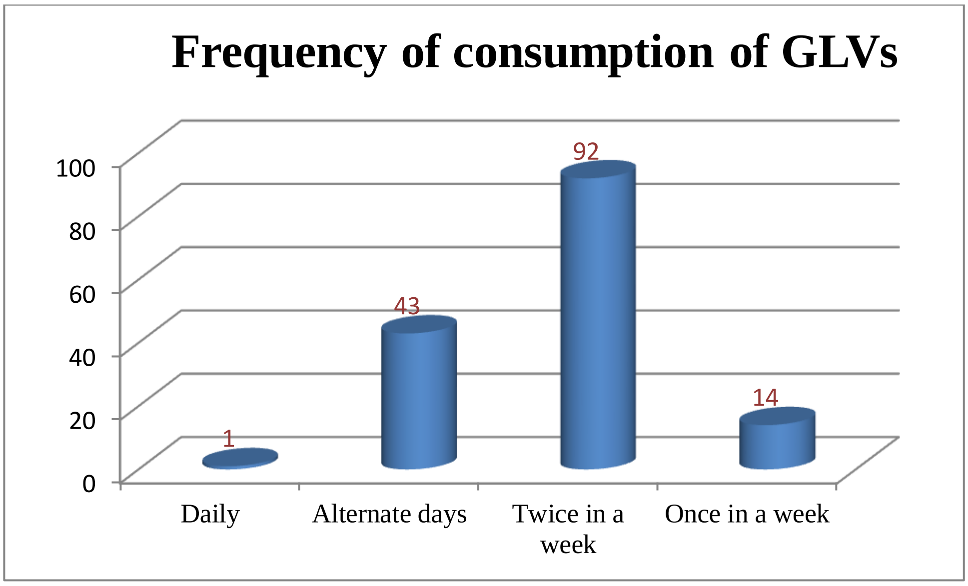

Figure 4.7. Subjects distribution (%) based on the frequency of consumption of GLVs.

Out of 150 respondents, one of the respondents was consuming GLVs daily, 43 were consuming on alternate days, 92 were consuming twice in a week, 14 were consuming once in a week. The data shows that that most of the respondents were consuming GLVs twice a day which is in accordance with the data reported by Prabha *et al*. (2009).

4.2.3 Preference of GLVs Powders: Subjects distribution based on the preference of GLVs powders is depicted in the Figure 4.8.

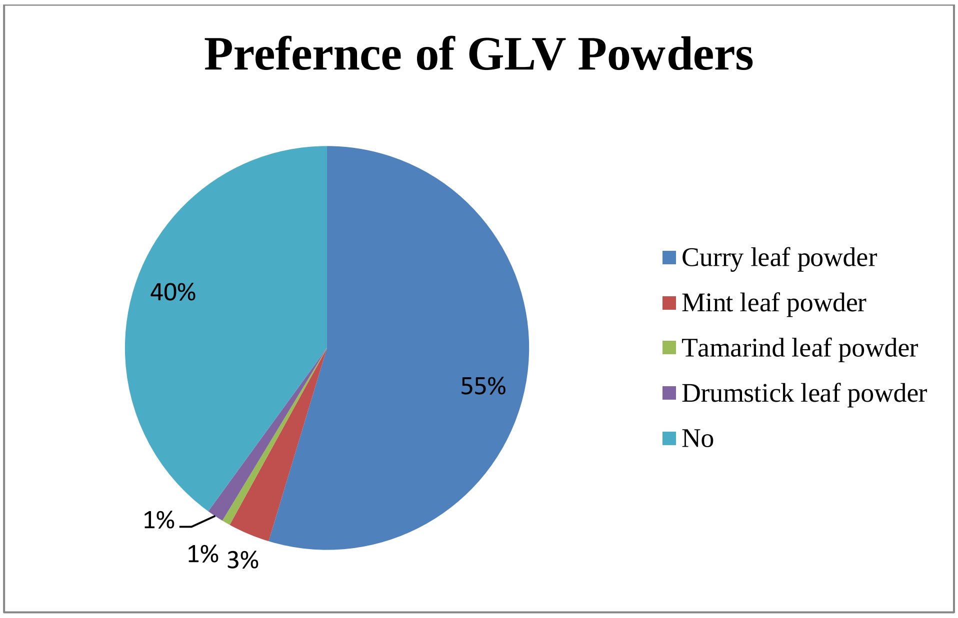

Figure 4.8. Subjects distribution (%) based on preference of GLV powders.

Out of 150 respondents, Fifty five percent of the respondents were not consuming GLVs in the form of powder. Forty percent were consuming Curry leaf powder, 3% were using mint leaf powder and only one percent of the respondents were using Tamarind and Drumstick leaf powder each.

4.2.4 Pre Processing Operations of GLVs: Pre processing operations commonly carried out for GLVs such as washing, cutting and storing etc.

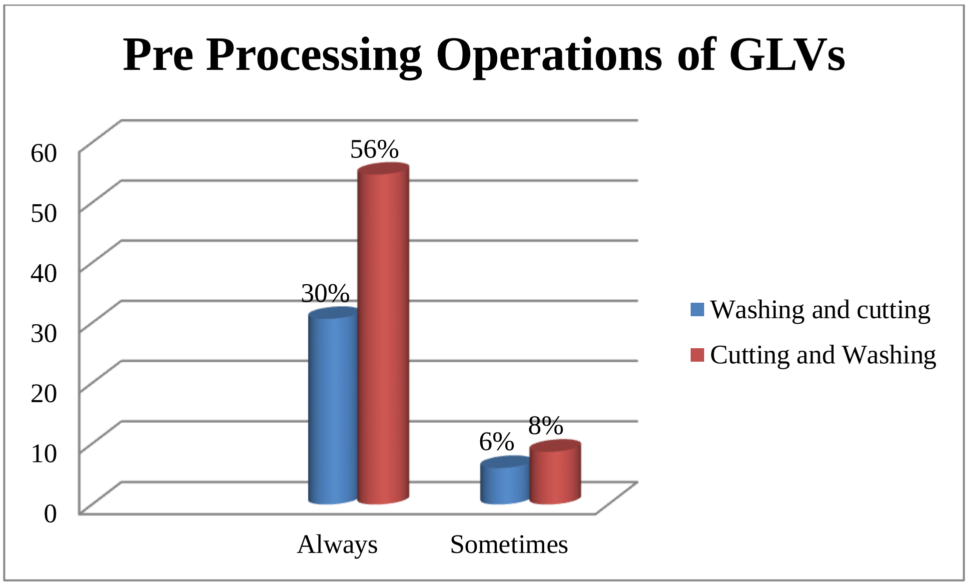

Figure 4.9. Subjects distribution (%) based on the pre processing operations.

Figure 4.9 depicts the subjects distribution based on the pre processing operations of GLVs. Fifty six per cent of the respondents were always cutting and washing the GLVs before processing. Only thirty per cent of the respondents were washing GLVs prior to cutting, 8% of the respondents were sometimes cutting and washing and 6% were washing and cutting the GLVs. Most of the respondents were cutting the GLVs prior to washing which may result in the loss of water soluble vitamins. Prabha *et al.* (2009) reported that about 37.5 % of the respondents cut the greens and then washed.

4.2.5 Processing of GLVs: Subjects distribution based on the commonly practiced processing methods of GLVs is depicted in the figure 4.10

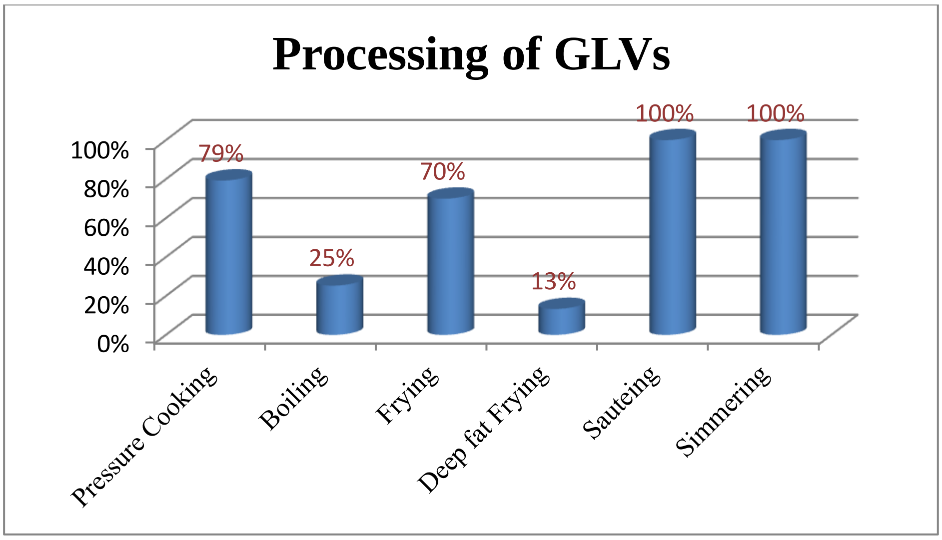

Figure 4.10. Subjects distribution (%) based on commonly followed processing methods of GLVs.

Out of 150 respondents, 79% of the respondents were processing the GLVs by pressure cooking, 25% by boiling, 70% by frying, 13% by deep fat frying and all of the respondents (100%) were practising sauteing and simmering.

4.2.6 Different Forms of Consumption of GLVs: Subjects distribution based of the different forms of consumption of GLVs is depicted in the figure 4.11.

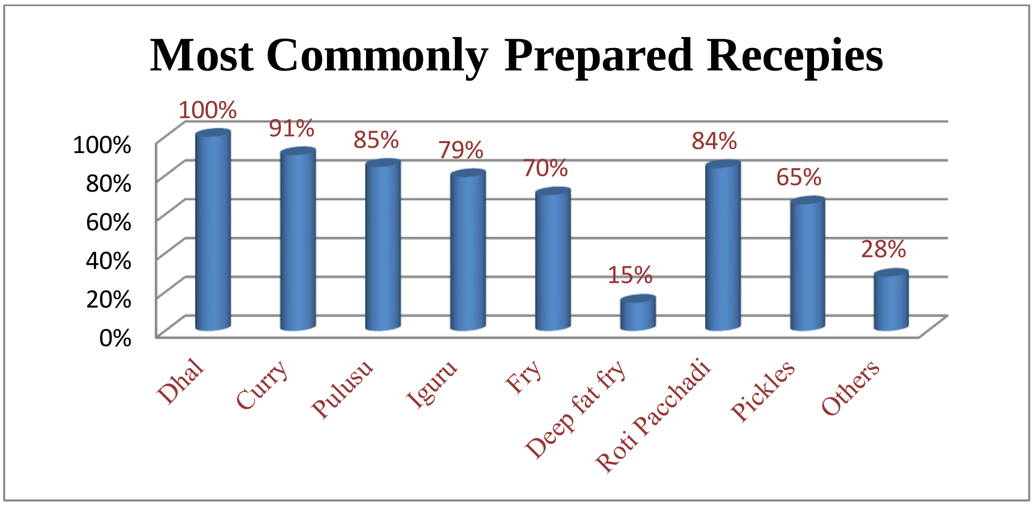

Figure 4.11. Subjects distribution (%) based on forms of consumption of GLVs.

Out of 150 respondents, 100% of the respondents were consuming GLVs in the form of *Dhal*, 91% in *Curry* form, 85% in *pulusu*, 70% in fry, 15% in deep fat fry, 84% in *rotipacchadi*, 65% in pickles and 28% in other forms such as GLVs chapathi, Gogu chicken, Gogu mutton, Methi chicken, Methi potato curry, Palak paneer, Pudina rice, Spinach rice and Tamarind leaves chicken etc.

