

## Results and Discussion

The results of the present study entitled “**Bioavailability of iron and zinc from regional diets**” is presented in the following headings.

- A. PHASE – I : Consumption pattern of regional diets from the households of selected districts of Tamil Nadu
- B. PHASE – II : Evaluation of nutrient potentials of regional diets and convenience foods
- C. PHASE – III : *In vitro* bioaccessibility of iron and zinc from the regional diets and convenience foods
- D. PHASE – IV : Nutrient evaluation of ready to eat foods from millets incorporated with shade dried drumstick leaves and *in vitro* bioaccessibility of iron and zinc
- E. PHASE – V : *In vivo* bioavailability of iron and zinc from ready to eat food and impact of interventions on iron nutriture of adolescent girls

The present study was a community based cross sectional survey, carried out in the households of four districts of Tamil Nadu, adopting multi stage random sampling. From the 32 districts of Tamil Nadu, four districts namely Chennai, Trichy, Coimbatore and Kanyakumari were selected, from the four regions namely North, East, West and South. From each district, two taluks were selected. From each taluk, one rural and one urban area were selected. Thus, a total of 427 households were surveyed. Data on regional diets and food consumption pattern of these districts were not available and hence they were considered for the present investigation.

The results of the study are presented and discussed in detail.

### **A. PHASE – I : CONSUMPTION PATTERN OF REGIONAL DIETS FROM THE HOUSEHOLDS OF SELECTED DISTRICTS OF TAMIL NADU**

#### **1. Socio- economic background of the households**

For the assessment of the socio-economic characteristics of the households details regarding, age of each family members, occupational status, educational status, religion, caste, type of family, size of family and total family income has been gathered using an interview schedule. Table III shows the background characteristics of the households.

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**TABLE III**  
**SOCIO- ECONOMIC BACKGROUND OF THE HOUSEHOLDS (HHs)**

S. No	Socio Economic Status	Criteria	Chennai		Trichy		Coimbatore		Kanyakumari		Total	
			108 HHs		103 HHs		110 HHs		106 HHs		427 HHs	
			No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1.	<b>Males</b> <b>(Age in years)</b>	0 – 6	8	7.41	7	6.80	9	8.18	12	11.32	36	8.43
		7-12	26	24.07	28	27.18	24	21.82	29	27.36	107	25.06
		13-19	34	31.48	37	35.92	39	35.45	46	43.40	156	36.53
		20 - 59	71	65.74	74	71.84	77	70.00	79	74.53	301	70.49
		>60	19	17.59	23	22.33	26	23.64	22	20.75	90	21.08
2.	<b>Females</b> <b>(Age in years)</b>	0 – 6	12	11.11	8	7.77	11	10.00	12	11.32	43	10.07
		7-12	9	8.33	13	12.62	6	7.27	11	10.38	102	23.89
		13-19	14	12.96	17	16.50	16	14.55	13	12.26	125	29.27
		20 - 59	51	47.22	52	50.49	46	41.82	53	50.00	341	79.86
		>60	16	14.81	13	12.62	17	15.45	19	17.92	107	25.06
3.	<b>Size of Family</b>	1 – 4	87	80.56	81	78.64	80	72.73	72	67.92	320	74.94
		5- 7	9	8.33	13	12.62	18	16.36	19	17.92	59	13.82
		> 8	12	11.11	9	8.74	12	10.91	15	14.15	48	11.24
4.	<b>Educational status of Adult Males</b>	Illiterate	0.0	0.0	0.0	0.0	2	1.82	3	2.83	5	1.17
		Read and Write	3	2.78	7	6.80	9	8.18	4	3.77	23	5.39
		Primary School	11	10.19	9	8.74	11	10.00	7	6.60	38	8.90
		Middle School	9	8.33	14	13.59	13	11.82	14	13.21	50	11.71
		High School	15	13.89	15	14.56	19	17.27	16	15.09	65	15.22
		Higher Secondary	35	32.41	39	37.86	37	33.64	14	13.21	125	29.27
		Graduates	23	21.30	12	11.65	15	13.64	41	38.68	91	21.31
		Professional graduates	12	11.11	7	6.80	6	5.45	10	9.43	35	8.20

*Results and Discussion*

S. No	Socio Economic Status	Criteria	Chennai		Trichy		Coimbatore		Kanyakumari		Total	
			108 HHs		103 HHs		110 HHs		106 HHs		427 HHs	
			No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
5.	Occupation of male members	Coolie	5	4.63	8	7.77	13	11.82	19	17.92	45	10.54
		Farmers	0.0	0.0	12	11.65	16	14.55	17	16.04	37	8.67
		Business	41	37.96	33	32.04	45	40.91	36	33.96	155	36.30
		Private sector	49	45.37	41	39.81	31	28.18	27	25.47	148	34.66
		Government sector	13	12.04	9	8.74	5	4.55	7	6.60	34	7.96
6.	Educational status of Female members	Illiterates	0	0.0	2	1.94	2	1.82	4	3.77	8	1.87
		Read and Write	6	5.56	7	6.80	5	4.55	12	11.32	30	7.03
		Primary School	7	6.48	9	8.74	9	8.18	17	16.04	42	9.84
		Middle School	6	5.56	10	9.71	12	10.91	11	10.38	39	9.13
		High School	11	10.19	13	12.62	14	12.73	13	12.26	51	11.94
		Higher Secondary	33	30.56	39	37.86	40	36.36	16	15.09	128	29.98
		Graduates and Above	29	26.85	16	15.53	21	19.09	28	26.42	94	22.01
Professional graduates	16	14.81	9	8.74	7	6.36	6	5.66	38	8.90		
7.	Educational status of Female members	Illiterates	0	0.0	2	1.94	2	1.82	4	3.77	8	1.87
		Read and Write	6	5.56	7	6.80	5	4.55	12	11.32	30	7.03
		Primary School	7	6.48	9	8.74	9	8.18	17	16.04	42	9.84
		Middle School	6	5.56	10	9.71	12	10.91	11	10.38	39	9.13
		High School	11	10.19	13	12.62	14	12.73	13	12.26	51	11.94
		Higher Secondary	33	30.56	39	37.86	40	36.36	16	15.09	128	29.98
		Graduates and Above	29	26.85	16	15.53	21	19.09	28	26.42	94	22.01
Professional graduates	16	14.81	9	8.74	7	6.36	6	5.66	38	8.90		
8.	Occupation of female members	Farmers/daily wages	8	7.41	11	10.68	19	16.38	14	12.73	52	12.18
		Homemakers	44	40.74	39	37.86	41	35.34	33	30.00	157	36.77
		Business	32	29.63	12	11.65	31	26.72	18	16.36	93	21.78
		Private sector	23	21.30	19	18.45	28	24.14	19	17.27	89	20.84
		Government sector	8	7.41	3	2.91	11	9.48	5	4.55	27	6.32

From Table III, it was found that, the male members in the age group of 20-59 years were 70.49 per cent whereas female members in the age group of 20-59 years were 79.86 per cent. Adolescent males (13-19 years) comprised of 36.53 per cent while adolescent females were 29.27 per cent. Elderly males (>60 years) were 21.08 per cent whereas 25.05 per cent were elderly females. Male children in the age group of 0-6 years were 18.97 per cent and that of female children in that age group were 25.06 per cent. Male Children in the age group of 7- 12 years were 25.06 per cent whereas female children in that age group were 23.89 per cent only.

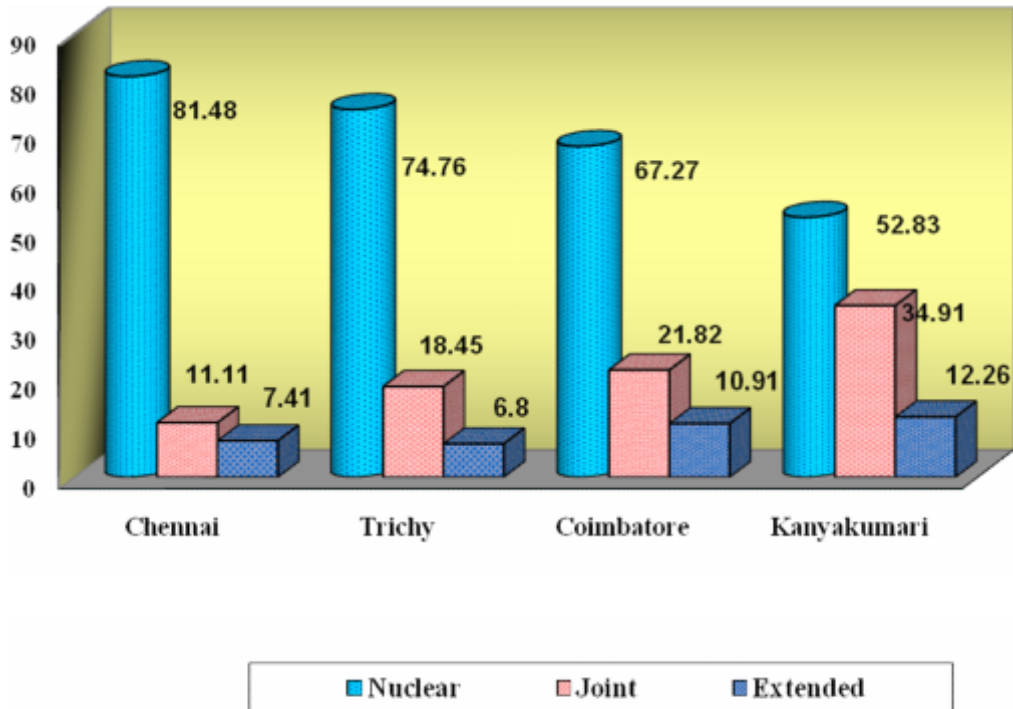
Out of the 427 households surveyed, 55.97 per cent belonged to Hindu, 29.27 per cent were Christians and 14.75per cent were Muslims. Assessment of the caste revealed that, 51.29 per cent of the households were Most Backward Class/ Backward Class, 29.74 per cent were other caste and 18.97 per cent were Scheduled Caste.

Assessment of type of the family showed that 69.09 per cent of the households belonged to nuclear families, 21.55 per cent belonged to joint families and 9.37 per cent belonged to extended families. Around 74.94 per cent of the households consisted of 1 to 4 members, 13.82 per cent has members between 5 to 7 and 11.24 per cent has members above eight numbers. Figure VI shows the distribution of households based on type of family. Survey conducted by National Nnutrition Monitoring Bureau also reported that majority of the husholds surveyed had family size of four, which is in line with the present study.

The education level of females has a major role in health and upbringing of the family, proper hygienic practices and providing balance diets to the family members. The educational status of the female members of the households revealed that 29.98per cent of them were educated upto Higher Secondary, 22.01 per cent of them were graduates and 8.90 per cent were professional graduates. Around 41 per cent of them hadstudied up to high school and 1.87 per cent of them were illiterates. This is in line with the census data (2011), which states that 73.86 per cent females and 86.81 per cent of the males are educated

in Tamil Nadu.

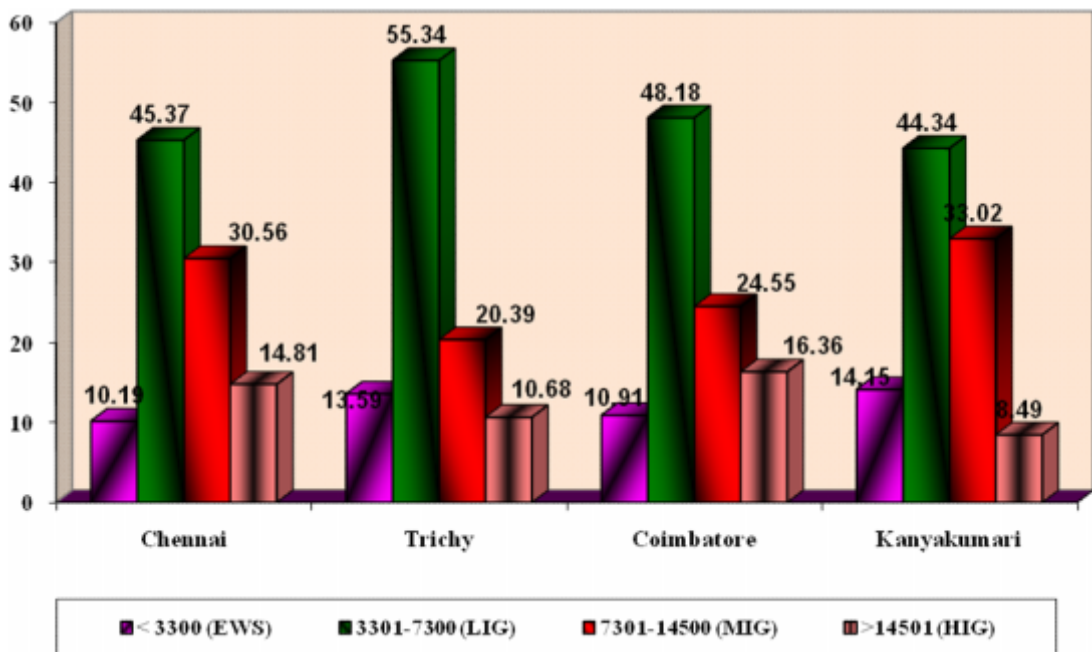
**FIGURE VI**  
**DISTRIBUTION OF HOUSEHOLDS BASED ON TYPE OF FAMILY**



The occupation expresses the income of the family to an extent. In the present study, 36.77 per cent of females were homemakers, 6.32 per cent were Government employees, 20.84 per cent of them were working in private sectors, 21.78 per cent of them were doing own business, 12.18 per cent of them were daily wage earners.

Figure VII shows the classification of the classification of households based on Income. According to the 11<sup>th</sup> 5 year plan (2012) classification, 48.01 per cent of the households belonged Lower Income Group (Rs 3301 – 7300), 27.17 per cent had a family income between Rs 7301 – 14500 (Middle Income Group), 12.65per cent had an income above Rs 14501 (High Income Group) and 12.18 per cent of the households had an income of Rs < 3300 /- only.

**FIGURE VII**  
**CLASSIFICATION OF HOUSEHOLDS BASED ON INCOME**



Source: 11<sup>th</sup> 5 year plan

## 2. Food consumption pattern of the households

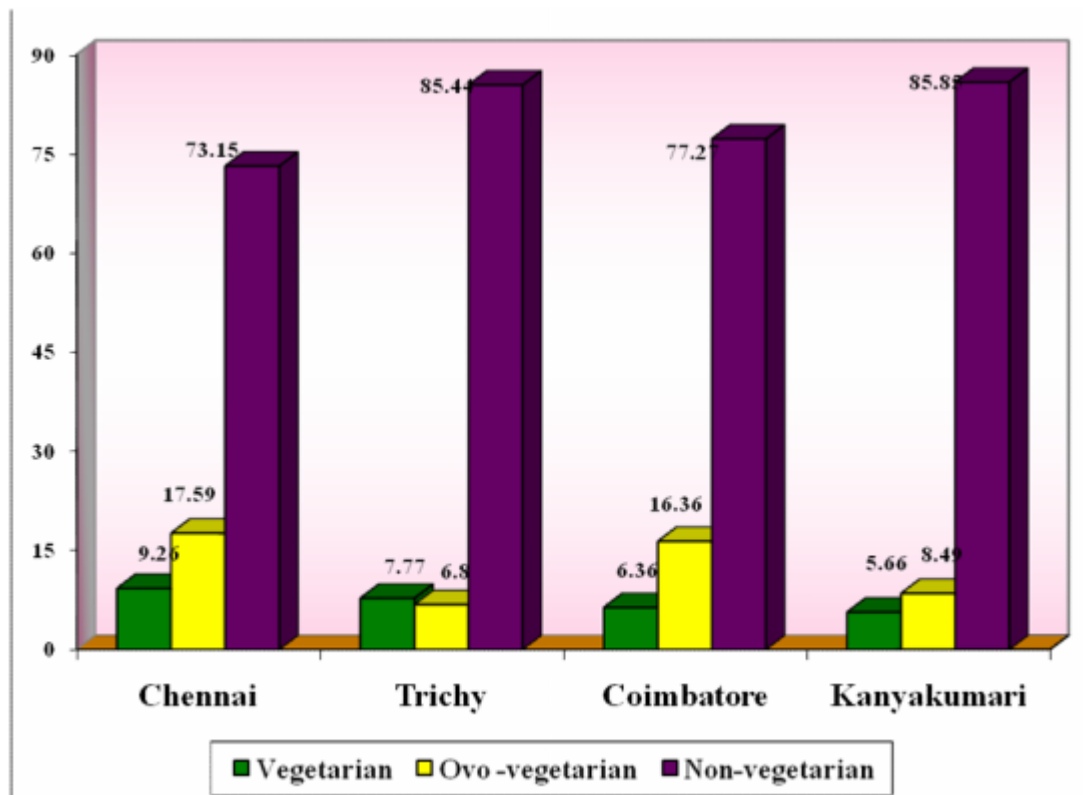
Food consumption pattern is defined as the general way of consuming foods by the households inspite of the changes arising in the market (Ogunniyi, *et al.*, 2012). Assessment of food consumption pattern helps in identifying the direct causes of malnutrition, and will predicts the adequacy of household food intake and nutritional status of family members.

The food consumption pattern of the households were assessed in terms of frequency of consumption of various food items in a month, commonly consumed regional diets, Foods consumed and avoided during various occasions such as minor illness, special occasions, during festivals.

**a. Food habits of the households**

The dietary characteristics of the respondents were assessed using interview schedule and the details regarding food habits, consumption pattern of various food items and frequency of consumption of foods by the respondents were collected. The food habits gives an idea of the general food consumption pattern of the households. Figure VIII shows the distribution of the households based on food habits.

**FIGURE VIII  
DISTRIBUTION OF THE HOUSEHOLDS BASED ON FOOD HABITS**



Out of the 427 households surveyed, 343 households (80.33 per cent) were non vegetarians, 12.41 per cent of the households were ovo-vegetarians and only 7.26 were vegetarians. About 80.33 per cent of the households of Kanyakumari and Trichy were non-vegetarians. In this survey, households of Kanyakumari and Trichy were non-vegetarians of above 85 per cent. Among the households of Chennai and Coimbatore, above 73 per cent and 77.27 per cent were non-vegetarians. Only 9.26 per cent of the households in Chennai were vegetarians and 17.59 per cent were ovo-vegetarians.

**b. Frequency of consumption of food items by the households**

Using the food frequency schedule, the consumption pattern of various food items for a period of one month was collected.

Frequency of consumption of food items revealed that among cereals, rice was consumed daily among the households of all the districts. Consumption of raw rice was above 60.38 per cent of the households and 50.93 per cent of the households of Chennai. In the households of Trichy and Coimbatore 49.51 per cent and 42.73 per cent respectively were consuming raw rice daily.

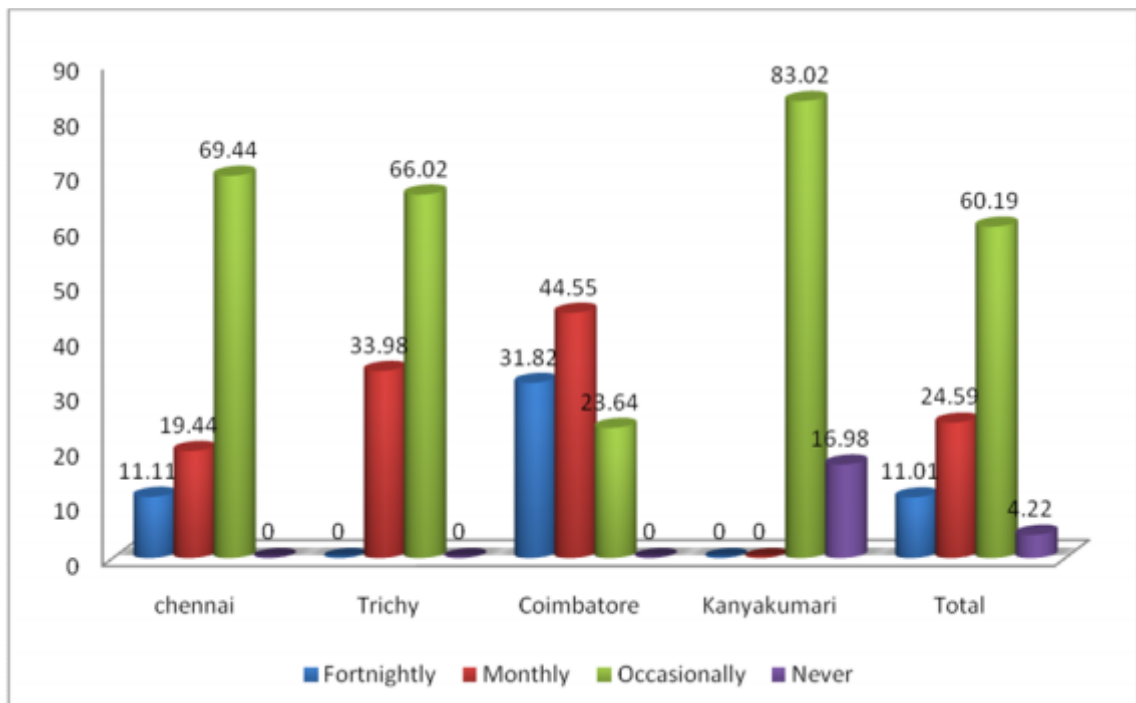
Regarding wheat consumption, around 52.78 per cent of the households of Chennai were consuming wheat in their daily diet. Among the households of Kanyakumari, Trichy and Coimbatore daily wheat consumption was 50.00 per cent, 44.66 per cent and 40.91 per cent respectively.

The frequency of consumption of maida (refined flour) was limited to fortnightly only among the households of all surveyed districts. Around 22.22 per cent households of Chennai, 20.75 per cent of Kanyakumari, 19.09 per cent of Coimbatore and 12.62 per cent households of Trichy were not at all using maida in their household preparations for fortnightly, monthly and occasionally.

Consumption of millets like bajra and ragi were also different in the four surveyed districts. Among 16.36 per cent of the households of Coimbatore were consuming bajra weekly once. Around 22.73 per cent and 6.48 per cent householdsof Coimbatore and Chennai respectively were consuming bajra fortnightly. Among the households of Trichy, 55.34per cent and none of the households of Kanyakumari and 33.33 per cent household of Chennai were not at all consuming bajra.

Frequency of consumption of ragi was also limited to fortnightly, monthly and occasionally only. Majority of the households 69.44, 66.02, 23.64 and 83.02 per cent households of Chennai, Trichy, Coimbatore and Kanyakumari respectively were consuming ragi occasionally. Around 16.91 per cent households were not consuming ragi in their diets. Consumption of pulses was daily by more than 50 per cent households in all the four districts. Figure IX shows the frequency of consumption of ragi by the households of four districts.

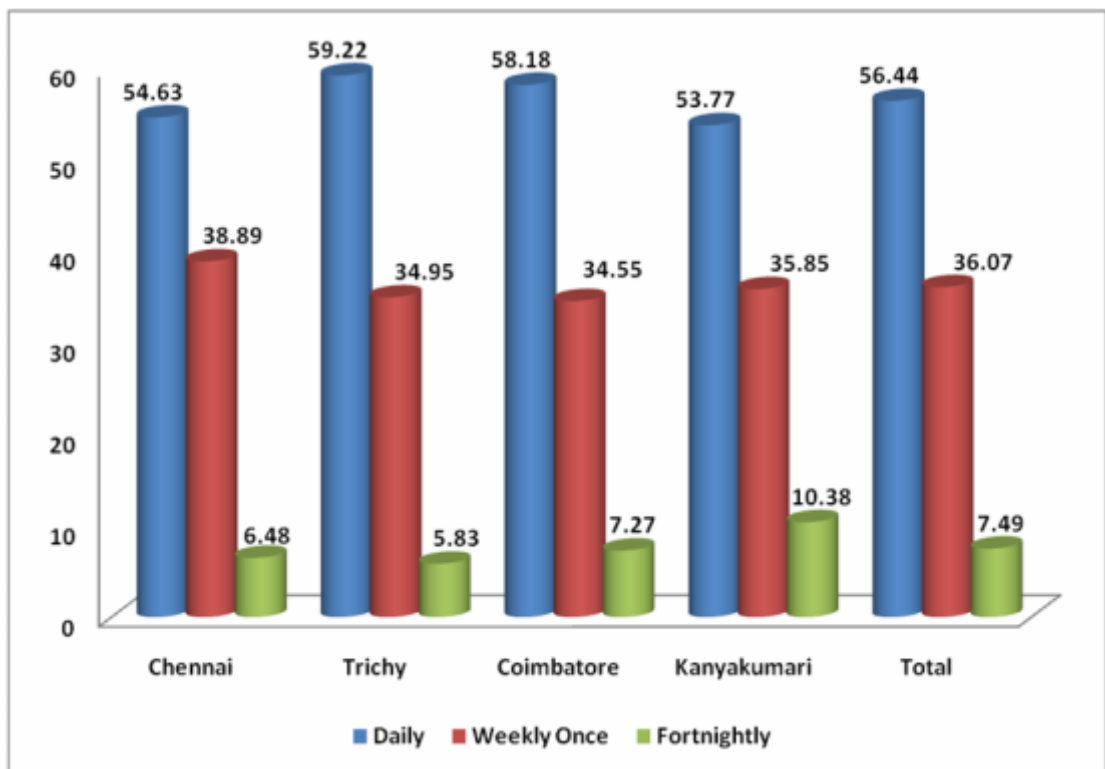
**FIGURE IX**  
**FREQUENCY OF CONSUMPTION OF RAGI**



Regarding the consumption of protein rich pulses, more than 50 per cent households in all the four districts were consuming pulses daily, while around 24 to 38 per cent of the households were consuming pulses weekly once, and 5 to 10 per cent of the households were consuming pulses fortnightly. Figure X shows the frequency of consumption of pulses by the households.

**FIGURE X**

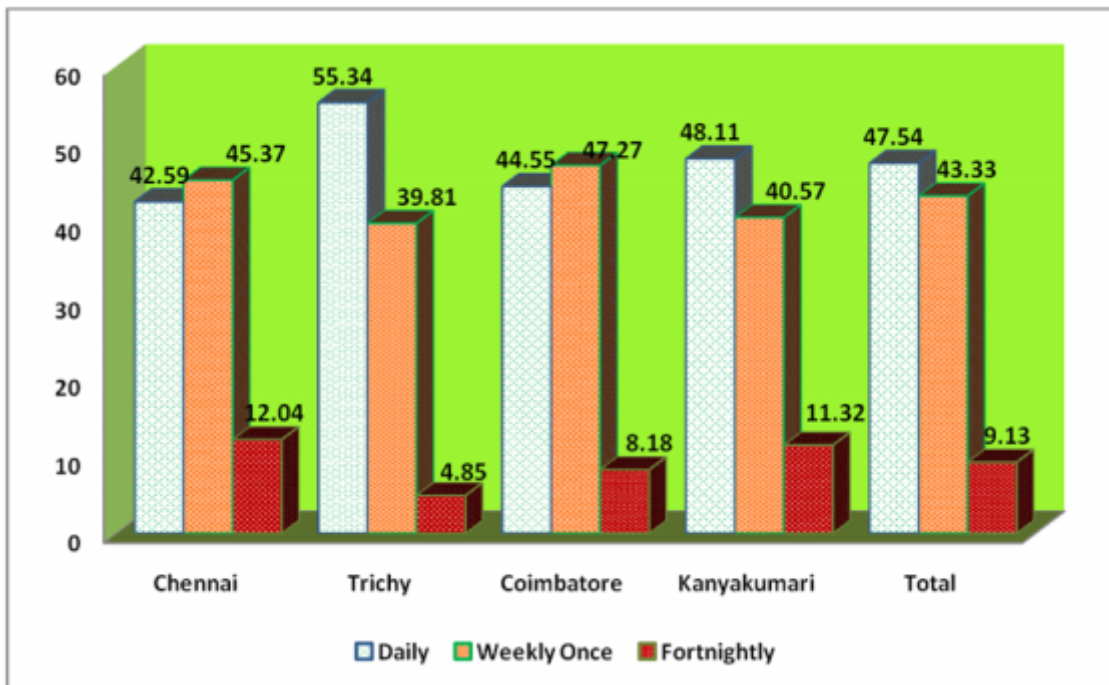
**FREQUENCY OF CONSUMPTION OF PULSES**



More than 40 per cent of the households of the four districts consumed roots and tubers daily. Frequency of consumption of other vegetables such as brinjal, ladies finger etc were daily by all households. Consumption of green leafy vegetables were limited to weekly once or less by all the households. For the

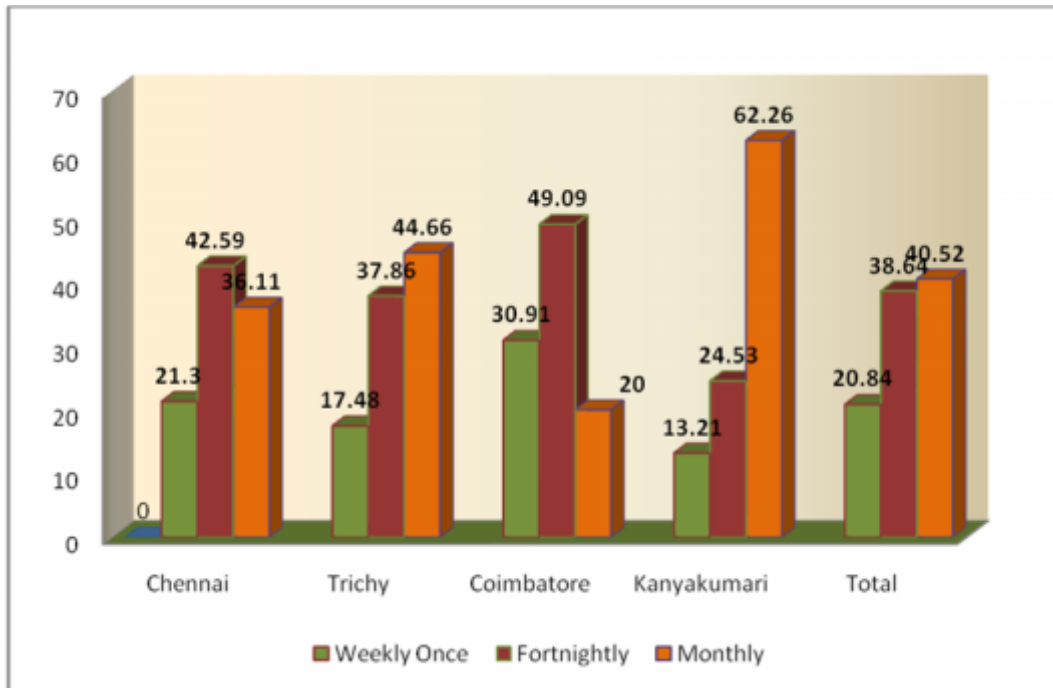
preparation of side dishes, vegetables are required, hence the consumption of vegetables were high. Figure XI shows the frequency of consumption of roots and tubers by the households.