4.2.7 Reasons for the Consumption of GLVs: Subjects distribution based on reasons behind their consumption of GLVs is presented in the table 4.1.

Table 4.1 Reasons for the consumption of GLVs

Reason	Percent (%)
Contains carotene good for vision	93
High in fiber	57
Rich in vitamins and minerals	77
Good for anaemic patients	52
Contains less sugar	26
Good for bone health	25
Habituated to consume greens	22
Any other	0

Out of 150 respondents, 93% percent of the respondents are with the knowledge that GLVs contains carotene which is good for vision, 57% of the respondents are with the knowledge that they are rich in fiber, 77% of the respondents are with the knowledge that GLVs are the good sources of vitamins and minerals, 52% of the respondents knew that they are good for anaemic patients, 26% of them were aware of GLVs containing low sugars, 25% of them were with the knowledge that the GLVs are good for bone health and 22% of the respondents were habituated to consuming GLVs in their daily diet.

4.2.6 Storage of GLVs: Subjects distribution based on the storage of GLVs is depicted in Figure 4.12.

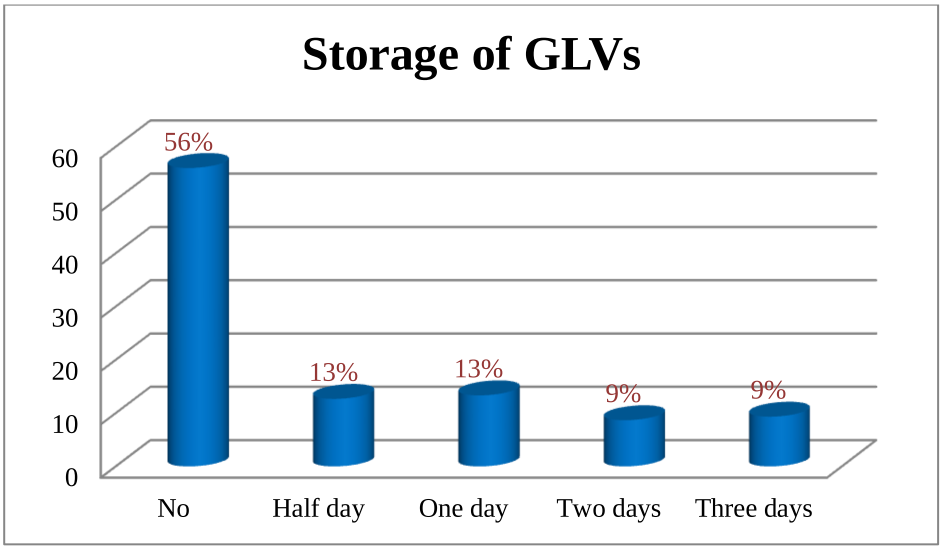

Figure 4.12. Subjects distribution (%) based on storage of GLVs.

Out of 150, respondents, 56% of the respondents were not storing GLVs. Only 44% of them were storing it for future use of them 13% were storing it for half day, 13% were storing it for one day, 9% were storing it for two days and 9% were storing it for three days. Uadal and Sagar (2008) had observed that dehydrated amaranth, spinach and fenugreek retained higher vitamin C and β-carotene when stored in high density polyethylene at low temperature. Vitamins are more prone to destruction on dehydration, while there seems to be little effect on the other proximate constituent.

4.2.6 Method of Storage of GLVs: Subjects distribution based on the method of storage of GLVs is depicted in the figure 4.13.

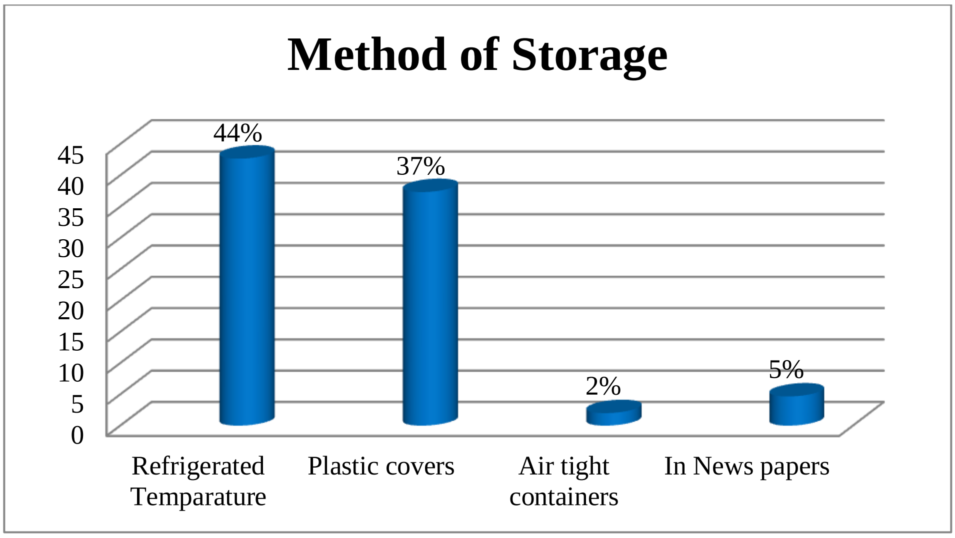

Figure 4.13. Subjects distribution (%) based on method of storage of GLVs.

Out of 44% of the respondents who are storing the GLVs all the 44% of respondents were storing GLVs in refrigerated temperature by storing in plastic covers (37%), air tight containers (2%) and newspapers (5%). Most of the respondents were storing GLVs at refrigerated temperature by placing in plastic covers.

4.3 Determination of Nutrient Availability in most Commonly Consumed GLVs

Based on the results obtained from the data collected through interview schedule the most common GLVs consumed by the subjects were found to be Amaranth, Spinach and Gogu. Hence they were chosen for further determination of nutrient availability after they were subjected to the commonly followed cooking methods such as Pressure Cooking, Sauteing and Simmering. The processed GLVs were analyzed for Total Carotenoids, β Carotene, Vitamin C, Calcium, Iron and Total Dietary Fiber content.

4.3.1 Total Carotenoids Content of Different GLVs in Fresh and Cooked Forms: Cooking results in higher decrease of carotenoids contents in GLVs. For carotenoids, losses at 15 min of cooking were estimated from 69.17 to 100% (Oulai *et al*., 2014). The decrease in the concentration of the total carotenoids observed during cooking could be due to damage and wilting of the leaf tissues which results in leaching. Excessive activity of lipoxygenase enzyme in the initial (warming) stages of cooking, oxidation and isomerization of β-carotene might account for the decrease in their concentration (Speek *et al.,* 1986).

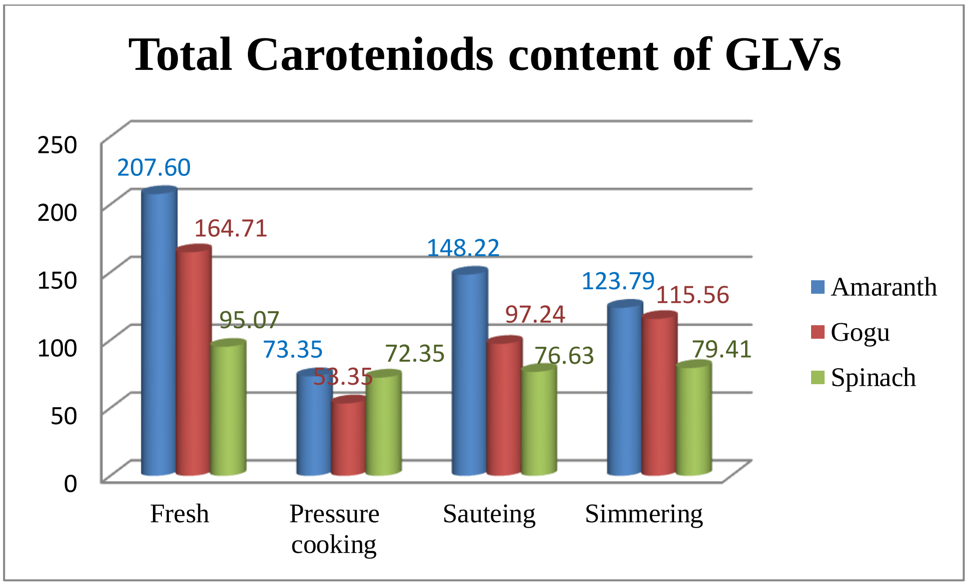

Figure 4.14. Total Carotenoids content (µg/100g) of GLVs in fresh and cooked forms.

Figure 4.14 depicts the Total Carotenoids content of Amaranth, Gogu and Spinach in fresh and processed forms such as pressure cooking, sauteing and simmering. Among all GLVs Amaranth (207 µg/100g) had highest Total Carotenoids content in fresh form followed by Gogu (164.7 µg/100g) and Spinach (95 µg/100g). After pressure cooking the Total Carotenoids content was declined to 76% in Spinach (72.3 µg/100g), 35% in Amaranth (73.3) which is followed 32% in Gogu (53.3 µg/100g). In sauted form among all the GLVs Total Carotenoids content was declined to 80% in Spinach (76.6 µg/100g), 72% in Amaranth (148.2 µg/100g) and 59% in Gogu (97.2 µg/100g). After simmering of fresh GLVs Total Carotenoids content was declined to 83% Spinach (79.4 µg/100g), 70% in (123.7 µg/100g) followed by 59% Gogu (115.56 µg/100g). Through spinach contains least amount of Total Carotenoids among the three GLVs but retention was high in Pressure cooking, Sauteing and simmering. Statistical interpretation through one way ANOVA showed significant decrease in the Total Carotenoids content of processed GLVs of Amaranth, Gogu and Spinach when compared to the fresh leaves.

Miglio *et al.* (2008) reported that both lutein and β-carotene were negatively affected by frying while boiling resulted in increase of β-carotene but 11% losses of lutein. Hence, β-carotene had a higher thermal stability than lutein. A variation in lutein and β-carotene retention could be due to type of vegetables, cooking method, and the interaction between type of vegetable and cooking method (Kidmose *et al.*, 2006; Vimala *et al.*, 2011). Cell walls softens on cooking which makes the carotenoids extraction easier. However, incorporation of oil and the formation of degradation products during cooking may pose some analytical difficulties (Rodriguez-Amaya and de Sa, 2004). The time-temperature relationship is important for all types of food preparation employing heat, but the impact varies with different cooking methods and products (Sungpuag *et al*., 1999; Miglio *et al*., 2008).

Stir-frying reduced lutein content for all vegetables ranging from 8-89% while the effect of boiling varied the lutein content from (0-428%) with different vegetables at both cooking durations of 4 and 8 min. Cooked vegetables showed variations in carotenoids composition by varying cooking conditions (time and temperature), type of vegetables and the interaction between cooking methods and type of vegetables (Chang *et al*., 2013).

Vimala *et al*. (2011) reported that the highest retention of carotenoids was observed in oven drying (total carotenoids 90%–91% and β-carotene 89%–96%) followed by boiling (total carotenoids 85%–90% and β-carotene 84%–90%) and frying (total carotenoids 77%–85% and β-carotene 72%– 86%). The lowest retention of total carotenoids (63%–73%) and β-carotene (63%–73%) was recorded in the sun drying method.

4.3.2 β Carotene Content of Different GLVs in Fresh and Cooked Forms: The β Carotene content of Amaranth Gogu and Spinach in fresh and processed forms such as pressure cooking, sauteing and simmering is depicted in the Figure 4.15.

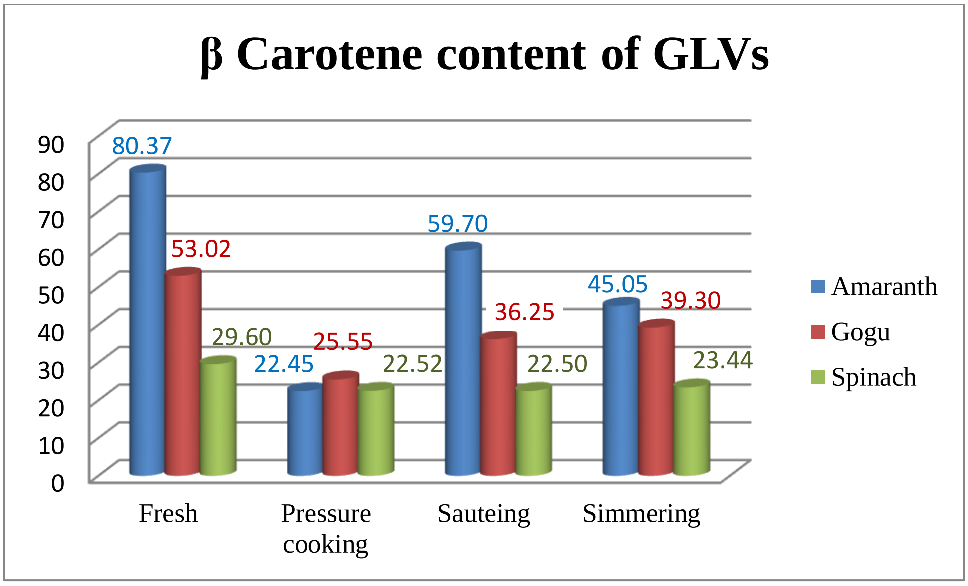

Figure 4.15. β Carotene content (μg/100g) of GLVs in fresh and cooked forms.

Among all GLVs Amaranth had highest β Carotene content (80.3) in fresh form followed by Gogu (53 μg/100g) and Spinach (29.6 μg/100g). After pressure cooking the β Carotenoids content was declined to 76% in Spinach (22.5 μg/100g), 48% in Gogu (25.5 μg/100g) which is followed by 28% in Amaranth (22.4 μg/100g). In sauted form among all the GLVs β Carotenoids content was declined to 76% in Spinach (22.4 μg/100g), 74% in Amaranth (59.7 μg/100g) followed by 68% in Gogu (36 μg/100g) and. After simmering of fresh GLVs β Carotenoids content was declined to 79% in Spinach (23.4 μg/100g), 74% in Amaranth (45 μg/100g) followed by 68% in Gogu (39.3 μg/100g). Statistical interpretation through one way ANOVA showed significant difference between the β Carotene content of fresh and processed GLVs of Amaranth, Gogu and Spinach. Processing had resulted in significant decrease in β Carotene content of all the GLVs.

According to Rodriguez-Amaya and de Sa, (2003) stir-frying had increased the retention of β-carotene in all vegetables 2-3 times than raw ones except for spinach and Ceylon spinach. Because of water loss, stir-frying may concentrate the carotenoids, giving higher β-carotene content per unit weight of vegetable.

The concentration of beta-carotene in GLVs decreased continuously with increase in boiling time. The reduction in beta-carotene content of the vegetables ranged from 16% to 55% after the twenty minutes of boiling. Dietz *et al*. (1998) reported that boiling for 30 minutes led to 53% and 40% reduction of carotene in lettuce and carrots, respectively. Anjum *et al*. (2008) reported a pronounced reduction in beta-carotene content of selected Indian vegetables which contradicts the report of Granado *et al*. (1992) that higher levels of carotene in cooked vegetables than in the uncooked vegetables after boiling 18 Spanish vegetables for 10 to 38 minutes.

Absorption of water by the vegetable during boiling did not cause dilution of the carotenoids. Changes in tissue structure, which occur on boiling, allows greater penetration of extracting solvents into the cells and enhance release of β-carotene as well as lutein that are resistant to heat treatment (Khachick *et al*., 1992; Bernhardt and Schlich, 2006). According to Gayathri *et al.* (2004) in pressure cooking and boiling with out lid, the loss ranged from 27 to 71% during pressure cooking and 16–67% during boiling for the four vegetables examined. Pressure cooking of GLVs resulted in a greater retention of β Carotene. In the presence of red gram dhal, which is a common ingredient in the diet, there was an underestimation of β-carotene due to poor extractability. Inclusion of acidulants—tamarind and citric acid-along with these vegetables brought about some changes in the level of retention of β-carotene. Addition of turmeric generally improved the retention of β-carotene in all four vegetables studied. Onion also had a similar effect. The combinations of acidulants and antioxidant spices also enhanced the β-carotene retention on cooking. Guo *et al*. (2008) showed that the rate of isomerization of lycopene exposed to heat and light are higher when compared to β-carotene due to the presence of β-ionone ring in β-carotene which reduces the electron delocalization even though both lycopene and β-carotene possess 11 conjugated π-bonds.

4.3.3 Total Ascorbic Acid Content of Different GLVs in Fresh and Cooked Forms: Vitamin C is easily destroyed by excessive heat and water as well as exposure to air. For retention of Vitamin C in cooked foods, it is recommended that foods containing Vitamin C be cooked as fast as possible with less heat and small amount of water. (Singh and Harsheal, 2016).

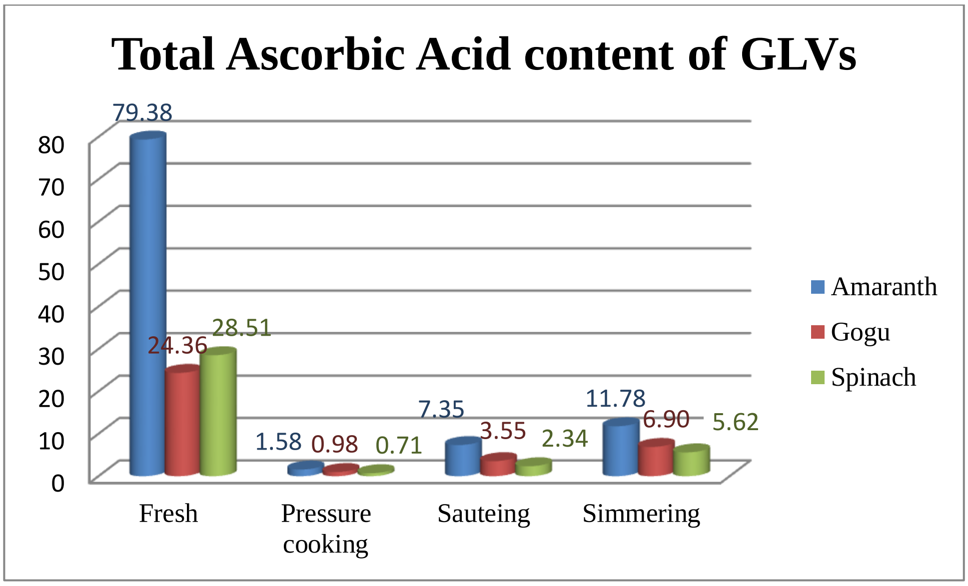

Figure 4.16. Total Ascorbic Acid content (µg/100g) of GLVs in fresh and cooked forms.

Figure 4.16 depicts the Total Ascorbic Acid content of Amaranth, Gogu and Spinach in fresh and processed forms such as Pressure cooking, Sauteing and Simmering. Among all GLVs Amaranth (79.3 µg/100g) had highest Total Ascorbic Acid content in fresh form followed by Spinach (28.5 µg/100g) and Gogu (24.3 µg/100g). After pressure cooking the Total Ascorbic Acid content was declined to 4% in Gogu (0.9 µg/100g) and 2% for Amaranth (1.5 µg/100g) and Spinach (0.7 µg/100g). In sauted form among all the GLVs Total Ascorbic Acid content was declined 14% in Gogu (3.5 µg/100g), 9% in Amaranth (7.3 µg/100g) followed by 8% in Spinach (2.3 µg/100g). After simmering of fresh GLVs Total Ascorbic Acid content was declined to 28% in Gogu (6.9 µg/100g), 20% in Spinach (5.6 µg/100g) followed by 15% in Amaranth (11.7 µg/100g)

. Statistical interpretation through one way ANOVA showed significant decrease in the Total Ascorbic Acid content of processed GLVs of Amaranth, Gogu and Spinach in comparison with the fresh.

Singh and Harsheal (2016) reported in their study that maximum reduction in Vitamin C activity of vegetables were reported in microwave cooking followed by boiling and blanching. Vitamin C content of boiled vegetable samples showed 40-50% reduction in the vitamin C activity, microwave heated samples resulted in 50-75% reduction and blanching lead to minimum reduction i.e. 20-35% as compared to unprocessed vegetable samples.

4.3.4 Calcium Content of Different GLVs in Fresh and Cooked forms: Calcium and phosphorus are associated with formation and functioning of bones, muscles and tooth Kawashima and Soares, (2005) have reported that brief cooking did not cause appreciable losses of any of the minerals in GLVs consumed in South Brazil.

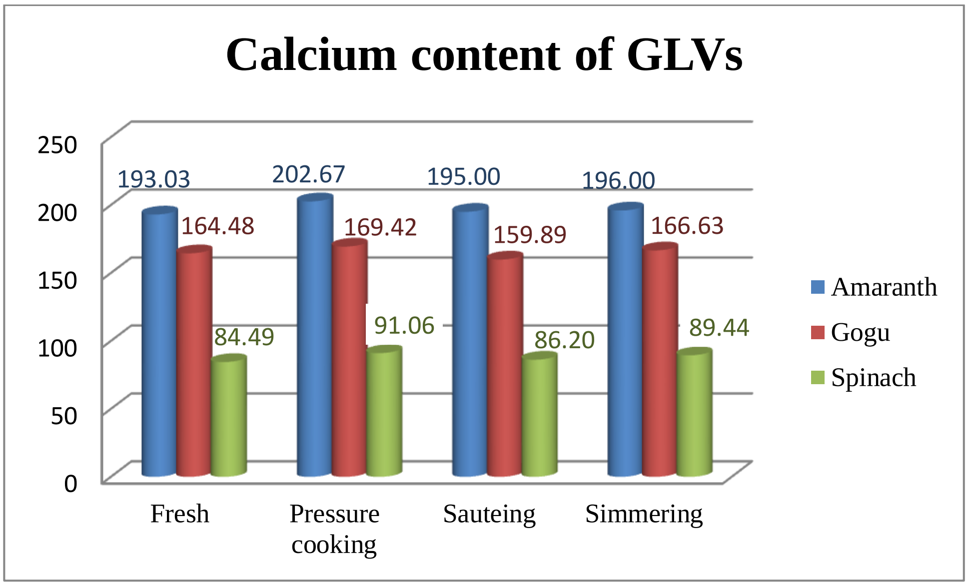

Figure 4.17. Calcium content (mg/100g) of GLVs in fresh and cooked forms.