**FIGURE XI**  
**FREQUENCY OF CONSUMPTION OF ROOTS AND TUBERS**



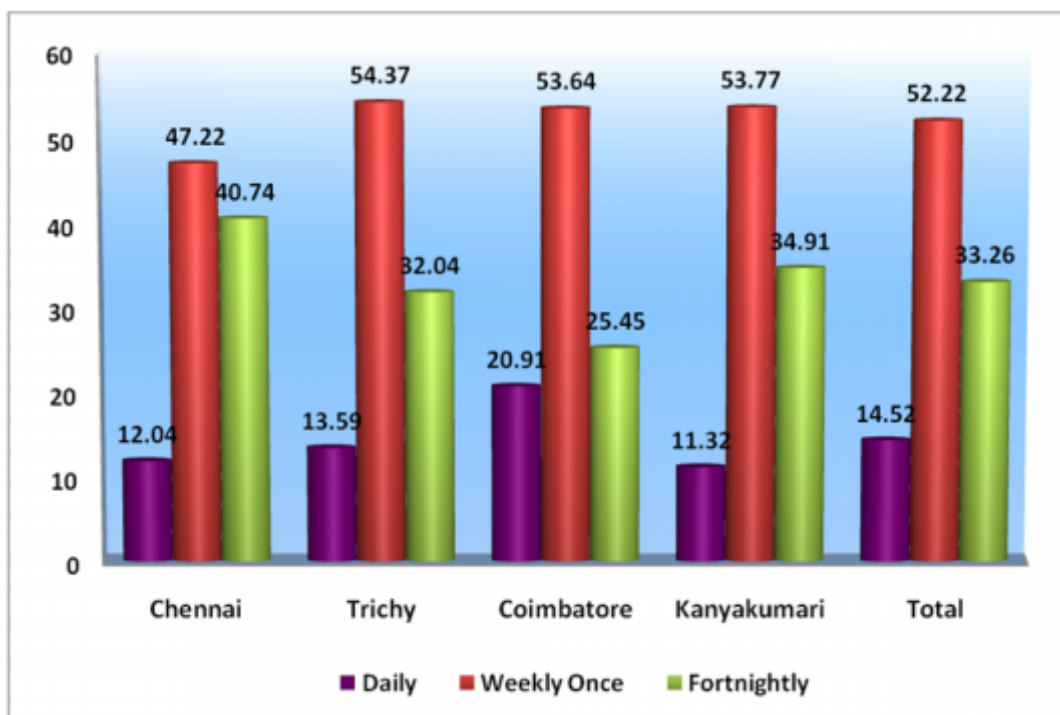
Above 30 per cent households of Coimbatore were consuming green leafy vegetables weekly once, while among Chennai households it was 21 to 30 per cent. Among the households of Trichy and Kanyakumari, 17.48 per cent and 13.21 per cent respectively were consuming green leafy vegetables weekly once only. More than 70 per cent households of the four districts were consuming green leafy vegetables monthly and occasionally only. Figure XII shows the frequency of consumption of green leafy vegetables by the households.

**FIGURE XII**  
**FREQUENCY OF CONSUMPTION OF GREEN LEAFY VEGETABLES**



Regarding the consumption of fruits, the households of the four districts, Coimbatore, Trichy, Chennai and Kanyakumari were 20.91 per cent, 13.59 per cent, 12.04 per cent and 11.32 per cent respectively. More than 50 per cent households were consuming fruits in their diets weekly once, among the households of Chennai district, 40.74 per cent of the households were consuming fruits fortnightly and the other three districts less than 35 per cent of the households were consuming fortnightly. Daily consumption was around 20.91 per cent households in Coimbatore and the rest of the districts, less than 13 per cent of the households were consuming fruits daily. Figure XIII shows the frequency of consumption of green leafy vegetables by the households.

**FIGURE XIII**  
**FREQUENCY OF CONSUMPTION OF FRUITS**



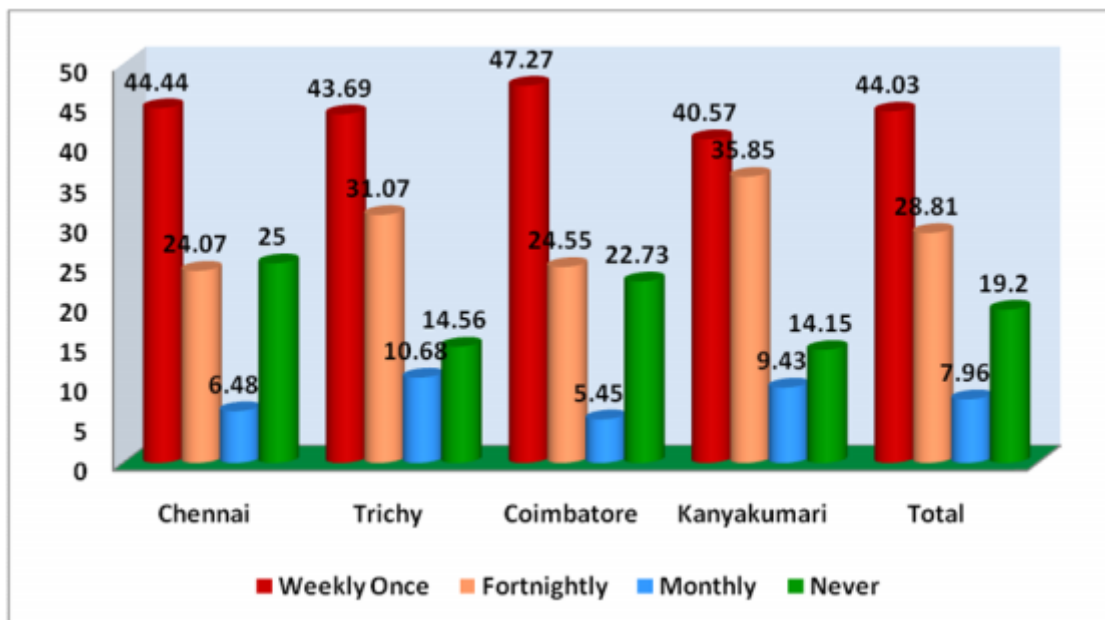
More than 50 per cent households were consuming fruits in their diets weekly once, among the households of Chennai district, 40.74 per cent of the households were consuming fruits fortnightly and the other three districts less than 35 per cent of the households were consuming fortnightly. Daily consumption was around 20.91 per cent households in Coimbatore and the rest of the districts, less than 13 per cent of the households were consuming fruits daily.

Regarding the consumption of meat and other non-vegetarian foods most of the households were consuming weekly once. About 47.27, 44.44, 43.69, 40.57 per cent households of Coimbatore, Trichy, Chennai and Kanyakumari districts respectively. Most of the households of Kanyakumari were consuming fish

in their daily diets. Figure XIV shows the frequency of consumption of meat and meat products by the households.

**FIGURE XIV**

**FREQUENCY OF CONSUMPTION OF MEAT AND MEAT PRODUCTS**



**c. Frequency of consumption of Regional diets by the households**

Using the food frequency schedule, the regional diets prepared and consumed during the past one month by the households were recorded. Thus a total of 75 regional diets were identified based on the frequency of foods consumption. It was organized according to the meal.

**i) Regional diets for breakfast**

The commonly prepared rice, wheat based preparations were recorded. Table IV shows the frequency of consumption of regional diets for breakfast

**TABLE IV**  
**FREQUENCY OF CONSUMPTION OF REGIONAL DIETS FOR BREAKFAST**  
**(Per cent)**

Regional Diets	Chennai	Trichy	Coimbatore	Kanyakumari
Dosa	95	90	93	87
Rice Puttu	6	11	86	86
Wheat Puttu	3	43	76	77
Idli	94	95	97	94
Idiyappam	12	68	81	81
Appam	9	37	83	83
Chapathi	80	76	77	77
Poori	76	72	68	56
Kichdi	87	79	86	32
Pongal	90	82	93	47
Rava Upma	79	64	71	52
Semiya Upma	84	65	65	65
Daliya	59	53	72	48
Sevai	89	62	73	30
Bajra Dosa	-	-	76	-
Ragi balls	-	5	71	-

Table IV shows the regional diets prepared and consumed during the referral period or recall period. The commonly prepared and consumed regional diets for breakfast included dosa, idli, sevai, appam, chapathi, poori, sevai, pongal, upma, bajra dosa and ragi balls. In each district, the households were following a common food consumption pattern like, among the households in

Chennai, Trichy and Coimbatore the breakfasts were mostly idli or dosa with sambhar and chutney, pongal chutney, sevai and the like. Among the households of Kanyakumari, the regular breakfasts were rice or wheat puttu, appam with Bengal gram or green gram. Among the households of Coimbatore, their diet includes millet made preparations like ragi balls with sambhar or Bajra dosa.

## ii) Regional diets for lunch as variety rice

Among the households of Tamil Nadu, different types of variety rice's were for prepared for lunch as well as dinner. This is accompanied with a dry vegetable, a pickle and fries. Table V shows the commonly prepared and consumed variety rice among the households of Tamil Nadu

**TABLE V**  
**REGIONAL DIETS FOR LUNCH AS VARIETY RICE(per cent)**

Lunch dishes	Chennai	Trichy	Coimbatore	Kanyakumari
Lemon Rice	92	71	76	42
Sambar Rice	96	72	81	47
Curd Rice	93	81	89	43
Tomato Rice	89	74	91	38
Tamarind Rice	91	83	81	34
Bisibelebath	97	86	83	22

From the above Table, it can be observed that, among the households of Chennai, Trichy and Coimbatore variety rice such as lemon rice, sambhar rice, curd rice, tomato rice tamarind rice, Bisibelebath were prepared and consumed during lunch. More than 90 per cent of the household of Chennai, around 70 to 80 per cent households of Trichy as well as Coimbatore and nearly 40 per cent of the households of Kanyakumari were consuming variety rice for their lunch. Majority of households of Kanyakumari were consuming plain rice with curries for

lunch.

**ii) Regional diets as vegetarian side dishes**

The vegetarian side dishes are consumed for breakfast, lunch and dinner. Table VI shows the regional diets as vegetarian side dishes

**Table VI**

**REGIONAL DIETS AS VEGETARIAN SIDE DISHES(per cent)**

Side Dishes	Chennai	Trichy	Coimbatore	Kanyakumari
Sambar	95	94	96	91
Rasam	98	87	97	84
Pulikozhambu	83	89	72	53
Urunda Kuzhambu	42	92	47	12
Aviyal	79	72	74	83
Green leaves poriyal	76	52	89	34
Carrot/ cabbage / beans/ poriyal	81	78	84	76
Keerai dal kootu	79	74	87	65
Vathakuzhambhu	87	84	78	54

The vegetarian side dishes commonly consumed by the households were sambhar, rasam, pulikozhambu, vathakuzhambhu, urunda kuzhambu, pachady, aviyal, green leaves poriyal, carrot/ cabbage / beans/ poriyal, keerai dal kootu. Among the households surveyed nearly, 85 to 90 per cent of the households were preparing these diets during the past one month.

**iv) Regional diets as Non-vegetarian side dishes**

Only the households of Kanyakumari were consuming non-vegetarian dishes like fish curries / fries on a daily basis. Other than that, most of the households were consuming non-vegetarian dishes on weekends only. Non-vegetarian items usually include chicken, mutton, crab, prawn, fish based preparations. Most of the households were consuming eggs occasionally only.

**v) Regional diets prepared during festivals or functions**

During special occasions or functions and festivals, sweet based as well as savoury based convenience foods are prepared by the households. Table VII depicts the foods prepared and consumed during festivals among the HHs.

**Table VII**  
**FOODS PREPARED AND CONSUMED DURING FESTIVALS (per cent)**

Festivals Celebrated	Foods Prepared	Chennai	Trichy	Coimbatore	Kanyakumari
		Per cent	Percent	Percent	Per cent
Pongal	Sweet, Ven Pongal, Turmeric Pongal	51	55	58	50
Easter	Easter egg	29.5	27	23.5	36.5
Chithirai	Mango Pachadi Vepampoo rasam	51	55	58	50
Ramdhan	Pumpkin Halwa Rava kesari Rice Kanji Keema vada	17.5	13.5	23	11
Aadi patinettu	Kali	50	55	58	50
Krishna jayanthi	Seedai, Adhirasam, Appam	51	55	58	50
Vinayachathurdthi	Kozhukattai	52	54	54	41
Onam	Sadhya	8	0	11	38
Deepavali	Diwali legiyam, Murukku Oma podi, Burfi	51	52	56	54
Christmas	Cake	29.5	27	23.5	36.5

Above Table shows the commonly celebrated festivals of Tamil Nadu and the foods prepared and consumed during that time.

During the harvest festival pongal, different types of pongal are prepared and consumed by the households of the surveyed districts. The different type of pongals prepared includes pongal, sarkkarai pongal, venpongal and turmeric pongal .During easter, easter eggs are consumed.

On the occasion of the Tamil New Year, Chithirai Pirappu, the commonly prepared diets includes vempanpoo rasam and mango pachady. During Ramdhan numerous sweet dishes, non-vegetarian items were prepared and consumed.