Figure 4.17 depicts the calcium content of Amaranth, Gogu and Spinach in fresh and processed forms such as Pressure cooking, Sauteing and Simmering. Among all GLVs Amaranth (193 mg/100g) had highest calcium content in fresh form followed by Gogu (164.4 mg/100g) and Spinach (84.4 mg/100g). After Pressure cooking there was a slight increase in the calcium content to 108% for Spinach (91 mg/100g), 105% for Amaranth (202.6 mg/100g) followed by 103% for Gogu (169.4 mg/100g). In sauted form calcium content was increased to Spinach (86.1 mg/100g), 101% in Amaranth But calcium content decline to 96% in Gogu (159.8 mg/100g). After simmering of fresh GLVs calcium content was increased to 105% in Spinach (89.4 mg/100g) and 101% in high for Amaranth (196 mg/100g) followed by Gogu (166 mg/100g). Statistical interpretation through one way ANOVA showed significant difference between the calcium content of fresh and processed GLVs of Amaranth and Gogu. Processing results in increase in the calcium content of Amaranth and Gogu. But non significant difference was found in the Spinach.

4.3.5 Iron Content of Different GLV'S in Fresh and Cooked Forms: Iron plays important role in prevention of anemia. Cooking in iron utensils increases the total as well as the available iron content of greens (Kumari *et al*. 2004).

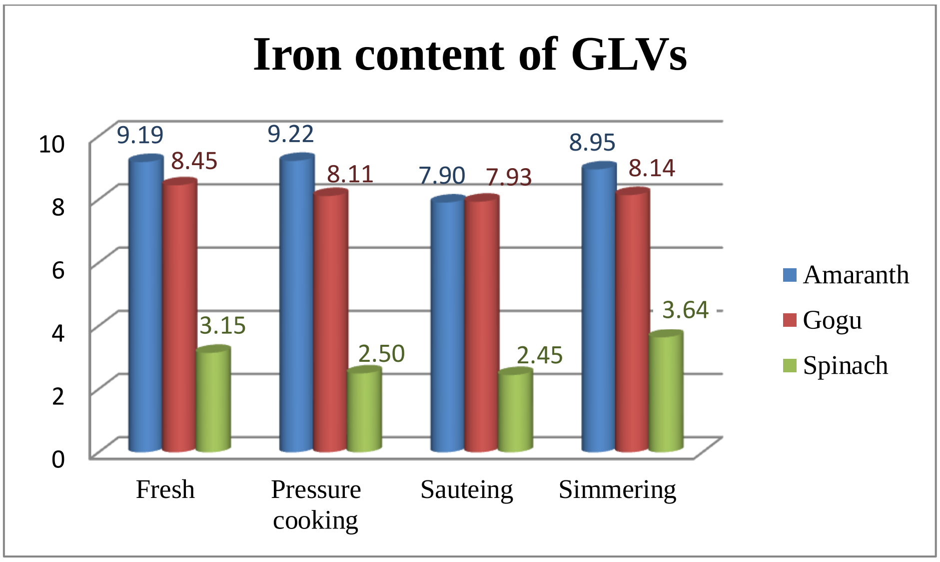

Figure 4.18. Iron content (mg/100g) of GLVs in fresh and cooked forms.

Figure 4.18 depicts the iron content of Amaranth Gogu and Spinach in fresh and processed forms such as Pressure cooking, Sautéing and Simmering. Among all GLVs Amaranth (9.2 mg/100g) had highest iron content in fresh form followed by Gogu (8.4 mg/100g) and Spinach (3.14 mg/100g). After pressure cooking the iron content was high for Amaranth (9.2 mg/100g) was same with the fresh followed but the iron content was declined to 96% in Gogu (8.1 mg/100g) and 79% in Spinach (2.4 mg/100g). In sauted form among all the GLVs the iron content was declined to 94% in Gogu (7.9 mg/100g), 86% in Amaranth (7.9 mg/100g) followed by 78% in Spinach (2.4 mg/100g). After simmering of fresh GLVs iron content of Spinach was (3.6 mg/100g) which was found to be more than the fresh leaves. But declined by 97% in Amaranth (8.9 mg/100g) followed by 96% in Gogu (8.1 mg/100g). Statistical interpretation through one way ANOVA showed non significant difference between the iron content of fresh and processed GLVs of Amaranth and Gogu. But in case of spinach simmering resulted a significant increase in the iron content.

4.3.6 Total Dietary Fiber Content of Different GLVs in Fresh and Cooked Forms:

Dietary fiber is a structural component of plant cell wall. It is classified as soluble dietary fiber (SDF) and insoluble dietary fiber (IDF), which is collectively termed as Total Dietary Fiber (TDF). GLVs have been proven to be as very good sources of dietary fiber. Consumption of higher levels of vegetable fiber reduces the risk of cardiovascular diseases and colon cancer (Jenkins *et al.* 2001). The amount of Total Dietary fiber in GLVs can vary with same species of different varieties, agro-climatic conditions, stages of maturity and type and rate of fertilizer applications (Natesh *et al.*, 2017).

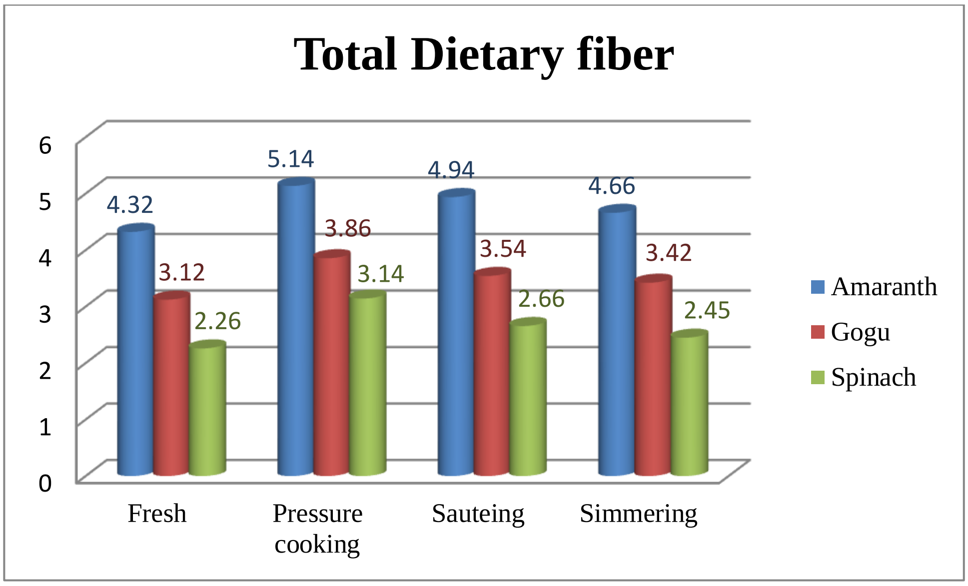

Figure 4.19. Total Dietary fiber (g/100g) content of GLVs in fresh and cooked forms.

Cooking GLVs resulted in a slight increase (1.96 – 6.34 %) in crude fiber content after 15 min of cooking (Oulai *et al.* 2014). Cooking increased soluble fiber content, with corresponding decrease in the insoluble fiber content (Slavin, 1987; Lintas and Cappelloni, 1998). Cooking of plant tissues results in changes in the physical and chemical properties of plant cell walls, which affects their performance as dietary fiber (McDougall, 1996). The increased temperature during cooking leads to breakage of weak bonds between polysaccharides and the cleavage of glycosidic linkages, which may result in solubilisation of the dietary fiber (Svanberg *et al.*, 1997). Adequate intake of cooked GLVs could lower the risk of hypertension, constipation, diabetes, colon and breast cancer (Ishida *et al.*, 2000).

Figure 4.19 depicts the Total Dietary fiber content of Amaranth, Gogu and Spinach in fresh and processed forms such as pressure cooking, sautéing and simmering. Among all GLVs Amaranth had highest Total Dietary fiber content (4.32g/100g) in fresh form followed by Gogu (3.12 g/100g) and Spinach (2.26 g/100g). After pressure cooking the Total Dietary Fiber content was increased to 121% in Spinach (3.14 g/100g), 121% in Gogu (3.8 g/100g) which is followed by Amaranth (5.13 g/100g). In sauted form among all the GLVs Total Dietary Fiber content was increased to 117% in Spinach (2.65 g/100g), 114% in Amaranth (4.94 g/100g) followed by113% in Gogu (3.54 g/100g). After simmering of fresh GLVs the Total Dietary Fiber content was increased to 108% Gogu (3.4 g/100g) and 106% in Amaranth (4.6 g/100g) and Spinach (2.4 g/100g). In comparison with the fresh leaves, the GLVs after pressure cooking, sauteing and simmering showed high Total Dietary fiber content. Statistical interpretation through one way ANOVA showed significant difference between the total dietary fiber content of fresh and processed GLVs of Amaranth and Spinach. There was a significant increase after processing of GLVs. But non significant difference was found between the Total Dietary Fiber content of fresh and processed Gogu. The above results are in par with Mc Dougall *et al.* (1996) and Amalraj and Pius (2015) who reported that cooking caused a significant ($p < 0.01$) increase in the TDF content of almost all GLVs, probably due to hydration or polymerization of its fractions. According to Kumar *et al.* (2004) and Amalraj and Pius (2015) amounts of SDF, IDF and TDF amount increased significantly ($p < 0.01$) in the cooked GLVs compared to the fresh leaves.

4.3.7 Retention of Nutrients in Green Leafy Vegetables on Different Methods of Cooking:

Table 4.2 Retention of Nutrients in GLVs on Processing

Nutrients	**GLVs**	**Pressure cooking**	**Sauteing**	**Simmering**
		Nutrient retention (%)		
Total Carotenoids	Amaranth	35	**72**	59
	Gogu	32	59	**70**
	Spinach	76	80	**83**
β - Carotene	Amaranth	28	**74**	56
	Gogu	48	68	**74**
	Spinach	76	76	**79**
Ascorbic Acid	Amaranth	2	9	**15**
	Gogu	4	14	**28**
	Spinach	2	8	**20**

There is no significant difference was found in the retention of Calcium, Iron and Total Dietary Fiber of three GLVs. But the significant difference was found in Vitamins like Total Carotenoids, β Carotene and Ascorbic Acid. The retention nutrients in GLVs are in Simmering>Sauteing>Pressure Cooking.

Chapter V

SUMMARY AND CONCLUSION

Green Leafy Vegetables are the commonly consumed vegetables which are found ubiquitously in Indian cuisine. They also add variety to the diet. Green Leafy Vegetables are consumed raw in the form of salad, or used along with spices and condiments. Sometimes the GLVs are subjected to processing method such as cooking, dehydration prior to consumption. They are mainly consumed for their nutrients such high dietary fiber, low lipids, and rich folic acid, ascorbic acid, vitamin K, Mg, and K. They also carry plenty of phytochemicals such as β-carotene flavonoids and poly phenolic compounds.

Cooking of GLVs ensures decline in the microbial quality and increase the palatability and bioavailability of nutrients. Cooking with other ingredients aids in increased retention of nutrients. The present study was carried out to interpret the consumption pattern of GLVs by respondents belonging to different income groups residing in Guntur Town.

To collect the information on the consumption pattern of GLVs a structured interview schedule was prepared. The total house holds selected for the study was 150, 50 each from Low income group, Middle income group and High income group. Random sampling method was used for selection of 10 wards out of 52 wards in Guntur town, Andhra Pradesh. Stratified random sampling procedure was followed to select 5 households each from Low income group, Middle income group, High income group from each ward.