During Krishnajayanthi sweet dishes like seedai, adhirasam and appam were prepared and served and vinayaka chathurthi is celebrated with sweet balls and savoury balls were offered among the households of Tamil Nadu.

Among a few households of Kanyakumari, Onam is celebrated. During Onam traditional sadya is served in plantain leaves and consumed.

During the nine days of navaratri festivals, each day sundals made of different pulses were served. During the festivals of light, diwali, murukku omapodi were prepared and consumed by the households. During the festival of karthigai deepam different kinds of tuber were cooked and served, apart from these sweet dishes were also being prepared and consumed.

#### **d. Foods consumed and avoided during minor diseases**

Minor ailments are conditions in which the patients with simple actions, they themselves could handle the disease with home remedies(Kristin *et al.*, 2011). Minor diseases or ailments are the diseases which are of short duration and require only simple medications with suitable diet modifications.

**i) Foods consumed during minor diseases**

During disease certain foods were consumed to reduce the ailment. Table VIII shows the foods to consumed during minor diseases

**TABLE VIII  
FOODS CONSUMED DURING MINOR DISEASES (N = 427)**

Diseases	Consumed	Chennai Per cent	Coimbatore Per cent	Trichy Per cent	Kanyakumari Per cent	Total
Cold and Cough	<ul style="list-style-type: none"> <li>• Rice Kanji</li> <li>• Dry ginger tea</li> <li>• Milk with turmeric</li> <li>• Pepper Rasam Rice</li> </ul>	20	14	18	36	44.89
Fever	<ul style="list-style-type: none"> <li>• Rice Kanji</li> <li>• Dry ginger tea</li> <li>• Bread</li> <li>• Rusk</li> </ul>	12	6	8	19	35.78
Stomach Upset	<ul style="list-style-type: none"> <li>• Black tea</li> <li>• Sago kanji without milk</li> <li>• Rice kanji</li> </ul>	6	9	11	14	12.98

Table VIII indicates that during cough and cold, 44.89 per cent of the households included rice kanji, dry ginger tea, milk with turmeric and pepper rasam rice. During fever conditions, whereas, 35.78 per cent included rice kanji,

dry ginger tea, bread, rusk etc. During the episodes of stomach upset, black tea, sago kanji without milk and rice kanji were used to prepare and serve. The reason for consuming these soft cooked foods as reported by the people were majority of the people (59.76 per cent) had the reason as easy digestion and 22.45 per cent of the people gave the reason as doctor's suggestion. Rest of the respondents (17.09) doesn't have any special reason.

## ii) Foods avoided during minor diseases

Certain foods were avoided during minor ailments as it aggravates the ailments. Avoiding such foods will reduce the frequency of such ailments. Table IX shows the foods avoided during minor diseases

**TABLE IX**  
**FOODS AVOIDED DURING MINOR DISEASES (N = 427)**

Diseases	Avoided	Chennai Per cent	Coimbatore Per cent	Trichy Per cent	Kanyakumari Per cent	Total Per cent
Cold and Cough	<ul style="list-style-type: none"> <li>• Curd</li> <li>• Cold foods</li> </ul>	84	86	89	85	87.05
Fever	<ul style="list-style-type: none"> <li>• Chapatti</li> <li>• Fried items</li> <li>• Curd</li> <li>• Cold foods</li> </ul>	81	83	92	86	85.76
Stomach Upset	<ul style="list-style-type: none"> <li>• Whole grain preparations</li> <li>• Chapatti</li> <li>• Fried items</li> <li>• Milk preparations</li> </ul>	88	85	93	91	91.45

The foods avoided during minor diseases indicates that curd rice and cold foods were avoided by 87.05 per cent of the people during cold and cough, while 85.76 per cent of the households avoided chapathi, fried foods, curds, cold foods during fever. During the episodes of stomach upset, foods such as whole grain preparations, chapatti, fried foods and milk preparations. Majority of the people (79.89 per cent) gave the reason for avoiding certain foods as it will increase body temperature and 25.11 per cent of the people gave the reason as stomach

irritation.

### 3. One day's meal pattern of the households

Using 24 hour recall method, previous day's diet was recorded and thus arrived at, one day's meal pattern of the households. One day's meal comprise of the meals from waking up to dinner as shown in Table X.

**TABLE X  
ONE DAY'S MEAL PATTERN OF THE HOUSEHOLDS**

Meals	Chennai	Trichy	Coimbatore	Kanyakumari
Wake up	Tea/Coffee /Milk	Tea/Coffee /Milk	Tea/Coffee /Milk	Tea/Coffee /Milk
Breakfast	Sevai and Chutney	Upma and Chutney	Dosa and Chutney	Puttu, Green gram and Pappad
Lunch	Lemon rice, Amaranth dal Poriyal, Pickle	Tomato rice and Brinjal poriyal	Rice, Ridge gourd kottu, bitter gourd sambar	Rice, Sambar, Aviyal
Evening Snack	Tea/Coffee , Snack	Tea/Coffee , Snack	Tea/Coffee , Snack	Tea/Coffee , SNAck
Dinner	Idly Chutney	Rice, Drumstick sambar, Cabbage poriyal	Ragi Dosa Sambar	Rice. Pulisery, Fish fry

Indian regional diets especially the South Indian diets are highly varied and it is strongly related to social identity, religion and other cultural factors as well as local agricultural practices and availability of diverse foods. From the consumption pattern survey, it was found that the consumption of millets were limited in Kanyakumari district while majority consumed in Coimbatore district. Fruit consumption was low among all households. Chennai district had more vegetarians than rest of the three districts while majority of households were non-vegetarians

### 4. Mean food intake of the adolescent girls

From the data obtained from the 24 hour recall method, mean food intake of the adolescent girls were calculated and compared with RDA (2010). Table XI shows the mean food intake of the adolescent girls of each district.

**TABLE XI**  
**MEAN FOOD INTAKE OF THE ADOLESCENT GIRLS**

Food	RDA*	Chennai	Trichy	Coimbatore	Kanyakumari
Cereals (g)	420	360	355	330	365
Pulses (g)	60	32.5	31.8	34.56	28.65
Other vegetables (g)	100	40.56	42.35	44.65	38.75
Roots and tubers (g)	200	75	90	100	80
Green leafy vegetables (g)	100	40	34	55	37
Fruits (g)	100	42.5	38	46	34
Fish and meat products(g)	50	15	25	20	35
Milk and milk products (ml)	500	150	200	250	300
Fats and oils(g)	25	22	20.5	20	18
Sugar(g)	35	15	10	20	10

\*(ICMR, 2010)

As shown, in the above Table the mean food intake of the adolescent girls calculated, revealed that, all food groups were below the normal level of Recommended Dietary Allowances (ICMR, 2010). The intake of micronutrient rich fruits, milk, green leafy vegetables were very low, met only 60 per cent of the RDA.

Study by Daniel *et al* (2011) on the cross sectional investigation of the regional patterns of diet and cardio metabolic risk in India, revealed that the diets of South Indian's are inclined towards traditional diet patterns, characterized by the intake of vegetables and pulse which is in line with the results of the present study.

Reports of NFHS IV stated that, the intake of non-vegetarian foods like fish, meat, eggs varied across the different regions and were very low. This is similar to the findings of the present study.

India's food consumption pattern has changed drastically from the coarse cereals to rice or wheat and other refined, oily and sugary foods. These resulted in emergence of lifestyle diseases coupled with hidden hunger. This is believed to have been resulted by improvement in income, change in taste and preferences, better health facility, hygiene etc. Indian rural diet is composed of cereals followed by milk products and consumption of other food items particularly vegetables and fruits are low (Gupta and Kumar, 2015).

According to National Council for Applied Economics Research (2014) reports, Per capita consumption in urban households declined from 12 kgs in 1999-00 to 9.6 kgs in 2009-10 and from 10 kgs to 8 kgs in rural households.

A study based on the National Sample Survey (NSS) 66<sup>th</sup> Consumer Expenditure Schedule (2009-10) exhibited food consumption and nutrition (in terms of energy, protein, carbohydrates, minerals, fat, vitamin C, iron and calcium) distribution across 85 NSS regions. The report points that In spite of the recent developments in income the consumption of foods in India fails to execute better on nutrition parameters since majority of the population has monotonous diet consisting of cereals especially rice and wheat while less attention is paid to micronutrient rich food items such as fruits, green leafy vegetables which has resulted into the higher prevalence of hidden hunger in the country.

Hence, there is a need to analyse the nutrient potentials of regional diets and convenience foods consumed among the households.

## **B. PHASE II NUTRITIONAL EVALUATION OF REGIONAL DIETS AND CONVENIENCE FOODS**

Zinc is an essential mineral present in the diet and its deficiency impairs the normal growth and development of children, affects senses such as smell and taste, and can also lead to anorexia as well as skin diseases. Using the food frequency questionnaire (FFQ), which is a limited checklist of foods with a frequency response to report how often each item was consumed over specified periods of time, the frequency of consumption of regional diets were identified. They were categorized as regional diets prepared for breakfast, side dishes, lunch varieties, non-vegetarian preparations and convenience foods.

In this phase, initially 22 regional diets were subjected to nutritional evaluation and the data is given in Appendix.

Later the iron and zinc content of fourty regional diets were analyzed in the laboratory as per the standard AOAC procedures. The results are presented and discussed below.

The total iron content of a diet, generally provides little information about its content of bioavailable iron, which is considerably influenced by the foods in the diet and can vary 10-fold from different meals of similar iron content. Although a vegetarian diet is likely to contain iron in amounts equivalent to amounts in a non-vegetarian diet, the iron from a vegetarian diet is likely to be substantially less available for absorption because of differences in the chemical form of iron and the accompanying constituents that enhance or inhibit iron absorption (Hunt and Vanderpool, 2001). In the present study, 40 frequently consumed regional diets were subjected to nutrients analysis and the results of total iron and zinc content are presented below.

The prepared regional diets were classified based on food groups such as cereal preparations, pulses and legumes preparations, vegetable preparations, roots and tuber preparations, green leaves preparations, non-vegetarian preparations, milk and sweet preparations, and convenience food preparations. Table VIII to XVI show the total iron and zinc content of the regional diets.

### **1. Total iron and zinc content of cereal based diets**

Cereal based preparations which include breakfast, lunch and dinner diets. For the present study, the commonly prepared and consumed diets for the past one month was selected and analysed. The cereal based diets analysed for total iron and zinc content were dosa, idli, appam, wheat dosa, rice puttu, upma, daliya, idiyappam, chapathi, puri, ven pongal, rice, lime rice, sesame rice, tomato, rice kanji, fried rice, curd rice. Table XII shows the total iron and zinc content of the cereal based diets.

**TABLE XII**  
**TOTAL IRON AND ZINC CONTENT OF CEREAL BASED DIETS (mg/100g)**

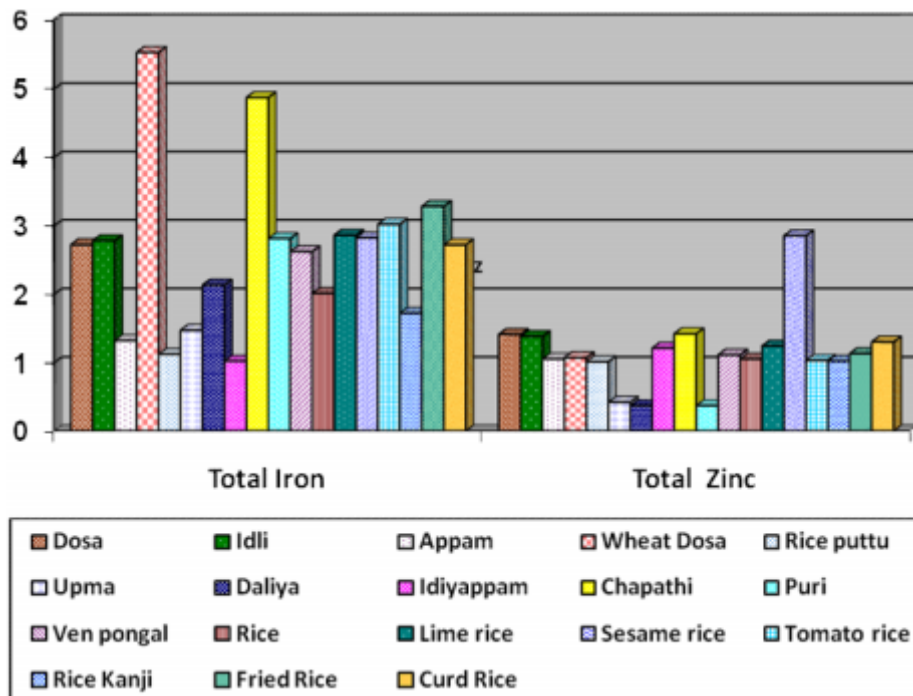
Cereal preparations	Total Iron	Total Zinc
Dosa	2.72 ± 0.02	1.41 ± 0.02
Idli	2.78 ± 0.02	1.38 ± 0.01
Appam	1.32 ± 0.02	1.05 ± 0.01
Wheat Dosa	5.53 ± 0.06	1.07 ± 0.01
Rice puttu	1.12 ± 0.02	1.01 ± 0.01
Upma	1.47 ± 0.03	0.42 ± 0.01
Daliya	2.13 ± 0.06	0.37 ± 0.01
Idiyappam	1.02 ± 0.02	1.21 ± 0.01
Chapathi	4.87 ± 0.06	1.42 ± 0.01
Puri	2.81 ± 0.06	0.37 ± 0.01
Ven pongal	2.62 ± 0.12	1.11 ± 0.01
Rice	2.01 ± 0.03	1.05 ± 0.01
Lime rice	2.86 ± 0.02	1.24 ± 0.01
Sesame rice	2.82 ± 0.06	2.85 ± 0.03
Tomato rice	3.02 ± 0.02	1.03 ± 0.02
Rice Kanji	1.72 ± 0.02	1.02 ± 0.01
Fried Rice	3.28 ± 0.05	1.13 ± 0.001
Curd Rice	2.72 ± 0.02	1.30 ± 0.01

As observed, the total iron content of the diets were in the range of 1.02 mg / 100 g to 4.87 mg /100 g. Total iron content of idiyappam made of raw rice roasted flour was low as 1.02 mg/100 g whereas chapati made of whole wheat had 4.87 mg /100 g. Most of the raw rice based preparations such as appam and puttu had a total iron content of 1.32 and 1.12 mg /100 g respectively. Variety rice such as tomato rice, sesame rice, curd rice, lime rice had an iron content ranging

between 2.72 to 3.28 mg/100 g while plain cooked rice had 2.01 and rice kanji has 1.72 mg/100 g total iron. This increase in iron in the variety rice preparation could be due to the addition of vegetables, spices and condiments.