The data collected using the interview schedule consisted of information on the type of the family, family size, occupation of head of the family, education of head of the family, monthly income of the family and socioeconomic status of the family which effects the consumption pattern of the family. The average size of the family was found to be 4-6 members comprising of parents and children. Out of 150 respondents 85% of the respondents belonged to nuclear family and 15% belonged to joint family. As far as Education of head of family is concerned 15% of the subjects were possessing professional or honours degree, 23% were graduates or post graduates, 9% were educated up to Intermediate or post high school diploma, 8% were high school certificate holders, 19% were Middle school certificate holders, 12% were primary school certificate holders and 13% were illiterates. Regarding the occupation of head of the family 15% were Legislators, Senior Officials and Managers, 14% were professionals, 11% were Technicians and Associate Professionals, 5% were Clerks, 22% were Skilled workers and shop and Market sales Workers, 1% were Skilled Agricultural and Fishery workers, 1% were Craft and Related Trade workers, 4% were Plant and Machine Operators and Assemblers, 27% belongs to Elementary Occupation and 0% were Unemployed. Regarding the monthly income of the subjects 11% of the subjects with income > 1,26,360, 21% with 63,182 -1,26,360, 16% with 47,266 – 63,178, 19% with 31,591 – 47, 262, 10% with 18,953 – 31,589, 16 % with 6,327 – 18,949 and 7% with ≤ 6,323 of income. Regarding the socio economic status of the subjects 20% of the respondents belongs to Upper class, 33% of the respondents belongs to Upper middle, 15% belongs to Lower middle, 27% belongs to Upper lower and 5% of the respondents belongs to Lower.

The most commonly consumed GLVs were found to be Amaranth, Spinach, Gogu, Fenugreek leaves, Rumex leaves, Basella leaves, Ponnanganni, Tamarind leaves, Drumstick leaves, Mint, Coriander and Curry leaves. The data on consumption of type of GLVs showed that 100% of the respondents were consuming coriander and curry leaves which are widely used as spices and condiments, 99% were consuming Amaranth, Spinach, Gogu and Mint. 95% were consuming Fenugreek leaves, 90% were consuming Rumex leaves, 73% were consuming Tamarind leaves seasonally, 61% were consuming Basella leaves, 46% were consuming Ponnanganni, 32% were consuming Drumstick leaves and consumption of Agathi leaves was not seen in the study area. Coriander and curry leaves are used by the consumers for making Chutney (*Roti pacchadi*), for garnishing salads and curries and for seasonings. Out of 150 respondents majority (92%) were consuming GLVs twice in a week followed by Alternate days (42%).

GLVs can also be consumed in the form of value added powders. Out of 150 respondents, 40% were consuming Curry leaf powder, 3% were using mint leaf powder and only one percent of the respondents were using Tamarind and Drumstick leaf powder each. Among all the GLV powders, curry leaf powder was commonly used by most of the respondents. Pre processing operations commonly carried out for GLVs such as washing, cutting and storing etc. Fifty six per cent of the respondents were always cutting and washing the GLVs before processing. Only 30% of the respondents were washing GLVs prior to cutting, 8% of the respondents were sometimes cutting and washing and 6% were washing and cutting the GLVs. Most of the respondents were cutting the GLVs prior to washing which may result in the loss of water soluble vitamins.

GLVs are processed prior to consumption. Seventy nine per cent of the respondents were processing the GLVs by pressure cooking, 25% by boiling, 70% by frying, 13% by deep fat frying and 100% of the respondents were practising sauteing and simmering.

GLVs are processed to make dhal by adding red gram dhal to GLVs apart from other ingredients, curry and *pulusu* are prepared by simmering the GLVs along with other ingredients. They are also consumed after frying in fat along with seasonings. Hundred percent of the respondents were consuming GLVs in the form of *Dhal*, 91% in *Curry* form, 85% in *pulusu*, 70% in shallow fried form, 15% in deep fat fried form, 84% in *rotipacchadi*, 65% in pickles and 28% in other forms such as GLVs chapathi, Gogu chicken, Gogu mutton, Methi chicken, Methi potato curry, Palak paneer, Pudina rice, Spinach rice and Tamarind leaves chicken etc. All the respondents were consuming GLVs dhal.

All the respondents were aware of the benefits of GLVs. Ninety three per cent of the respondents are with the knowledge that GLVs contains carotene which is good for vision, 57% of the respondents are with the knowledge that they are rich in fiber, 77% of the respondents are with the knowledge that GLVs are rich in vitamins and minerals, 52% of the respondents knew that they are good for anaemic patients, 26% of them were aware of GLVs containing low sugars, 25% of them were with the knowledge that the GLVs are good for bone health and 22% of the respondents were habituated to consuming GLVs in their daily diet.

Regarding the storage of GLVs 56% of the respondents were not storing GLVs. 13% were storing it for half a day, 13% were storing them for one day, 9% were storing them for two days and 9% were storing for three days. The GLVs were stored in refrigerated temperature by placing in poly ethylene covers by majority of the respondents.

Based on the results obtained from the data collected through interview schedule the commonly consumed GLVs by the subjects were found to be Amaranth, Spinach and Gogu. Hence they were chosen for further determination of nutrient availability after they were subjected to the commonly practised cooking methods such as Pressure Cooking, Sauteing and Simmering. The processed GLVs were analysed for Total Dietary fiber, Total Carotenoids, β Carotene, Vitamin C, Calcium and Iron content.

After the processing of Amaranth, Gogu and Spinach Total Carotenoids was found in the highest amount in Amaranth but there is a significant decrease in the Total carotenoids content of all the GLVs with processing. But the retention of Total Carotenoids was high in Sauteing followed by simmering. β Carotene content was also found to be high in Amaranth. β Carotene content was also found to be high in Amaranth. There is a significant decrease in the β carotene content of all the GLVs with processing. Retention of β Carotenoids was high in Sauteing followed by simmering. Ascorbic Acid of content of GLVs is present in high amounts in Amaranth. With the processing of GLVs. There is a significant decrease in the Ascorbic Acid content of all the GLVs with processing. Processing declined the Ascorbic Acid content to extreme. Comparatively simmering retained better amount of Ascorbic Acid than the other processing methods.

Processing results in significant increase in the calcium content of Amaranth and Gogu. But non significant difference was found in the Spinach. With processing the calcium content was increased as the cell walls break during the processing and increases the availability of calcium. Iron content of the Amaranth and spinach does not show any significant difference with processing. But spinach showed significant difference with processing due to increase of iron content of spinach simmering. Total Dietary fiber content of Amaranth and Spinach was increased upon processing. Among all processing methods pressure cooking increased the TDF content of all GLVs. But non significant difference was found between the total dietary fiber content of fresh and processed Gogu. TDF content of all GLVs increases on all the processing methods.

It can be concluded from the present study that Amaranth, Spinach and Gogu are the commonly consumed GLVs and the cooking methods used for the GLVs resulted in good retention of the nutrients except for Ascorbic acid.

Scope for further studies: The nutrient retention of most commonly used GLVs mentioned in the study can be studied by subjecting them to the other processing methods. The nutrient retention of other GLVs can also be studied by subjecting them to the Pressure Cooking, Sauteing and Simmering.

LITERATURE CITED

Ahmed, S.A., Hanif, S and Iftkhar, T. 2013. Phytochemical profiling with antioxidant and antimicrobial screening of amaranthus viridis L. leaf and seed extracts. *Open Journal of Medical Microbiology*. 3: 164-171.

Albihin, P and Savage, G.P. 2000. Effect of cooking on the soluble oxalate content of three cultivars of oca (*Oxalis tuberosa*). *Proceedings of the Nutrition Society of New Zealand*. 25 : 66-69.

Amalraj and Pius, A. 2015. Bioavailability of calcium and its absorption inhibitors in raw and cooked green leafy vegetables commonly consumed in India – An in vitro study. *Food Chemistry*. 1: 430-436.

Amornrit, W and Santiyanont, R. 2016. Neuroprotective effect of Amaranthus lividus and Amaranthus tricolor and their effects on gene expression of RAGE during oxidative stress in SH-SY5Y cells. *Genetics and Molecular Research*. 15 (2).

Anjum, F, Khan, B.A., Noreen, N and Faisal, T. 2008. Effect of Boiling and Storage on Beta-Carotene Content of Different Vegetables. *Pakistan Journal of Life Sciece*. 63-67.

Antonio, P. 2012. Conducted a study on Mineral composition of boiled, green leafy vegetables found in hawai‘i and iron bioavailability using the in-vitro digestion/caco-2 cell method. A thesis submitted to the graduate division of the university of hawai‘i at mānoa partial.

AOAC. 1980. Official Methods of Analysis of β carotene. *Association of Official Analytical Chemists.* 13th ed. Howitz (ed.). 734-740.

AOAC. 2006. Official methods of analysis of Fiber, Minerals (Iron and Calcium). *Association of Official Analytical Chemists.* 17th ed. Gaithersburg, Maryland, USA. AOAC.985.29, 984.27.

AOAC. 2007. Official Methods of Analysis for vitamin – C. *Association of Official Analytical Chemists.*18th ed. Gaithersburg, Maryland, USA. AOAC 967.21.

Bernhardt, S and Schlich, E. 2006. Impact of different cooking methods on food quality: Retention of lipophilic vitamins in fresh and frozen vegetables. *Journal of Food Engineering.* 77 (2): 327-33.

Chang, S.K., Prasad, N.K and Amin, I. 2012. Carotenoids retention in leafy vegetables based on cooking methods. *International Food Research Journal*. 20 (1): 457-465.

Das, L., Bhaumik, E., Raychaudhuri, U and Chakraborty, R. 2012. Role of nutraceuticals in human health. *Journal of Food Science and Technology*. 49 : 173-183.

Dietz, J.M., Kantha, S.S and Erdman, J.W. 1998. Reversed phase HPLC analysis of α and β- carotene from selected raw and cooked vegetables. *Plant Foods Human Nutrition*. 333-341.

Eriksen, J. N., Luu, A. Y., Dragsted, L. O and Arrigoni, E. 2017. Adaption of an in vitro digestion method to screen carotenoid liberation and in vitro accessibility from differently processed spinach preparations. *Food Chemistry*. 224: 407–413.

Gacche, R.N., Kabaliye, V.N., Dhole, N.A and Jadhav, A.D. 2010. Antioxidant potential of selected vegetables commonly used in diet in Asian subcontinent. *Indian Journal of Natural products and Resources*. 1 (3): 306-313.

Khanam, U.K.S., Oba, S., Yanase, E and Murakami, Y. 2012. Phenolic acids, flavonoids and total antioxidant capacity of selected leafy vegetables. *Journal of Functional Foods*. 4 (4): 979-987.

Gayathri, G,N., Platel, K., Prakash, J and Srinivasan, K. 2004. Influence of antioxidant spices on the retention of β-carotene in vegetables during domestic cooking processes. *Food Chemistry*. 84 (1): 35-43.

Gibson, R.S., Perlas, L and Hotz, C. 2006. Improving the bioavailability of nutrients in plant foods at the household level. *Proceeding of the Nutrition Society* 65 (2):160–168.

Gopi, R., Kavinal, J., Nair, D.V., Kumar, M.M., Lakshmanan, A.G.M., Gomathinayagam, M and Panneerselvam, R. 2011. Anti-Oxygen radical potential of leafy vegetables a comparative study. *Journal of Pharmacy Research*. 4 (4): 1100-1101.

Granado, F., Olmedilla, B., Blanco, I and Rojas-Hidalgo, E. 1992. Carotenoid composition in raw and cooked Spanish vegetables. *Journal of Agricultural and Food Chemistry*. 40 (11): 2135–2140.