Total zinc content of the diets were in the range of 0.37 mg / 100 g to 2.85 mg /100 g. Total zinc content of dalia and puri were low of 0.37 mg/100 g while sesame rice had high of 2.85 mg / 100 g. Figure XV shows the iron and zinc content of cereal based preparations

**FIGURE XV**  
**IRON AND ZINC CONTENT OF CEREAL BASED PREPARATIONS**



## 2. Total iron and zinc content of pulses and legume preparations

The grains of beans are an important source of vegetable protein in the diet especially where the consumption of animal protein is limited. Pulses and legumes are also good sources of iron. The regional diets selected for analysis were spinach dal kootu, spinach poriyal, cabbage dal kootu, snake gourd dal kootu. Table XIII shows the total iron and zinc content of pulses and legume

preparations.

**TABLE XIII**  
**TOTAL IRON AND ZINC CONTENT OF PULSES AND LEGUME PREPARATIONS (mg/100g)**

Pulses and legume preparations	Total Iron	Total Zinc
Spinach Dal Kootu	9.75 ± 0.05	2.74 ± 0.02
Cowpea poriyal	4.12± 0.02	2.33 ± 0.01
French beans poriyal	3.18± 0.02	2.72 ± 0.01
Spinach Poriyal	3.72 ±0.02	1.89 ± 0.01
Cabbage dal kootu	2.87 ± 0.03	1.37 ± 0.03
Snake gourd Dal kootu	2.34 ± 0.02	1.26 ± 0.02

From Table XIII, it can be depicted that the total iron content of the pulses and legume preparations were ranging from 2.34 mg / 100 g in snake gourd dal kootu to 9.75 mg/ 100g in spinach dal kootu. The total zinc content was in the range of 1.26 mg/100g to 2.74 mg/100g. Poriyal made out of cow pea and french beans had a total iron of 4.12 and 3.18 mg/100g respectively, while the total zinc content was 2.33 and 2.72 mg/100g respectively.

Work done by Hemalatha *et al* (2007) reported that pressure cooking and soaking in water previously will influence the iron and zinc retention in the cooked beans.

### 3.Total iron and zinc contentof vegetable preparations

Vegetables are considered to be rich sources of micronutrients which also possess the anti-nutritional factors. Moreover processing methods such as cutting and cooking will also lead to nutrient loss. Analysis of the total iron and zinc content of the cooked vegetable preparations will give knowledge on the nutrient loss during cooking. Table XIV shows the iron and zinc content of the vegetable preparations.

**TABLE XIV**  
**TOTAL IRON AND ZINC CONTENT OF VEGETABLE PREPARATIONS (mg/100g)**

Vegetable preparations	Total Iron	Total Zinc
Sambar	5.14 $\pm$ 0.52	1.28 $\pm$ 0.02
Carrot beans poriyal	2.22 $\pm$ 0.12	0.71 $\pm$ 0.01
Pulikozhambu	3.82 $\pm$ 0.02	1.21 $\pm$ 0.01

The iron content of the vegetarian side dishes ranged between 3.4 to 6.5 mg /100g while the zinc content of the diets ranged from 1.7 to 3.6 mg /100g. Iron content of the vegetable preparations were ranged between and 3.3 to 17.2 mg per cent dry matter with an average value of 9.51 and 8.46 mg per cent, respectively. This wide variation in the iron content of vegetable preparations was due to the fact that green leafy vegetables are good source of iron as compared to roots and tubers and other vegetables. The loss in iron after cooking of vegetable preparations was in the range of 6.5 to 18.9 per cent. The zinc content of the vegetable preparations were in the range of 0.9 to 1.6 mg per cent dry matter with an average value of 1.5 and 2.4 mg per cent, respectively. In the vegetable preparations, the losses of zinc content ranged between 6.4 to 16.8 per cent. Earlier work done by Sathya *et al*(2002) on the impact of iron and zinc content on the vegetable preparations showed similar results.

#### 4. Total iron and zinc content of green leafy preparations

Green leaves are store house of micronutrients especially iron and zinc. Hence knowing the total iron and zinc content of green leaves preparations will help in planning diets for anaemic population, especially. Table XV shows the total iron and zinc content of green leafy preparations.

**TABLE XV**  
**TOTAL IRON AND ZINC CONTENT OF**  
**GREEN LEAFY PREPARATIONS (mg/100g)**

Green leaves preparations	Total Iron	Total Zinc
Methi green gram chutney	12.32 ± 0.40	2.85 ± 0.01
Arakeerai leaves masiyal	4.32±0.02	1.36 ± 0.02
Drumstick leaves curry	1.26 ± 0.06	1.37 ± 0.01

The vegetarian side dishes of Tamil Nadu are predominantly based on pulses and legumes, vegetables, green leaves and roots and tubers. From these food groups, the households used to prepare diets such as masiyal, kootu, poriyal, kuzhambu and sambhar. Iron content of the vegetable preparations differed from 1.26 to 12.32 mg/100 g with highest in methi green gram curry and lowest in drumstick leaves curry. The total zinc content of the green leaf preparations were 2.85, 1.37, 1.36 mg/100 g respectively for methi green gram chutney, arakeerai leaves masiyal and drumstick leaves curry. This could be due the higher amount of iron in methi leaves (1.93 mg /100g)

Bains and Shruti (2007) reported the mean iron content of vegetable preparations were 1.6mg / 100g fresh weight with an average loss of 12.6 per cent during preparations and cooking respectively.

#### **5. Total iron and zinc content of roots and tuber preparations**

Roots and tubers are good sources of carbohydrates, fibre, iron and B-carotene. Roots and tubers store these nutrients and provide proper nutrition to the plant. Hence consuming these roots and tubers will make a person healthy. Table XVI shows the total iron and zinc content of roots and tuber preparations.

**TABLE –XVI**  
**TOTAL IRON AND ZINC CONTENT OF ROOTS AND TUBER**  
**PREPARATIONS (mg/100g)**

Roots and tuber preparations	Total Iron	Total Zinc
Potato poriyal	1.36 ± 0.02	1.21 ± 0.01
Vegetable kuruma	4.80 ± 0.02	2.89 ± 0.03
Potato carrot poriyal	3.34 ± 0.02	2.46 ± 0.02

The iron content in roots and tuber preparations ranged between and 1.36 to 4.80, with highest of 4.80 mg in vegetable kuruma made of potato, carrot, beans, onion, peas while poriyal made out of potato had an iron content of 1.36 and potato carrot poriyal had 3.34 mg respectively. Regarding the total zinc content, vegetable kuruma had 2.89, poriyal made out of potato had 1.21 and that of potato carrot poriyal had 2.46 mg/ 100 g respectively.

#### **6. Total iron and zinc content of non-vegetarian preparations**

Non-vegetarian preparations are rich sources of iron and zinc besides their higher bioavailable form. In the present study, majority of the household were non vegetarians and a few were ovo-vegetarians. Still, the consumption was limited to weekends except the households of Kanyakumari, where fish based preparations were consumed daily. Table XVII shows the total iron and zinc content of non-vegetarian preparations.

**TABLE XVII**  
**TOTAL IRON AND ZINC CONTENT OF NON-VEGETARIAN**  
**PREPARATIONS (mg/100g)**

Non-vegetarian preparations	Total Iron	Total Zinc
Omlettee	4.68 $\pm$ 0.02	2.64 $\pm$ 0.04
Fish curry	5.72 $\pm$ 0.02	1.21 $\pm$ 0.03
Fish fry	3.87 $\pm$ 0.03	2.37 $\pm$ 0.03
Chicken gravy	8.15 $\pm$ 1.60	4.12 $\pm$ 0.06
Chicken fry	5.12 $\pm$ 0.26	2.37 $\pm$ 0.03

The total iron content of non -vegetarian preparations was in the range of 8.15mg to3.87 and zinc content were 1.21 to 4.12 mg/ 100 g. Previous work done by Neimer *et al* (2006) reported that, in their study iron content ranged from 0.12  $\pm$  0.03 mg/100g for chicken rice. Non-vegetarian diets with considerable amount of red meat provides about 2 mg/d, or 10 to 12 per cent of the total iron in the heame form.

### 7. Total iron and zinc content of convenience foods

Generally traditional food items are prepared with various combinations of food grains-cereals, millets, legumes etc. Taking into consideration their contribution to nutritional or functional properties, these multigrain composite mixes can be used for the preparation of various or specific food items. Among the households of the four districts, the commonly prepared convenience foods were urundai or laddoo, which is a combination of grains, millets, green gram, roasted Bengal gram, with jaggery syrup. This ready to eat food forms one of the traditional preparations and it is still maintained by households. These ready to eat foods were considered nutritionally balanced. Table XVIII total iron and zinc content of convenience food preparations

**TABLE XVIII**  
**TOTAL IRON AND ZINC CONTENT OF CONVENIENCE FOOD**  
**PREPARATIONS (mg/100g)**

Convenience food preparations	Total Iron	Total Zinc
Porulvilanga urundai	5.14 $\pm$ 0.02	2.06 $\pm$ 0.01
Navadhaniya urundai	4.58 $\pm$ 0.02	1.85 $\pm$ 0.01
Awalose urundai	2.12 $\pm$ 0.01	1.01 $\pm$ 0.01

As observed from the above Table, the total iron content of the convenience foods were in the range of 2.12, 4.58 and 5.14mg/100 g for awalose urundai, navadhaniya urundai and porulvilanga urundairespectively. The zinc content were 1.01, 1.85, 2.06 mg/ 100 g for awalose urundai, navadhaniya urundai and porulvilanga urundairespectively,

#### **8. Total iron and zinc content from one days' diet**

One day's diet of the adolescent girl was analysed in the lab for total iron and zinc content as per AOAC (2005) procedures. These total iron and zinc was then compared with the RDA (2010) for adolescent girls (15 -17 yrs). Table XIX shows the total iron and zinc content from one days' diet.

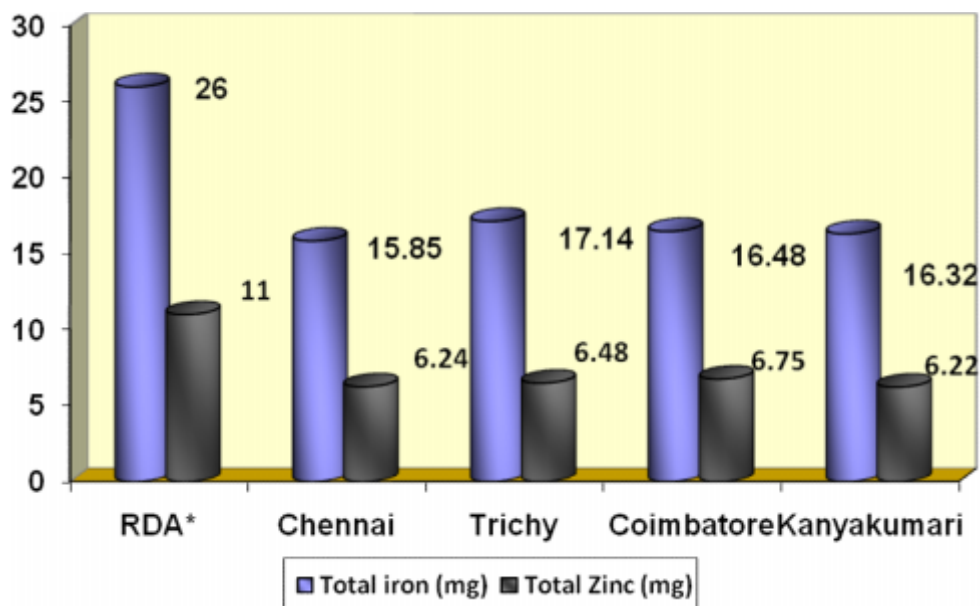
**TABLE XIX**  
**TOTAL IRON AND ZINC CONTENT FROM ONE DAYS' DIET OF**  
**ADOLESCENT GIRL**

	<b>RDA *</b>	<b>Chennai</b>	<b>Trichy</b>	<b>Coimbatore</b>	<b>Kanyakumari</b>
<b>Total iron (mg)</b>	26	15.85 ± 0.36	17.14± 0.60	16.48 ± 0.04	16.32 ± 0.74
<b>Per cent RDA met</b>		60.96	65.92	63.38	62.77
<b>Total Zinc (mg)</b>	11	6.24± 0.03	6.48± 0.02	6.75± 0.05	6.22 ± 0.06
<b>Per cent RDA met</b>		56.72	58.91	61.36	56.54

**\*RDA (2010)**

Table XIX shows mean iron and zinc content of an adolescent girl's one day's diet. The mean iron intakes of the adolescent girls were in the range of 15.24 to 17.14 mg/ day and zinc intake was in the range of 6.22 to 6.81 mg/day for the four districts. The highest iron intakes were by adolescent girls of Trichy district followed by Coimbatore (16.48 mg), Kanyakumari (16.32 mg) and Chennai, only 15.85 mg/ day. Regarding the zinc intakes by adolescent girls, Coimbatore district had 6.75 mg/day, Trichy district (6.46 mg/day), Kanyakumari (6.22 mg/day) while Chennai had 6.24 mg/ day. When compared with RDA (2010), the mean intakes of iron as well as zinc were low. The iron intake met only 60.96 to 65.92 per cent of the RDA. The percent RDA met for zinc is only 56.54 to 61.36. There is a deficit of 43.44 to 39.44 in the zinc intake of the adolescent girls of four districts. Figure XVI shows the total iron and zinc content from one days' diet of adolescent girl

**FIGUREXVI**  
**TOTAL IRON AND ZINC CONTENT FROM ONE DAYS' DIET OF**  
**ADOLESCENT GIRL**



Mineral levels of the soils will vary accordingly from region to region which can affect the mineral content of food crops. Also, from the mean iron and zinc intake results showed that they were deficient in the diets of the adolescent girls. Hence policies should be brought to enhance the nutritive content of the food crops for maximum crop yield and fortification of the crops, cereals or grains to ensure that the products developed would give sufficient portion of the RDA to maintain the health status of the population.

### **PHASE III *In-vitro* bioaccessibility of iron and zinc from regional diets**

Bioavailability is a general term that refers to how well a nutrient can be absorbed and used by the body. It can be affected by many factors such as the presence of anti-nutrients, for example, phytate, oxalate, tannins and polyphenols in foods, a person's need, fibre, competition with other nutrients and acidity of intestinal environment (Paulet *et al.*, 2004). Bioavailability of iron is influenced by various dietary components, which includes both inhibitors as well as enhancers of absorption. Among inhibitors, phytic acid, tannins, dietary fiber and calcium are the most potent, while organic acids are known to promote iron absorption (Sandberg, 2002). For the study, bioaccessibility of iron and zinc from 40 regional diets were analyzed by the *in vitro* method of Luten *et al* (1996).