Gunathilake, K., Ranaweera, K and Rupasinghe, H. 2018. Influence of boiling, steaming and frying of selected leafy vegetables on the in vitro anti-inflammation associated biological activities. *Plants*. 7 (1): 22.

Gunathilake, K.D.P.P and Ranaweera, K.K.D.S. 2016. Antioxidative properties of 34 green leafy vegetables. *Journal of Functional Foods*. 26: 176 -186.

Guo, W.H., Tu, C.Y and Hu, C.H. 2008. Cis-Trans isomerizations of β-carotene and lycopene: A Theoretical Study. *Journal of Physical Chemistry* 112: 12158-12167.

Gupta, S., Gowri, B.S., Lakshmi, A.J and Prakash, J. 2013. Retention of nutrients in green leafy vegetables on dehydration. *Journal of Food Science and Technology*. 50 (5): 918–925.

HHS & USDA. 2015 – 2020 Dietary Guidelines for Americans. 8 th Edition. Retreived 2016. from http://health.gov/dietaryguidelines/2015/guidelines/.

Horska, E. and Sparke, K. 2007. Marketing attitudes towards the functional food and implications for market segmentation. *Journal of European Consumer and Consumer Behaviour*. 53 (8): 349-353.

Ilelaboye, N.O.A., Amoo, I. A and Pikuda, O. O. 2013. Effect of cooking methods on mineral and anti nutrient composition of some green leafy vegetables. *Archives of Applied Science Research*. 5 (3): 254-260.

Ishida, H., Suzuno, H., Sugiyama, N., Innami, S., Todokoro, T. and Maekawa, A. 2000. Nutritional evaluation of chemical component of leaves stalks and stems of sweet potatoes (Ipomea batatas). *Food Chemistry*. 68: 359- 367.

Jacob, S.J.P and Shenbagaraman, S. 2011. Evaluation of antioxidant and antimicrobial activities of the selected green leafy vegetables. *International Journal of Pharmacy and Pharmaceutical Sciences*. 3 (1): 148-152.

Jenkins, D.J., Kendall, C.W., Popovich, D.G., et al. 2001. Effect of a very high fiber vegetable, fruit, and nut diet on serum lipids and Colonic function. *Metabolism*. 50 (4):494-503.

Jimenez-Aguilar D.M and Grusak, M.A. 2017. Minerals, vitamin C, phenolics, flavonoids and antioxidant activity of amaranthus leafy vegetables. *Journal of Food Composition and Analysis*. 58: 33–39.

Jogelkar, A., Banerjee, S and Mishra, M. 2014. Awareness, knowledge and attitude towards green leafy vegetables among urban women. *Studies on Home and Community Science*. 8 (2-3): 75-79.

Kawashima, L.M and Soares, L.M.V. 2005. Effect of blanching time on selective mineral elements extraction from the spinach substitute commonly used in brazil (*Tetragonia expansa*). *Ciência e Tecnologia de Alimentos*. 25 (3): 419-424.

Khachick, F., Goli, M.B., Beecher, G.R., Holden, J., Lusby, W.R., Tenorio, M.D and Barrera, M.R. 1992. Effect of food preparation on quantitative and qualitative distribution of major carotenoid constituents of tomatoes and several green vegetables. *Journal of Agricultural and Food Chemistry*. 40: 390-98.

Kidmose, U., Yang, R.Y., Thilsted, S.H., Christensen, L.P and Brandt, K. 2006. Content of carotenoids in commonly consumed Asian vegetables and stability and extractability during frying. *Journal of Food Composition and Analysis*. 19 (6): 562-71.

Kim, S, J., Cho, A.R and JaejoonHan. 2013. Antioxidant and antimicrobial activities of leafy green vegetable extracts and their applications to meat product preservation. *Food Control*. 29 (1): 112-120.

Kumar, C.K.A., Sree, M.S.D., Joshna, A., Lakshmi, M and Kumar, D.S. 2013. A review on south indian edible leafy vegetables. *Journal of Global Trends in Pharmaceutical Sciences*. 4 (4): 1248-1256.

Kumari, M., Gupta, S., Jyothi Lakshmi, A and Prakash, J. (2004). Iron bioavailability in green leafy vegetables cooked in different utensils. *Food Chemistry*. 86: 217–222.

Lewu, M. N and Kambizi, L. 2014. Comparative nutritional assessment of selected leafy vegetables. *Journal of Food Agriculture and Environment*. 12 (2):85-88.

Lintas, C and Cappelloni, M. 1998. Dietary fiber, resistant starch and in vitro starch digestibility of cereal meals. *Food Science and Nutrition*. 42: 117 – 124.

Mathiventhan, U., Sivaganeshan, R and Mathiventhan T. 2014. Identification, market availability and consumption of green leafy vegetables in batticaloa, Sri Lanka. *Tropical Plant Research*. 1(2): 17–25.

McDougall G.J., Morrison I.M., Stewart D and Hillman J.R. 1996. Plant cell walls as dietary fibre: range, structure, processing and function. *Journal of the Science of Food and Agriculture*. 70: 133–150.

Mibei, E.K., Ojijo, N.K.O., Karanja, S, M and Kinyua, J.K. 2012. Phytochemical and antioxidant analysis of methanolic extracts of four african indigenous leafy vegetables. *Food Science and Technology*. 13 (1): 37-42.

Miglio, C., Chiavaro, E., Visconti, A., Fogliano, V and Pellegrini, N. 2008. Effects of different cooking methods on nutritional and physicochemical characteristics of selected vegetables. *Journal of Agriculture and Food Chemistry*. 56: 139–147.

Mirsa, S., Maikhuri, R.K., Kala, C.P., Rao, K.S and Saxena. 2008. Wild leafy vegetables: A study of their subsistence dietetic support to the inhabitants of nanda devi biosphere reserve, India. *Journal of Ethnobiology and Ethnomedicine*. 4-5

Morris, M.C., Wang, Y., Barnes, L.L., Bennett, D.A., Dawson-Hughes, B., and Booth, S.L. 2018. Nutrients and bioactives in green leafy vegetables and cognitive decline. *Neurology*. 90 (3): 214-222.

Natesh, H.N., Abbey, L and Asiedu, S.K. 2017. An overview of nutritional and anti nutritional factors in green leafy vegetables. *Horticulture International Journal*. 1 (2): 58–65.

Nkafamiya, I.I., Oseameahon, S.A., Modibbo, U.U and Haggai, D. 2010. Vitamins and effect of blanching on nutritional and antinutritional values of non-conventional leafy vegetables. *African Journal of Food Science*. 4 (6): 335 – 341.

Noonan and Savage, G.P. 1999. Oxalate content of foods and its effect on humans. *Asia Pacific Journal of Clinical Nutrition*. 8(1):64-74.

Oulai, P.D., Zoue, L.T., Bedikou, M. E. R., Megnanou, O and Niamke, S.L. 2014. Impact of cooking on nutritive and antioxidant characteristics of leafy vegetables consumed in northern côte d'ivoire. *International Journal of Plant, Animal and Environmental Sciences*. 4 (3): 577- 585.

Pandey, P and Neerubala. 2013. Conducted a study on food consumption patterns of adult population in rural and urban areas of faizabad district of uttar pradesh, India. *International Journal of Science and Research.* 5 (2): 2080-2084.

Prabha, P., Nath, K.G and Ramya, B.S. 2008. Consumption pattern of green leafy vegetables among selected urban households in bangalore, India. *Asian Journal of Home Science*. 3 (2): 180-185.

Radek, M and Savage, G. 2008. Oxalates in some Indian green leafy vegetables. *International Journal of Food Science and Nutrition*. 59 (3): 246–260.

Randhawa, M. F., Khan, A.A., Javed, M.S and Sajid, M.W. 2015. Green Leafy Vegetables: A Health Promoting Source. *Hand Book of Fertility Nutrition, Diet, Lifestyle and Reproductive Health*. Academic press. 205- 220.

Rao, J. S and Bhaskarachary, K. 2014. Retention based bio accessibility of carotenoids in green leafy vegetables: effect of different Indian culinary practices. *Indian Journal of Community Health*. 26 (2): 270-278.

Rodriguez-Amaya, D.B and de Sa, M.C. 2004. Optimization of HPLC quantification of carotenoids in cooked green vegetables-Comparison of analytical and calculated data. *Journal of Food Composition and Analysis*. 17: 37-51.

Routray, R., Kar, M and Sahu, R, K. 2103. Evaluation of antioxidant potential in selected leafy vegetables of odisha, India. *International Journal of Pharmacy and Pharmaceutical Sciences*. 5 (1): 0975-1491.

Sahu, R, K., Kar, M and Routray, R. 2013. DPPH Free Radical Scavenging Activity of Some Leafy Vegetables used by tribals of odisha, India. *Journal of Medicinal Plants Studies*. 1 (4): 21-27.

Saleh, A.S.M., Zhang, Q., Chen, J and Shen, Q. 2013. Millet grains: nutritional quality, processing, and potential health benefits. *Comprehensive Reviews in Food Science and Food Safety*. 12: 281-295.

Saranya R, Devanesan G, Ramesh S and Gopi R. 2017. Effect of Processing on Nutritional Quality and Antioxidant Potentials of Leafy Vegetables. *Journal of Food Processing and Technology*. 8 (9): 694.

Scaglioni, S., Salvioni, M and Galimberti, *C. 2008*. Influence of parental attitudes in the development of children’s eating behavior. *British Journal of Nutrition*. 99 (1): S22–S25.

Schonfeldt, H. C and Pretorius, B. 2011. The nutrient content of five traditional South African dark green leafy vegetables - A preliminary study. *Journal of Food Composition and Analysis*. 24: 1141–1146.

Shukla, N.K., Shukla, M., Ahmad, S and Shukla, R. 2017. A preliminary study on eating habits among school going adolescent girls in barabanki district, Uttar pradesh. *Scholars Journal of Applied Medical Sciences*. 5 (1C): 184-187.

Singh, R.R and Harshal, A. 2016. Effects of cooking on content of vitamin C in green leafy vegetables. *Scholars Journal of Agriculture and Veterinary Sciences*. 3 (6): 416-423.

Slavin, J.L. 1987. Dietary fiber and body weight. *Journal of the Academy of Nutrition and Dietetics*. 87: 1164-1168.

Sotelo, A., Gonzalez-Osnaya, L., Sanchez-Chinchillas, A and Trejo, A. 2010. Role of oxate, phytate, tannins and cooking on iron bioavailability from foods commonly consumed in mexico. *International Journal of Food Sciences and Nutrition*. 61 (1): 29-39.

Speek, A.J., Temalilwa, G.R., Schrijver, J. 1986. Determination of β-carotene content and vitamin A activity of vegetables by HPLC. *Food Chemistry*. 19: 65-74.

Svanberg, S.S.M., Nyman, E.M.G., Andersson, L and Nilsson R. 1997. Effects of boiling and storage on dietary fiber and digestible carbohydrates in various cultivars of carrots. *Journal of the Science of Food and Agriculture*. 73: 245-254.

Tiwari, A.K., Jyothi, A.L., Tejeswini, V.B., Madhusudana, K., Kumar, D,A., Zehra, A and Agawane, S.B. 2013. Mitigation of starch and glucose-induced postprandial glycemic excursion in rats by antioxidant-rich green-leafy vegetables juice. *Pharmacognosy Magazine*. 9(1): S66–S73.

Uadal, S and Sagar, V.R. 2008. Influence of packaging and storage temperature on the quality of dehydrated selected leafy vegetables. *Journal of Food Science and Technology*. 45: 450 – 453.