According to Cozzoino (2007) bioavailability of minerals is defined as the proportion of the minerals that can be absorbed and utilized within the body. The concept of bioavailability is not only associated with the absorption and utilization of nutrients by the intestinal mucosa, but also, includes cellular transport, cellular uptake and conversion of a nutrient into biologically active forms. Whereas, bioaccessibility is defined as the fraction of a compound that is released from its matrix in the gastrointestinal tract enables for intestinal absorption.

#### **1. *In-vitro* bioaccessibility of iron and zinc from selected regional diets**

Rice is the main staple food of Tamil Nadu. Among the cereal preparations, most commonly made preparations were rice based followed by wheat. In this study a total of 18 cereals based regional diets were analyzed for iron and zinc content described in the earlier phase. These diets were analysed for *in-vitro* bioaccessibility of iron and zinc using the procedure developed by Luten *et al* (1996). Table XX shows the *in-vitro* bioaccessibility of iron and zinc from selected regional diets.

**TABLE – XX****IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM SELECTED REGIONAL DIETS**

<b>Cereal preparations</b>	<b>Total Iron mg/100g</b>	<b>Bioavailable Iron (%)</b>	<b>Total Zinc mg/100g</b>	<b>Bioavailable Zinc (%)</b>
Dosa	2.72 ±0.02	19.05 ± 1.54	1.41 ± 0.02	17.01± 0.03
Idli	2.78 ±0.02	21.05± 0.05	1.38 ± 0.01	16.42± 0.03
Appam	1.32 ±0.02	20.15 ±0.05	1.01 ± 0.01	12.35 ± 0.05
Wheat Dosa	5.53 ± 0.06	6.43 ± 0.02	2.37 ± 0.01	10.28 ± 0.04
Rice puttu	1.12 ±0.02	8.35± 0.02	1.01 ± 0.01	10.34 ± 0.04
Upma	1.47 ± 0.03	5.06 ± 0.04	0.37 ± 0.01	11.45 ± 0.05
Daliya	2.13 ± 0.06	6.12 ± 0.04	0.37 ± 0.01	12.12 ± 0.02
Idiyappam	1.02 ±0.02	8.04 ± 0.02	1.21 ± 0.01	10.34 ± 0.04
Chapathi	4.87 ± 0.06	6.77 ± 0.03	1.47 ± 0.01	8.48 ± 0.03
Puri	2.81 ± 0.06	2.15± 0.02	0.37 ± 0.01	1.25± 0.05
Ven pongal	2.62 ±0.12	13.12± 0.02	1.11 ± 0.01	4.03± 0.03
Rice	2.01 ±0.03	8.32± 0.42	1.05 ± 0.01	2.03 ± 0.02
Lime rice	2.86 ±0.02	22.38 ± 0.02	1.24 ± 0.01	2.35 ± 0.05
Sesame rice	2.82 ±0.06	11.12 ± 0.02	3.85 ± 0.03	4.25 ± 0.05
Tomato rice	3.02 ±0.02	17.03± 0.03	1.03 ± 0.02	7.36±0.02
Rice Kanji	1.72 ± 0.02	3.35± 0.02	1.02 ± 0.01	1.34 ± 0.04
Fried Rice	3.28 ± 0.05	10.36 ± 0.02	1.13 ± 0.01	2.03 ± 0.01
Curd Rice	2.72 ±0.02	12.35 ± 0.05	1.30 ± 0.01	3.12 ± 0.02

From, the above Table it can be inferred that, bioaccessibility of iron was in the range of 2.15 to 22.38, while the bioaccessibility of zinc was in the range of 1.01 to 17.01. The highest iron bioaccessibility was observed in Lime rice with 22.38 per cent. Though the total iron content of lime rice was only 2.86 mg/ 100g; the bioaccessibility of iron from lime rice was 22.38. This may be due to the presence of ascorbic acid in the lime rice, which is considered to be an enhancer for iron absorption. Fermented cereal and pulse based products such as dosa and idli also had iron bioaccessibility of 19.05 to 21.05 per cent. Literature reviewed also pointed that, processing method such as fermentation enhances the iron bioaccessibility of food. Bioaccessibility of iron was low in puri, only 2.15 per cent.

Bioaccessibility of zinc was in the range of 1.25 to 17.01 per cent. The highest zinc bioaccessibility was observed in fermented cereal and pulse based foods like dosa and idli (17.01 and 16.42 respectively). The lowest bioaccessibility of iron and zinc was seen in rice based preparations like cooked rice, rice kanji which were 2.03 and 1.34 respectively.

On cooking, the cereals modifies in composition, which in turn affects the iron and zinc bioaccessibility. Cooking reduces the phytate content. These differences in *in vitro* bioaccessibility exist of iron and zinc and iron in the diets could be due to the varied chemical forms, differences in their interaction with other grain constituents (Pereira *et al.*, 2016). Study by Fabbri and Crosby (2015) also reported that soaking and cooking peas and beans are effective in removing or reducing anti-nutrients such as tannins and phytic acid contents.

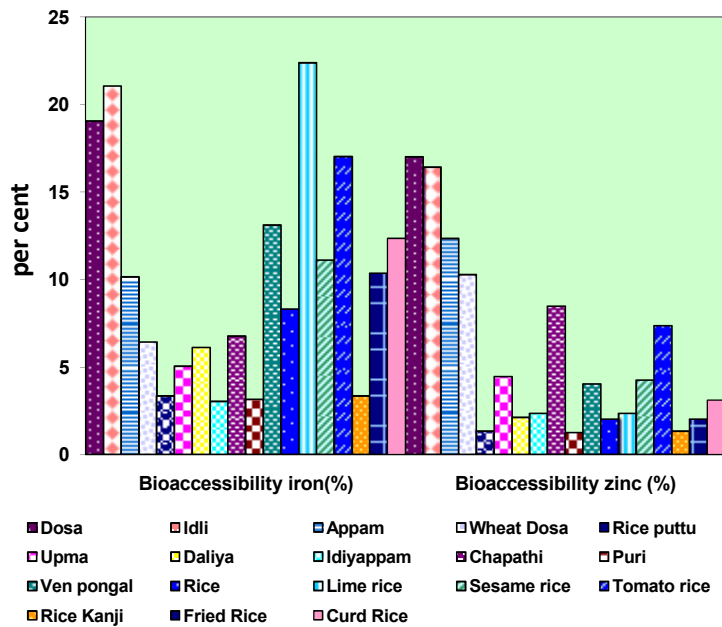
Earlier study by Srinivasn *et al* (2010) reported that, cooking reduces the zinc bioaccessibility of grains to nearly half in rice, wheat, maize, finger millet and sorghum. Figure shows the *in-vitro* bioaccessibility of iron and zinc from selected regional diets.

This study is by the work done by Sahai and Gupta (2012) on *in vitro*

*bioavailability* of iron from the products prepared from the leaves of the weed, Indian Sorrel (*Oxalis Corniculata*). Indian sorrel leaves incorporated 10%, 20% and 30% into three recipes, peanut chutney, lemon drink and idli” using their standard ingredients.

Figure XVII shows the *In-vitro* bioaccessibility of iron and zinc from selected regional diets

**FIGURE XVII**  
**IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM SELECTED REGIONAL DIETS**



Regional Diet

**2. *In-vitro* bioaccessibility of iron and zinc from side dishes**

The dishes used along with major meal forms the side dishes. In the present study, dishes made out of vegetables, pulses and legumes, roots and tubers as well as green leafy vegetables. Table XXI shows the *In-vitro* bioaccessibility of iron and zinc from side dishes

**TABLE XXI**

**IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM SIDE DISHES  
(per 100g)**

Side dishes	Total Iron mg	Bioavailable iron (%)	Total Zinc mg	Bioavailable Zinc (%)
Spinach dal Kootu	5.75 ± 0.05	11.05 ± 1.54	2.74 ± 0.02	7.01 ± 0.01
Cowpea poriyal	4.12± 0.02	12.05 ± 0.05	2.33 ± 0.01	11.42 ±0.02
French beans poriyal	3.18± 0.02	11.72 ± 0.02	2.72 ± 0.01	12.35±0.01
Spinach Poriyal	3.72 ±0.02	6.05 ± 0.05	1.89 ± 0.01	3.45 ± 0.05
Cabbage dal kootu	2.87 ± 0.03	11.15 ± 0.05	1.37 ± 0.03	6.12 ± .02
Snake gourd dal kootu	2.34 ± 0.02	6.43 ± 0.01	1.26 ± 0.02	4.78 ± 0.02
Sambar	5.14 ± 0.02	8.35± 0.01	1.28 ±0.02	5.33 ±0.01
Carrot beans poriyal	2.22±0.12	5.06 ± 0.02	0.71 ± 0.01	2.45 ± 0.01
Pulikozhambu	3.82±0.02	6.12 ± 0.02	1.21 ± 0.01	2.12 ±0.02
Methi green gram chutney	12.32 ± 0.40	18.04 ± 0.02	2.85 ± 0.01	10.34 ± 0.01
Arakeerai leaves masiyal	4.32±0.02	6.77 ± 0.01	1.36 ± 0.02	8.48 ± 0.01
Drumstick leaves curry	1.26 ± 0.06	3.15 ± 0.01	1.37 ± 0.01	6.25 ± 0.01
Potato poriyal	1.36 ± 0.02	6.12 ± 0.01	1.21 ± 0.01	4.03 ± 0.01
Vegetable kuruma	4.80 ± 0.02	8.32 ± 0.01	2.89 ± 0.03	2.12 ± 0.01
Potato carrot poriyal	3.34 ± 0.02	7.38 ± 0.01	2.46 ± 0.02	2.35 ± 0.01

Table XXI depicts the bioaccessibility of iron and zinc from the side dishes. The bioaccessibility of iron ranged from 3.15 per cent to 18.04 per cent. The zinc bioaccessibility were in the range of 2.12 per cent to 10.34 per cent. When compared to total iron content, cooking pulses and green leaves together enhanced the iron bioaccessibility from 20 to 25 per cent whereas for zinc bioaccessibility from 8 to 12 per cent.

Yadav and Sehgal (2002) reported that the iron content of bathua and spinach leaves was 20.63 and 26.54 mg/100 g, respectively on dry weight basis and also studied, *in vitro* and *in vivo availability* of iron from bathua and spinach leaves and found that iron contents of these green leafy vegetables varied from 20 percent to 26 percent (on dry weight basis) and *in vitro* availabilities of iron ranged from 2.79 to 3.03 percent. Micronutrient content as well as the bioavailability of micronutrients gives the necessary information about the nutritional quality of a food especially in the Indian scenario, where more the 50 per cent of people in all age groups, covering all physiological status suffers from different form of micronutrient deficiencies.

The maximum bioavailable iron was mungbean masial with 98.52 $\mu$ g of available iron. Tomato enhances the bioaccessibility of iron in the recipe. Total iron for mung bean masial is 6.50mg/100mg. The other recipes had more available iron were cabbage kottu (95.34  $\mu$ g) and spinach kottu (90.04 $\mu$ g) with total iron content of 7.22mg/100mg and 6.55mg/100g respectively.

Cabbage and spinach leaves are rich in ascorbic acid and are easily available and highly acceptable ones. Ascorbic acid, a highly powerful reducing agent and a chelating agent, serves as a remarkable enhancer of iron bioavailability as it can reduce ferric ions to ferrous (otherwise prevents the formation of ferric compounds) as well as of chelating iron to form a soluble complex compound that remains solution even at pH values similar to the ones of the intestine.

Mung bean dhal masial stands next among all the recipes which also had tomato. The available iron in this is 84.23 $\mu$ g and total iron was 6.5mg.

For Arakeeerai leaves masiyal had iron bioavailability of 6.77 whereas the total iron content was 4.32 mg. The zinc bioavailability 8.48 per cent and the total zinc content was 1.36 mg. Though the green leaves were rich ascorbic acid the iron and zinc bioavailability was low that may be due to phytates and oxalates which may inhibit the iron availability.

With regard to the bioavailability of iron, among the 13 recipes prepared mung bean dhal masial had 10.88 per cent bioavailability spinach kottu and cabbage kottu with 10.59 per cent and 10.1 per cent iron bioavailability respectively, so in these high iron bioavailability recipes, the addition of tomato and vegetable like Spinach and cabbage has the enhancing effect.

The bioavailability of mung masial was 8.83per cent. Salad with dhal and sprouts are found to be equal to that of mung bean masial in their bioavailability. Recipes made only with rice and mung bean are found to be low in their percentage of iron bio availability. When no vegetable or enhancing ingredients was included in the recipes like pongal,poriyals the bioavailability of iron as well as Zinc were low. The diets which has green leaves and pulse combination, sprouts, with lime enhanced the bioavailability of iron and zinc,we should include ingredients rich in ascorbic acid or Vitamin A ( $\beta$ -carotene).

### **3. Anti-nutritional factors in the regional diets**

The average oxalate content of recipes varied between 0.13 to 5.57 g per cent. The oxalates were found to be higher in green leafy vegetables ranging from 0.02 to 1.37g per cent.

The anti-nutritional effects of phytate, many attempts were carried to reduce it. Soaking is a domestic technological treatment that is often used by mothers to prepare complementary foods at home. Previous study Vijayakumari *et al* (2007) have shown that soaking significantly reduced phytate, trypsin

inhibitor activity, and tannins contents.

**4. *In-vitro* bioaccessibility of iron and zinc from different salads**

Even though mixed vegetable salads were not consumed by the households, out of interest, *In-vitro* bioaccessibility of iron and zinc from different salads was carried out. . Table XXII shows the *in-vitro* bioaccessibility of iron and zinc from different vegetable salads

**TABLE XXII**

**IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM DIFFERENT VEGETABLE SALADS**

<b>Diets</b>	<b>Total Iron mg</b>	<b>Bioaccessible Iron (%)</b>	<b>Total Zinc mg</b>	<b>Bioaccessible Zinc (%)</b>
<b>Mixed Vegetable salad</b>	3.20 ± 0.74	18.20 ± 1.30	2.11 ± 0.36	13.14 ± 1.08
<b>Vegetable salad with lime</b>	3.08 ± 0.28	35.32 ± 1.36	2.10 ± 0.22	22.14 ± 1.27
<b>Sprouted green gram salad with lime</b>	3.90 ± 0.19	43.20 ± 2.32	2.50 ± 0.17	26.30 ± 1.67
<b>F value</b>	1.98 <sup>NS</sup>	15.36 <sup>**</sup>	1.024 <sup>NS</sup>	12.52 <sup>**</sup>

\*\* - Significant at 1% level; \* - Significant at 5% level; <sup>NS</sup> – Not significant

The above Table shows the total iron and zinc contents well as bioaccessible iron and zinc content of the salads. The total iron content of the three salads were in the range of 3.20 ± 0.74 to 3.90 ± 0.19 and zinc were in the range of 2.10 ± 0.22 to 2.50 ± 0.17. The bioaccessibility of iron increased from 18 per cent to 35 per cent on addition of lime in the vegetable salad. In sprouted green gram the bioaccessibility of iron was 43 per cent.

The total zinc content was in the range of 2.10 ± 0.22 to 2.50 ± 0.17. The bioaccessibility of zinc has not significantly increased on the addition of lime or by

sprouting. The bioaccessibility of zinc among the salads were in the range of 13.14 ± 1.08, 22.14 ± 1.27 and 26.30 ± 1.67 mg / 100 gamong vegetable salad, vegetable salad with lime and sprouted green gram salad with lime respectively. Earlier study by Luo and Xie(2013) among the effect of soaking and sprouting of green and white faba bean also showed that, the bioavailability of iron and zinc were significantly improved as a result of soaking and sprouting treatments especially. This is similar to findings of the present study.

**5. *In-vitro* bioaccessibility of iron and zinc from meals**

The most commonly consumed food in the form of meals were analysed for total iron and zinc contents as well as bioaccessibility of iron and zinc. The selected meals were prepared in the Food Science Laboratory and were then subjected to analysis for total iron and zinc using AOAC procedures and *in vitro* bioaccessibility of iron and zinc using Lutten *et al*(1996). Table XXIII shows the *in-vitro* bioaccessibility of iron and zinc from meals.

**Table XXIII**

**IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM MEALS**

<b>Meals</b>	<b>Total Iron</b>	<b>Bioaccessible Iron (%)</b>	<b>Total Zinc</b>	<b>Bioaccessible Zinc (%)</b>
<b>Dosa with Sambar</b>	2.72 ± 0.02	19.05 ± 0.50	3.05 ± 0.05	17.01 ± 0.03
<b>Rice with sambar</b>	5.79 ± 0.01	5.58 ± 0.22	2.30 ± 0.01	8.49 ± 0.06
<b>Chapati with Kuruma</b>	6.53 ± 0.01	4.78 ± 0.02	2.12 ± 0.10	1.57 ± 0.02
<b>Pongal chutney</b>	2.18 ± 0.02	5.08 ± 0.02	1.13 ± 0.01	1.11 ± 0.01
<b>Tomato rice with chutney</b>	3.76 ± 0.01	11.05 ± 0.01	3.13 ± 0.01	8.08 ± 0.02

Table XXIII depicts the iron and zinc bioaccessibility from meals commonly consumed by the households. The bioaccessibility of iron ranged from 5.08 per cent to 19.05 per cent. The highest bioaccessible iron was observed in dosa with sambar, while pongal with chutney has a low iron of 5.08 per cent. In the present study as well as the previous studies done elsewhere, dosa, the fermented cereal and pulse based preparation had higher bioaccessible iron content. A meal of rice with sambar has an iron content of 5.79mg/100g and the bioaccessibility of iron is 11.58 per cent, tomato rice with chutney had bioaccessible iron of 16.05per cent and chapathi with kuruma had 8.78 per cent. The bioaccessibility of zinc ranged from 1.11 per cent to 17.01 per cent. Dosa with sambar had bioaccessibility of 17.01 per cent while pongal with chutney had zinc 1.11 per cent.

According to Hemalatha *et al* (2006) acidulants which are most commonly used at household level such as lime juice, tomatoes, tamarind and raw mango powder when added to products such sambar, variety rices etc., had a significant positive influence in enhancing bioaccessible iron and zinc. This might be the reason for higher bioaccessible iron and zinc as observed among the diets such as sambar, dosa, meal of dosa and sambar.

The bioavailability of zinc from vegetarian diets is also likely to be less than that of non-vegetarian diets. Plant foods rich in zinc—such as legumes, whole grains, nuts, and seeds—are also high in phytic acid, an inhibitor of zinc bioavailability. Among the micronutrients, especially among the minerals, total iron and zinc content and the bioavailability of iron and zinc are the most important information which was considered essential for nutritional evaluation of a diet. Although there is extensive information on the iron and zinc content of various diets (values were contradictory due to the differences in mineral content from the soil, method of preparation and utensils used).

Hence, the results of the study in this phase, revealed that, bioaccessibility of certain foods enhanced on cooking, processing, and with the help of

enhancers' or reducing the inhibitors. Food processing by heat or cooking can alter the bioavailability of iron. This improved bioaccessibility of macro and micronutrients are the results of softening of the food matrix and releasing of the protein-bound iron, which facilitates the absorption (Lombardi-Boccia *et al.*, 1995). This may be the reason that most of the regional diets enhanced iron bioavailability on cooking. Bioaccessibility of zinc from food grains, was observed to be lowered upon heat processing as stated by Hemalatha *et al* (2006).

## **PHASE IV**

### **D. FORMULATION AND EVALUATION OF READY TO EAT FOODS FROM MILLETS INCORPORATED WITH SHADE DRIED DRUMSTICK LEAVES**

Incorporation of foods rich in micronutrients and adopting suitable household processing methods are the strategies to combat micronutrient malnutrition, especially iron and zinc deficiencies. Selection of nutritionally dense ingredients such as pearl millet, green gram, Bengal gram roasted, ground nut and drumstick leaves and adopting household processing methods resulted in the formulation of four variations of ready to eat foods in the form of laddoo. Moringa leaf powder, rich in iron, zinc, and vitamin A (recently shown to promote the solubility of iron), is used as a supplement to improve the nutritional quality of food in areas affected by malnutrition (Dhakaret *al.*, 2011). Variation 1 consists of 5 per cent shade dried drumstick leaves powder, variation 2 consists of 10 per cent shade dried drumstick leaves and variation 3 consists 15 per cent shade dried drumstick leaves powder. Standard ready to eat food is devoid of drumstick leaves powder.

These formulated ready to eat foods were analyzed for macronutrient contents, micronutrient contents, antinutritional factors, bioaccessibility of iron and zinc, sensory evaluation and then the costs were calculated.

#### **1. Macronutrient content of the Ready to Eat Foods**

For the formulated ready to eat foods, the macronutrients were analyzed protein, fat and carbohydrate as per the AOAC procedure. The energy content of the ready to eat foods were calculated from carbohydrate, protein and fat.

Table XXIV shows the Macronutrient content of the Ready to Eat Foods Per 100 g.

**TABLE XXIV**

**MACRONUTRIENT CONTENT OF THE READY TO EAT FOODS (Per 100g)**

Nutrients	Standard	Variation 1	Variation 2	Variation 3	F value
Energy (K.cal)	428.42 ± 3.40	472.11± 1.57**	508.84 ± 2.16**	548.27 ±3.40**	24.58
Protein (g)	17.16 ± 0.34	18.14 ± 0.50**	18.79 ±1.06**	19.46 ± 2.34**	9.67
Fat (g)	6.38 ± 0.27	7.19 ± 0.34*	8.10 ± 0.34*	8.67 ± 0.26*	4.59
Carbohydrate (g)	75.59 ± 2.30	83.72 ± 4.63**	90.02 ± 2.74**	98.10 ± 3.04**	57.24

\*\* - Significant at 1% level;

\* - Significant at 5% level;

From the above Table, it can be observed that, incorporation of shade dried drumstick leaves enhanced the macronutrient content of the ready to eat food (the ladoos). The energy content (calculated) of the ready to eat food ranged from 428.42 K cal to 548.27 K cal from standard to variation 3. The protein content of four ready to eat foods were in the range of 17.16g to 19.46g. The fat content of the ready to eat foods were in the range of 6.38g in standard to 8.67gin variation 3. The carbohydrates increased from 75.59gin standard to 98.10g in variation 3. Earlier study done by Joshi and Mehta (2012) also reported that, dehydration of drumstick leaves enhanced the nutrient content than the fresh samples. Hence, in the present study, on addition of the shade dried drum stick leaves in 5 per cent, 10 per cent and 15 per cent levels increased the macronutrient contents of the ready to eat foods. Nutritional evaluation of a poha based ladoo formulated elsewhere reported that 100 g of poha based ladoo had energy of 427.67 K cal., protein of 8.63gm, and fat content of 13.70gm. The ladoo prepared in the present study had a protein comparatively higher while fat less and energy almost the same.

The macronutrient content of the three variations were compared with standard using ANOVA. The results revealed that, there is significant difference in the protein, carbohydrate and fat content of the three variations from the

standard. The level of significance is 1% for protein and carbohydrate and for fat 5 % level of significance.

**2. Micronutrient content of the Ready to Eat Foods**

The micronutrients analyzed for the formulated ready to eat foods were vitamin A, iron, zinc, calcium, and phosphorus. These micronutrients were analyzed using standard procedures. Table XXV shows the micronutrient content of the ready to eat foods per 100g

**TABLE XXV**

**MICRONUTRIENT CONTENT OF THE READY TO EAT FOODS (Per 100g)**

Nutrients	Standard	Variation 1	Variation 2	Variation 3	F value
<b>Vitamin A (µg)</b>	30.90 ± 0.87	878.43 ± 3.41**	1720.76 ± 1.10**	2558.29±12.21**	73.54**
<b>Iron (mg)</b>	8.53 ± 0.25	9.68 ± 0.14**	10.71 ± 0.08**	11.03 ± 0.21**	13.46**
<b>Zinc (mg)</b>	2.82 ± 0.69	2.87± 0.02 <sup>NS</sup>	2.93± 0.09 <sup>NS</sup>	2.98± 0.08 <sup>NS</sup>	2.032 <sup>NS</sup>
<b>Calcium (mg)</b>	83.85 ± 0.11	298.22 ± 0.75**	525.49 ± 1.04**	737.32 ± 2.38**	18.42**
<b>Phosphorus (mg)</b>	315.51 ± 0.56	356.22 ± 1.10**	384.55 ± 1.60**	402.11 ± 2.08**	21.59**

\*\* - Significant at 1% level;NS – Not significant

The above Table shows that, the micronutrient content of the ready eat foods also increased on the addition of dried drumstick leaves. Standard ready to eat food has a vitamin A of 30.9 µg, while the variation 1, 2 and 3 had 878.43 µg, 1720.76 µg and 2558.29 µg respectively. Total iron content of the ready to eat foods ranged from 8.53 g to 11.03 g from standard to variation 3. Similarly zinc, calcium and phosphorus values also increased from standard to variation 3. Standard laddoo has zinc content of 2.82mg, calcium of 83.85mg and phosphorus of 315.51 mg / 100g respectively. Laddoo made out of 5 per cent drumstick leaves incorporated had zinc content of 2.87 mg, calcium of 298.22 mg and phosphorus of 356.22 mg / 100g respectively. Likewise variation 2 and 3 increased from 2.93 to 2.98 for zinc, 525.49 to 737.32 for calcium and 348.55 to

402.11 for phosphorus respectively. Thus, the results of the present study proves that incorporation on locally available drumstick leaves coupled with household processing method can enhance the nutritional quality of ready to eat foods which can combat anaemia from household levels. Previous work done by Singh and Sehgal (2008), on developing a laddoo from popped pearl millet, dehulled chickpea and groundnut also reported high iron content, which is in line with the present study. Vitamin C content showed a decrement as vitamin C is a heat labile vitamin and is destroyed when exposed to direct sunlight and heat due to oxidation.

Singh *et al* (2009) studied the nutrient composition of products prepared by incorporating amaranth (*Amaranthustricolour*) leaf powder. Fresh amaranth leaves were dried and products like biscuits, mathi, matar and sev were prepared using five per cent of leaf powder and products prepared without addition of leaf powder served as control. The products with leaf powder had significantly higher protein, fat, ash and fibre contents compared to the control.

The micronutrient content of the three variations was also compared with the standard food using ANOVA. The results revealed that, there is significant difference in the vitamin A, iron, calcium and phosphorus content of the three variations from the standard. The level of significance is 1%. The increase in zinc content in the three variations that the standard food, it is not significant.

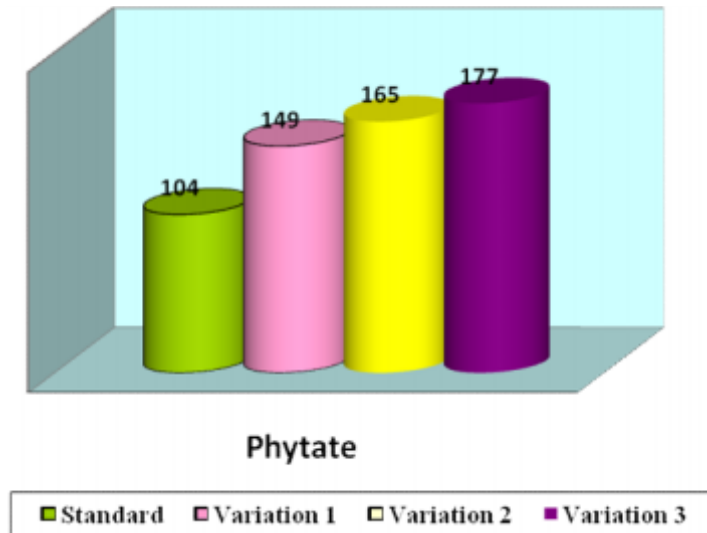
### **3. Anti - nutrient contents of the Ready to Eat Foods**

Moringa leaves are rich in nutrients as well as anti-nutrients. When drying as the nutrients gets concentrated, so as the anti-nutrients also gets concentrated. From formulated ready to eat foods, the anti-nutrients analysed were oxalate and phytate.

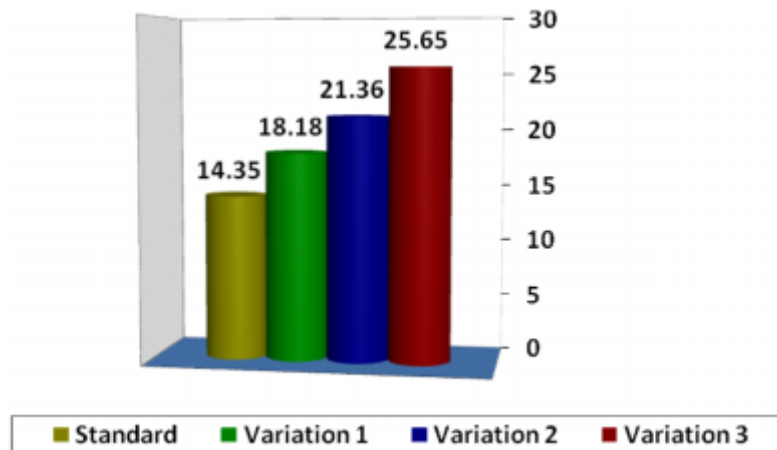
Phytate content of the ready to eat foods was low in the standard food which is devoid of drumstick leaves. As drum stick leaves were added the phytate content also increased. The phytate content were in the range of 104 mg in standard ready to eat food to 117 mg in the variation 3 which has 15 per cent of the shade dried drum stick leaves. Fig. XVIII and Fig. XIX shows the anti-

nutritional factors present per 100 g of the Ready to Eat foods

**FIGURE XVIII**  
**PHYTATE CONTENT OF THE READY TO EAT FOODS**



**FIGURE XIX**  
**Oxalate content of the ready to eat foods**



Phytic acid being an anti-nutrient, it lowers the bioavailability of minerals and inhibits the digestibility of proteins. Addition of shade dried drumstick leaves

increased the oxalate content of the ready to eat foods. Standard food devoid of drum stick leaves had an oxalate content of 14.35 mg while variation 1 had 18.18 mg, variation 2 had 21.36 and variation 3 had 25.65 mg respectively.