Velderrain-Rodriguez, G. R., Palafox-Carlos, H., Wall-Medrano, A., Ayala-Zavala, J. F., Chen, C. Y., Robles-Sanchez, M., Astiazaran-Garcia, H., Alvarez-Parrilla, E and Gonzalez-Aguilar G. A. 2014. Phenolic compounds: their journey after intake. *Food and Function*. 5 (2): 189-197.

Venu, S., Khushbu, S., Santhi, S., Ashish, R., Sunil, C.K and Sureshkumar, K. 2019. Phytochemical profile and Therapeutic properties of leafy vegetables. *Plant and Human Health.* 2: 627-660.

Vimala, B, Nambisan, B and Hariprakash, B. 2011. Retention of carotenoids in orange-fleshed sweet potato during processing. *Journal of food science and technology*. 48 (4): 520-24.

Vimala, B., Nambisan, B and Hariprakash, B. 2011. Retention of carotenoids in orange-fleshed sweet potato during processing. *Journal of Food Science and Technology*. 48 (4): 520–524.

Zerfu, T.A., Pinto, E and Baye, K. 2018. Conducted a study on consumption of dairy, fruits and dark green leafy vegetables is associated with lower risk of adverse pregnancy outcomes (APO): a prospective cohort study in rural Ethiopia. *Nutrition and Diabetes.* 8: 52.

Note: The pattern of Literature Cited presented above is in accordance with the guidelines for thesis presentation. Acharya N.G Ranga Agricultural University, Lam Guntur

APPENDICES

Appendix-A:

Interview Schedule for eliciting information on "Consumption pattern of green leafy vegetables among different income groups in Guntur Town".

Date: Schedule No.: __________

1. Name of the Respondent:

2. Address:

3. Type of the family:

4. Family size (No.): Men:______ Women:_______ Children:_______

5. Family composition:

S.No	Name of the family members	Sex (F/M)	Age (yrs.)
1.			
2.			
3.			
4.			
5.			
6.			

6. Socioeconomic status of the family: (Kuppuswamy, 2019)

S.No		Score
I.	**Occupation of the head of the family**	
	Legislatures, Senior Officials and Managers	10
	Professionals	9
	Technicians and Associate Professionals	8
	Clerks	7
	Skilled Workers and Shop & Market Sales Workers	6
	Skilled Agricultural & Fishery Workers	5
	Craft & Related Trade Workers	4
	Plant & Machine Operators and Assemblers	3
	Elementary Occupation	2
	Unemployed	1
II.	**Education of the head of the family**	
	Profession or honours	7
	Graduate or post graduate	6
	Intermediate or post high school diploma	5
	High school certificate	4
	Middle school certificate	3
	Primary school certificate	2
	Illiterate	1
III.	**Monthly income of the family**	
	>1,26,360	12

	63,182-126,356	10
	47,266-63178	6
	31,591-47262	4
	18,953-31589	3
	6327-18949	2
	≤6323	1
V.	**Socio economic class**	
	Upper (I)	26- 29
	Upper middle (II)	16- 25
	Lower middle (III)	11- 15
	Upper lower (IV)	5- 10
	Lower (V)	< 5

7. Do you consume green leafy vegetables?

S.No	Green leafy vegetables	Tick
1.	Amaranth (Thotakura)	
2.	Spinach (Paalakura)	
3.	Gogu (Gongura)	
4.	Fenugreek leaves (Menthikura)	
5.	Rumex leaves (Chukka Kura)	
6.	Basella leaves (Bacchalakura)	
7.	Punnanganni (Ponnagantikura)	
8.	Tamarind leaves (Chintha aaku)	
9.	Drum stick leaves (Munaga aaku)	
10.	Agathi leaves (Avise aaku)	
11.	Mint (Pudina)	
12.	Coriander (Kotthimeera)	
13.	Curry Leaves (Karivaepaku)	
14.	Any others	
15.		

8. If you consume green leafy vegetables how frequently?

Green leafy vegetables	Daily	Alter-nate days	Twice in a week	Once in a week	Once in fortnight	Montly once	Season -ally	Never
Tick								

9. What are the most frequently consumed green leafy vegetables?

S.No	Green leafy vegetables	Tick
1.	Amaranth (Thotakura)	
2.	Spinach (Paalakura)	
3.	Gogu (Gongura)	
4.	Fenugreek leaves (Menthikura)	
5.	Rumex leaves (Chukka Kura)	
6.	Basella leaves (Bacchalakura)	
7.	Punnanganni (Ponnagantikura)	
8.	Tamarind leaves (Chintha aaku)	
9.	Drum stick leaves (Munaga aaku)	

10.	Agathi leaves (Avise aaku)	
11.	Mint (Pudina)	
12.	Coriander (Kotthimeera)	
13.	Curry Leaves (Karivaepaku)	
14.	Any others	
15.		

Remarks:

10. Do you use condiments in every seasoning?

S. No	Green leafy vegetables	Tick
1.	Coriander (Kotthimeera)	
2.	Curry leaves (Karvepaku)	

11. If you use whether you consume those seasoned greens or discard?

    Remarks:

12. If yes how frequently?

S.No	Green leafy vegetables	Daily	Alternate days	Twice in a week	Once in a week	Once in fortnight	Monthly once
1.	Coriander (Kotthimeera)						
2.	Curry leaves (Karvepaku)						

13. Do you find it difficult to use green leafy vegetables? Yes/No

14. If yes what are the difficulties?

S.No	Difficulties	Tick
1.	Difficulty in cleaning	
2.	It contain many worms	
3.	Lower shelf life	

15. Do you use green leafy vegetables powders in cooking?

16. Do you consume dried green leafy vegetables?

17. What is the reason behind the consumption of green leafy vegetables?

S.No	Reason	Tick
1.	Contains carotene good for vision	
2.	High in fiber	
3.	Rich in vitamins and minerals	
4.	Good for anaemic patients	
5.	Contains less sugar	
6.	Good for bone health	
7.	Habituated to consume greens	
8.	Any other	

18. What is the quantity of the green leafy that you purchase?

S.No	Green leafy vegetables	10- 50g	50-100g	100-200g	200-300g	300-400g	400-500g
1.	Amaranth (Thotakura)						
2.	Spinach (Paalakura)						
3.	Gogu (Gongura)						
4.	Fenugreek leaves (Menthikura)						
5.	Rumex leaves (Chukka Kura)						
6.	Basella leaves (Bacchalakura)						
7.	Ponnanganni (Ponnagantikura)						
8.	Tamarind leaves (Chintha aaku)						
9.	Drum stick leaves (Munaga aaku)						
10.	Agathi leaves (Avise aaku)						
11.	Mint (Pudina)						
12.	Coriander (Kotthimeera)						
13.	Curry Leaves (Karivaepaku)						
14.	Any others						

19. What is the cost of each bundle of green leafy vegetables? Did you observe any seasonal variations in the cost of green leafy vegetables?

S.No	Season	Cost per bundle
1.	Summer	
2.	Rainy	
3.	Winter	

20. Where do you procure green leafy vegetables?

21. What is the selection criterion for purchasing green leafy vegetables?

22. What are the most commonly processed/practiced cooking methods used for cooking green leafy vegetables?

S.No	Cooking method	Tick
1.	Pressure cooking	

2.	Boiling	
3.	Frying	
4.	Deep fat frying	
5.	Sauteing	
6.	Simmering	

23. What are the most commonly prepared and preferred recipes using green leafy vegetables?

S.No	Recipes	Prepared	Preferred
1.	Dhal		
2.	Curry		
3.	Pulusu		
4.	Iguru		
5.	Fry		
6.	Deep fat fry		
7.	Roti pacchadi		
8.	Pickles		
9.	Others		
10.			

24. Recipes along with details of cooking?

S.No	Recipes	Cooking methods
1.	Dhal	
2.	Curry	
3.	Pulusu	
4.	Iguru	
5.	Fry	
6.	Deep fat fry	
7.	Roti pacchadi	
8.	Pickles	
9.	Others	
10.		

25. Do you cook green leafy vegetables immediately after purchasing?

26. Do you store green leafy vegetables? Yes/No

27. If yes for how long ?

S.No	Duration	Tick
1.	Half day	
2.	One day	
3.	Two days	
4.	Three days or more	

28. What is the method of storage practiced?

S.No	Method of storage	Tick
1.	Refrigerated temperature	
2.	Ambient temperature	
3.	Plastic covers	
4.	Air tight containers	
5.	Wrapped in News papers	
6.	Wrapped in Tissue papers	
7.	Other method	

29. What are the pre-processing operations that you follow while cooking green leafy vegetables?

S.No	Pre Processing Operations	Always	Sometimes
1.	Washing and cutting		
2.	Cutting and washing		
3.	Cooking green leafy vegetables in excess of water and discarding the water		

Appendix –B:

Estimation of Total Carotenoids and β Carotene

Reagents

1. Acetone – Dry, alcohol – free

2. Commercial hexane – B.P 60 - 70°; distilled over KOH.

3. Adsorbent – Activated magnesia (Sea Sorb 43; Fisher Scientific Co., No. S-120).

4. Diatomaceous earth – Hyflo Super- Cel

Extraction: Finely grind the Green leafy vegetables and to assure the representative sample.

If the analysis cannot be performed immediately, blanch in boiling H_20 for 5 - 10 min and store in frozen condition.

Procedure: Place 2 -5 g weighed sample in high speed blender and add 4 ml acetone, 60 ml hexane, 0.1 g $MgC0_3$ and blend 5 min. Filter with suction or let residue settle and decant into separator. Wash residue with two 25 ml portions acetone, then wit 25 ml hexane and combine the extracts. Wash acetone from extracts with five 100 ml portions of H_20, transfer upper layer to 100 ml Volume flask containing 9 ml acetone and dilute with hexane. If desired, alcohol may be used instead of acetone for extraction. Use 80 ml alcohol and 60 ml hexane in blender; other volumes are same as for acetone.

Separation of Pigments:

Pack activated magnesia – diatomous earth mixture (1+1) in chromatographic tube 22 mm od x 175 mm sealed to 10 mm od tube at bottom. To prepare column place small glass wool or cotton plug inside tube, Add lose adsorbent to 15 cm depth, attach tube to suction flask and apply full vacuum of H_2O pump. Use flat instrument (such as inverted cork mounted on rod or tamping rod) to gently press adsorbent and flatten surface (Packed column should be 10 cm deep). Place 1 cm layer anhyd. Na_2S0_4 above adsorbent. With vac. continuously applied to flask, pour extract into column. Use 50 ml acetone-hexane (1 +9) or slightly more, if necessary, to develop chromatogram and wash visible carotenes through adsorbent. Keep top of column covered with layer of solvent during entire operation (conveniently done by clamping inverted volumetric flask full of solvent above column with neck 1-2 cm above surface of adsorbent). Collect entire elute. (Carotenes pass rapidly through column; bands of xanthophylls, carotene oxidant products, and chlorophylls should be present in column when operation is complete). Transfer elute, which has been reduced in volume by loss of vapour through H20 pump, to 100 ml volumetric flask and dilute to volume with acetone hexane (1+9), and determine carotene content photometrically,

Collect entire elute. (Carotenes pass rapidly through column; bands of xanthophylls, carotene oxidant products, and chlorophylls should be present in column when operation is complete.)

Transfer elute, which has been reduced in volume by loss of vapour through H20 pump, to 100 ml volumetric flask and dilute to volume with acetone hexane (1 +9), and determine carotene content photometrically.

Determination

Determine A of solution as soon as possible with spectrophotometer at 436 nm or with instrument having suitable filter system, such as Klett photometer with No. 44 filter, or Evelyn photoelectric colorimeter with 440 nm filter. Calibrate these instruments first with solutions of high purity f β -carotene as shown by characteristic absorption curve . Prepare calibration chart and convert A of solution to be detected to carotene concentration from chart.

When determinations are made with properly calibrated spectrophotometer at 436 nm,

C = (A x 454)/(196 x L x WI).

where C = concentration carotene (mg/lb) in original sample,

L = cell length in cm, and

W = g sample/mL final dilution.

Report results as mg of β-carotene/lb.

Multiply by 2.2 to give ppm or by 1667 to give International Units/lb.

Appendix – C:

Estimation of Vitamin C

Principle:

2, 6 – dichlorophenol indophenol is reduced to a colourless form by ascorbic acid. The reaction is specific for ascorbic acid at pH 1 to 35. The dye is blue in alkaline solution and red in acid.

Reagent:

(1) Standard Indophenol Solution – Dissolve 0.05 g, 2,6 dicholorophenol indophenol in water, dilute to 100 ml and filter. They dye solution keeps for a few weeks if stored in refrigerator.

(2) Standared Ascorbic acid solution – Dissolve 0.05 g pure ascorbic acid in 60 ml of 20% metaphosphoric acid (HPO_3) and dilute with water to exactly 250 ml in a volumetric flask.

(3) Metaphosphoric acid – 20%

(4) Acetone

Standardisation of Dye:

Pipette 10 ml of standard Ascorbic acid solution in a small flask and titrate with indophenol solution until a faint pink colour persists for 15 seconds. Express the concentration as mg Ascorbic acid equivalent to 1 ml of dye solution i.e 10 ml of Ascorbic acid solution = 0.002/V gm ascorbic acid.

Procedure:

Pippette 50ml of unconcentrated juice (or the equivalent juice) into a 100ml volumetric flasck, add 25 mlof 20% meta Metaphosphoric acid as stabilizing agent and dilute to volume. Pippette 10 ml in a small flask and add 2,5 ml acetone. Titrate with indophenol solution until a faint pink colour persist for 15 seconds.

Blank correction: Dissolve 50 mg 2,6- dichloroindophenol Na salt that has been stored in desiccator over soda lime, in 50 ml H_2O to which has been added 42 mg $NaHCO_3$, shake vigoursly, and when dye dissolves, dilute to 200 ml with H_2O . Filter through fluted paper into amber glass- stoppered bottle. Keep the stoppered out of direct sunlight, store in refrigerator. (Decomposition products that make end point in distinct occur in some batches of dry indophenol and also develops with time in stock solution. Add 5 ml extracting solution containing excess ascorbic acid to 15 ml dye reagent. If reduced solution is not practically colourless, discard and prepare new stock solution. If dry dye is at fault, obtain new supply).

Transfer three 2 ml aliquots ascorbic acid standard solution to each of three 50 ml Erlenmeyer's containing 5 ml HPO_3 – CH_3COOH solution, B (a) (*I*). Titrate rapidly with indophenol solution from 50 ml burette until light but distinct rose pink persists 5 s. (Each titration should require a 15ml indophenol solution, and titrations should check within 0.1 ml). similarly titrate 3 blanks composed of 7.0 ml $HPO_{3,}$-CH_3COOH solution. B (a)(I), plus volume H_2O ca equal to volume indophenols solution used in direct titrations. After subtracting average blanks (usually ca 0.1 ml) from standardization titration, calculate and express to 1.0 ml reagent. Standardize indophenol solution daily with freshly prepared ascorbic acid standard solution.

Calculation

Vitamin C (mg/100 ml juice) = 20 (V) (C)

Where,

V= ml indophenol solution

C= Vitamin C per ml indophenol solution mg Ascorbic acid/g= (X-B) x (F/E) x (V/Y)

Where,

X = average ml for test solution titration,

B = average ml for test blank solution titration,

F = mg ascorbic acid equivalent to one ml indophenol standard solution,

E = no. of g, tablets, ml, etc. assayed

V = volume initial test solution

Y = volume test solution titrated

Appendix – D:

Estimation of Minerals

Distillation of hydrochloric acid

Take 500 ml of concentrated HCL and mix with equal volume of distilled water and the whole mixture then placed in the distillation flask and distilled. A few ml of distillate first collected should be discarded and the collection of distillate continued. The distillation of HCL is a must as it contains lots of micro nutrient impurities even in analar grade.

The conical flask should be thoroughly washed with corning glass distilled HCL for a number of times and finally washed with coarning glass distilled water.

Preparation of tri-acid mixture

Concentration nitric acid and concentrated sulphuric acid perchloric acid are mixed in the proportion of HNO3: H2SO4: HCLO4 – 10: 0.5: 2.0 by volume and stored in a pyrex or corning make reagent bottle. All the three acid should be analar grade.

Tri-acid digestion and solution preparation

0.5 g of sample is accurately weighted into a 150 ml conical flask. 10 ml of the triacid mixture is added to the sample and a funnel kept over the digestion flask. The contents are left overnight for cold digestion. The next day the contents are digested at low temperature for about 2 to 3 hours at 50 to 600C on hot plate. The temperature of the hot plate is increased to 2000C till the contents become white and the major portion of perchloric acid is expelled, i.e., the dense white fumes of perchloric acid to appear on heating. Then the flask is removed from the hot plate, cooled and diluted to50 ml and filtered through Whitman No.1 filter paper. This solution is used for determination of micro quantities of Ca and Fe.

Readings

The sample solutions are analyzed for mineral estimation in atomic absorption spectrophotometer.

Appendix – E:

Estimation of Crude Fibre

Principle

During the acid and subsequent alkali treatment, oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin occurs. The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The loss in weight is the crude fiber content.

Reagents

- 0.255 ± 0.005 N standard H_2SO_4
- 0.313 ± 0.005 N standard NaOH

Procedure

Weighed amount of (2.5-5g) of moisture and fat free sample was transferred to a fibre bag which was pre heated and weighed. These bags were inserted into tubes and placed in a beaker provided in the instrument. The sample was boiled with 300ml 0.255 ± 0.005N H_2SO_4 for 30 minutes. Then the residue was washed with boiling water until acid free. Then residue was boiled with 300ml of 0.313 ± 0.005 N NaOH for 30 minutes. Again, the residue was washed with boiling water followed by alcohol wash. The residue was transferred to pre-weighed crucibles (W1) and it was dried to 2 hours at 130± 2°C, cooled in desiccators the weighed (W2). The dried desiccators containing samples were then ignited for 30 minutes at 60˚ ± 15°C. Finally, the sample was cooled and weighed again.

$$\text{Crude Fibre}\left(\frac{\text{g}}{100\text{g}}\text{of sample}\right) = \frac{[(100-(\text{Moisture}+\text{Fat}\,)]\times(W_1-W_2)}{\text{Weight Of Sample Taken (Moisture And Fat Free)}}$$

Where,

- W1 = Pre-weighed ashing dish
- W2 = Weight of the dish after ashing

Appendix –F:

Structure of ANOVA

ANOVA					
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F_{cal} Value**	**F_{tab} Value**
Treatment	(t-1)		TSS	TMS	TMS/EMS
Error	(n-1)		ESS	EMS	
Total	(n-1)				

Where, t = Number of treatments

n = Number of Observations

TSS = Treatment Sum of Squares

ESS = Error Sum of Squares

TMS = Treatment Sum of Squares

EMS = Error Mean Sum of Squares

CV =	SQRT (EMS/GM)* 100
SED =	SQRT (2)* Treatments
CD =	t (0.05)*SED

Where, CV = Co-efficient of variation

SED = Standard error of difference

GM = General Mean

CD = Critical Diffrence

t (0.05) = t value at 5% probability level

Appendix- G:

ANOVA OF TOTAL CAROTENOIDS FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Between Groups	3	27988.489	9329.4963	488.2089	4.07	0
Within Group	8	152.8771	19.1096			
Total	11	28141.3661				

Appendix- H:

ANOVA OF β CAROTENE FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Between Groups	3	5355.8058	1785.2686	487.0513	4.07	0
Within Group	8	29.3237	3.6655			
Total	11	5385.1295				

Appendix- I:

ANOVA OF ASCORBIC ACID FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Between Groups	3	11976.0571	3992.019	3305.8331	4.07	0
Within Groups	8	9.6605	1.2076			
Total	11	11985.7176				

Appendix- J:

ANOVA OF CALCIUM FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	157.2711	52.4237	10.4657	4.07	0.0038
Error	8	40.0727	5.0091			
Total	11	197.3438				

Appendix- K:

ANOVA OF IRON FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	3.4655	1.1552	12.6531	4.07	0.0021
Error	8	0.7304	0.0913			
Total	11	4.1959				

Appendix- L:

ANOVA OF TOTAL DIETARY FIBER FOR AMARANTH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	1.1247	0.3749	69.2217	4.07	0
Error	8	0.0433	0.0054			
Total	11	1.1681				

Appendix- M:

ANOVA OF TOTAL CAROTENOIDS FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	882.9347	294.3116	96.8413	4.07	0
Error	8	24.3129	3.0391			
Total	11	907.2476				

Appendix- N:

ANOVA OF β-CAROTENE FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P- Value**
Treatment	3	105.2205	35.0735	10.3263	4.07	0
Error	8	27.1722	3.3965			
Total	11	132.3927				

Appendix- O:

ANOVA OF ASCORBIC ACID FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	1514.4934	504.8311	1712.3297	4.07	0
Error	8	2.3586	0.2948			
Total	11	1.516.852				

Appendix- P:

ANOVA OF CALCIUM FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	80.5644	26.8548	11.2064	4.07	0.0031
Error	8	19.171	2.3964			
Total	11	99.7355				

Appendix- Q:

ANOVA OF IRON FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P- Value**
Treatment	3	2.9171	0.9724	14.5144	4.07	0.0013
Error	8	0.5359	0.064			
Total	11	3.453				

Appendix- R:

ANOVA OF TOTAL DIETARY FIBER FOR SPINACH

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	1.3004	0.4335	6.1449	4.07	0
Error	8	0.5643	0.0705			
Total	11	1.8647				

Appendix- S:

ANOVA OF TOTAL CAROTENOIDS FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	19127.25	6375.75	1246.5606	4.07	0
Error	8	40.9174	5.1147			
Total	11	19168.1674				

Appendix- T:

ANOVA OF β CAROTENE FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	1152.6503	384.2168	66.3547	4.07	0
Error	8	46.3228	5.7903			
Total	11	1198.973				

Appendix- U:

ANOVA OF ASCORBIC ACID FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	1002.658	334.2193	546.1736	4.07	0
Error	8	4.8954	0.6119			
Total	11	1007.5534				

Appendix- V:

ANOVA OF CALCIUM FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	145.7232	48.5744	12.2408	4.07	0
Error	8	31.7458	3.9682			
Total	11	177.469				

Appendix- W:

ANOVA OF IRON FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	0.4196	0.1399	1.6374	4.07	0
Error	8	0.6834	0.0854			
Total	11	1.103				

Appendix- X:

ANOVA OF TOTAL DIETARY FIBER FOR GOGU

ANOVA						
Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F -Stat**	**F- Tab**	**P-Value**
Treatment	3	0.8285	0.2762	3.8825	4.07	0
Error	8	0.5691	0.0711			
Total	11	1.3976				