#### **4. *In-vitro* bioaccessibility of iron and zinc from the Ready to Eat foods**

The formulated ready to eat food was subjected to *in vitro* bioaccessibility of iron and zinc by the procedure of Lutén *et al* (1996). TABLE XXVI shows the *in-vitro* bioaccessibility of iron and zinc from the Ready to Eat foods

**TABLE XXVI**

**IN-VITRO BIOACCESSIBILITY OF IRON AND ZINC FROM  
THE READY TO EAT FOODS**

<b>Ready to eat food</b>	<b>Total iron mg/100g</b>	<b>% Bioaccessible iron mg/100 of food</b>	<b>Total zinc mg/100g</b>	<b>% Bioaccessible zinc mg/100 of food</b>
<b>Standard</b>	9.09	6.3	2.90	2.70
<b>Variation 1</b>	8.63	5.4	2.93	2.12
<b>Variation 2</b>	8.61	2.3	2.95	1.78
<b>Variation 3</b>	8.59	1.2	2.96	1.42

From, the above Table, it can be found that, the ready to eat food formulated had iron bioaccessibility ranged between 6.7 per cent to 35.3 per cent and zinc bioaccessibility ranged between 1.2 per cent to 6.3 per cent. Even though, anti-nutritional factors such as phytate and oxalate increased by the incorporation of drumstick leaves

Though a food contains both iron and zinc, the presence of iron will not reduce zinc absorption. Although foods high in phytic acid also contain high amounts of dietary fibre, fibre itself does not interfere with zinc absorption. Studies by Sandstorm and Cederblad (1987) have shown that the total amount of zinc in a meal may have a greater effect on zinc absorption than the presence of phytate. Likewise, higher levels of dietary protein will enhance zinc absorption, as zinc binds to proteins. These might be the reason for higher bioaccessibility of zinc from ready to eat foods.

Study conducted by Prasad *et al* (2014) on the *in vitro* method for predicting the bioavailability of iron from Bathua (*Chenopodium album*) and Fenugreek (*Trigonellafoenumgraecum*) leaves in Indian cookies found the total iron content as 15.16mg/100g in laddoo incorporated with dehydrated GLVs whereas *in vitro* bioavailability of iron was found to be 2.78mg/100g in laddoo.

### 5. Sensory evaluation of the ready to eat foods

The formulated foods were subjected to sensory evaluation by 30 panel members. The panelist did the sensory scores of appearance, taste, texture, flavour, doneness and over all acceptability were significantly different among the four variations of the ready to eat foods. TABLE XXVII shows the sensory evaluation of ready to eat foods.

**TABLE XXVII**  
**SENSORY EVALUATION OF READY TO EAT FOODS**

Criteria	Standard	Variation 1	Variation2	Variation 3	CD (p<0.05)
Appearance	6.43 ± 1.38	7.93 ± 0.90**	5.13 ± 1.07**	3.90 ± 0.84**	0.725
Colour	7.50 ± 0.86	7.43 ± 0.72 <sup>ns</sup>	4.23 ± 0.67**	1.86 ± 0.73**	0.509
Flavour	7.93 ± 0.58	6.10 ± 0.71**	2.50 ± 0.50**	2.22 ± 0.61**	0.411
Taste	8.13 ± 1.13	7.86 ± 0.68 <sup>ns</sup>	2.23 ± 0.43**	1.57 ± 0.50**	0.506
Texture	7.767 ± 0.67	7.73 ± 0.74 <sup>ns</sup>	2.80 ± 0.71**	2.70 ± 0.46**	0.445
Doneness	7.90 ± 0.66	8.13 ± 0.74 <sup>ns</sup>	4.43 ± 1.13**	3.70 ± 1.05**	0.640
Overall Acceptability	7.63 ± 0.49	7.73 ± 0.69 <sup>ns</sup>	4.03 ± 0.71**	2.92 ± 0.60**	0.429

Values are expressed by mean ± SD

\*\* - Significant at 1% level; ns – Not significant

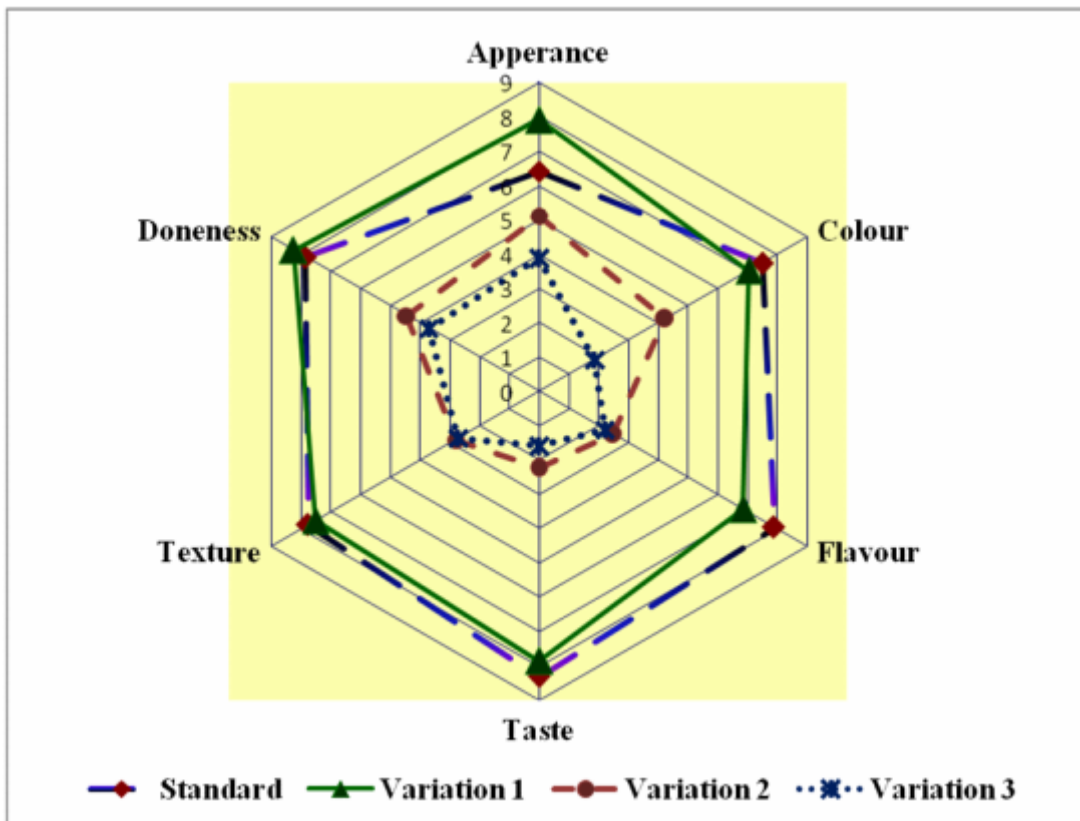
From the above Table, it can be inferred that, there was a significant difference in the overall acceptability with increasing level of shade dried drumstick leaves. The appearance of Variation 1 had high score of 7.93 ± 0.90 and Variation 3 had a score of 3.90 ± 0.84. The addition of shade dried drumstick

leaves increased the colours of the ready to eat foods from standard to variation. The score for colour ranged from  $7.50 \pm 0.86$  to  $1.86 \pm 0.73$  in Variation 3. The textures of the ready to eat foods were significantly different on the addition of shade dried drumstick leaves. Addition of shade dried drumstick leaves decreased the taste of the ready to eat foods from standard to Variation 3. The scores were in the range of 8.30 in the standard to 1.57 in the Variation 3 ready to eat foods.

The overall acceptability mean scores ranged from 7.73 to 2.92, revealing that the Variation 1 ready to eat food with five per cent incorporation of shade dried drumstick leaves had a mean score of 7.73 while ready to eat food of Variation 3 with 15 per cent incorporation of shade dried drumstick leaves had a mean score of 2.92 only. Figure XX shows the sensory evaluations of the ready to eat foods.

**FIGURE XX**

**OVERALL ACCEPTABILITY OF READY TO EAT FOODS**



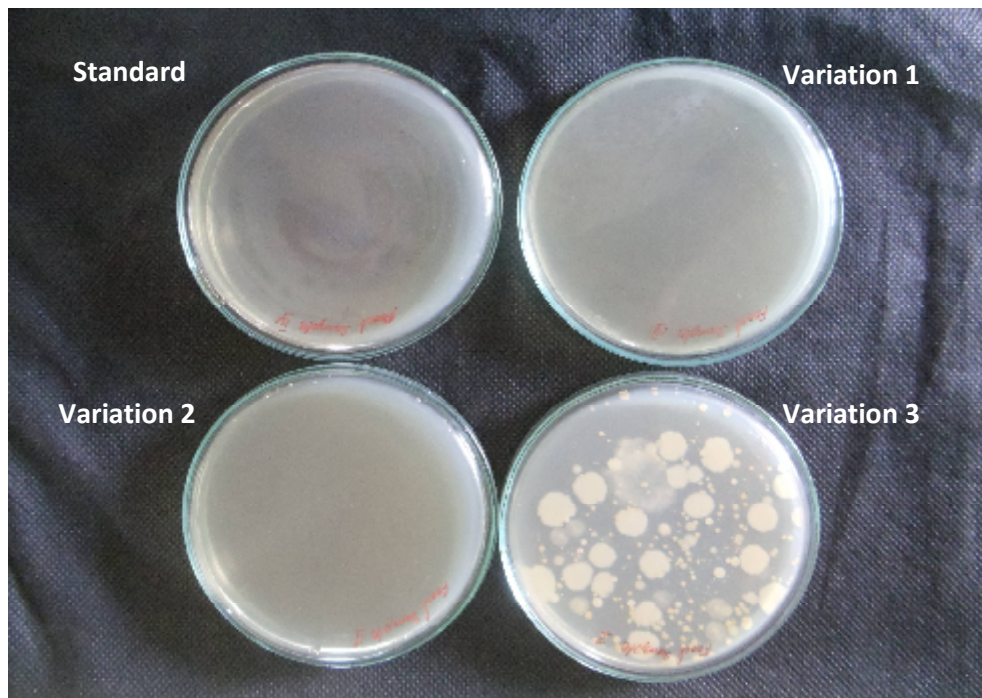
## 6. Shelf evaluation of the ready to eat foods

The formulated foods were evaluated for shelf-life. The shelf-life of the food mixes were analyzed by storing them in airtight containers at room temperature for a period of 0 days, 7 days, and 15 days respectively. The shelf-life was determined by the serial dilution 1:100 and plated from 10-2 using spread plate technique as stated by Jideani and Jideani (2006). The parameters analyzed were moisture content, peroxide value, total bacterial count and total fungal count. TABLE XXVIII shows the shelf evaluation of ready to eat foods.

Plate XVI shows the total plate count of the ready to eat food

### PLATE XVI

#### TOTAL PLATE COUNT OF THE READY TO EAT FOOD



*Results and Discussion*

**TABLE XXVIII**

**SHELF – LIFE EVALUATION OF THE READY TO EAT FOODS**

Criteria / No. of Days	Standard			Variation I			Variation II			Variation III		
	0	7	15	0	7	15	0	7	15	0	7	15
<b><i>Chemical Analysis</i></b>												
<b>Moisture (g%)</b>	4	6.50	8.25	4.2	6.65	8.30	4.6	6.80	8.35	4.80	7.20	8.45
<b>Peroxide Value (mEq/kg)</b>	1.01	2.04	3.12	1.05	2.10	3.15	1.05	2.12	3.18	1.06	2.13	3.20
<b><i>Microbial Analysis</i></b>												
<b>Total Plate Count (cfu/g)</b>	1.01 x 10 <sup>2</sup>	4.60 x 10 <sup>2</sup>	10.25 x 10 <sup>2</sup>	1.04 x 10 <sup>2</sup>	4.70 x 10 <sup>2</sup>	10.65 x 10 <sup>2</sup>	1.50 x 10 <sup>2</sup>	5.25 x 10 <sup>2</sup>	12.25 x 10 <sup>2</sup>	1.25 x 10 <sup>2</sup>	5.60 x 10 <sup>2</sup>	12.85 x 10 <sup>2</sup>
<b>Total Fungal Count (cfu/0.1g)</b>	26	43	67	28	52	71	26	54	73	31	59	76

The shelf-life studies of supplementary foods were carried out in polyethylene and laminated pouches for a period of 15 days at an ambient temperature. Samples were packed and kept at room temperature for 90 days. All samples were drawn periodically after 0, 7, 15 days and the shelf life was analysed. As shown in the above table, the peroxide value of the samples were minimum (0.115) in 15 days and thereafter started increasing microbial contamination at a slow pace.

#### 7. Calculation of the cost of ready to eat foods (per kg)

The cost of the ready to eat foods were calculated by totaling the cost of the ingredients. TABLE– XXIX shows the cost of ready to eat foods (per kg).

**TABLE XXIX**  
**COST OF READY TO EAT FOODS (per kg)**

	<b>COST OF Ready to Eat foods (per kg)</b>
<b>Standard</b>	<b>79.00/-</b>
<b>Variation 1</b>	<b>81.00/-</b>
<b>Variation 2</b>	<b>84.50/-</b>
<b>Variation 3</b>	<b>87.75/-</b>

Table XXIX shows the cost of Ready to Eat foods per kg. One kg of the ready to eat laddoo contains a total of 20 laddoos (each 50g). Hence the cost of one laddoo will be Rs. 4 to 4.50 /-. The cost of ready to eat foods when compared with other commercial products reveals that the cost is minimal and affordable.

The ready to eat food, laddoo made of variation 1 has maximum iron bioaccessibility. The ingredients are locally available and simple household processing techniques can be adopted for the preparation. The shelf-life of the food was 15 days. In this way, iron deficiency anaemia can be mitigated at household level in a cost effective way. Earlier study by Singh *et al*(2014) reported that in terms mineral bioavailability, total dialyzable iron is 2 to 4 times superior in pearl millets than other major millets. Food processing methods such

as soaking, germination have shown to reduce phytate content and thereby improve absorption of zinc. These methods are simple and can be practiced at household level to improve zinc nutrition (Chavan and Kadam, 1992).

Research work done by Kodkanyet *al*(2013) reported that the use of biofortified crops significantly increased dietary iron and zinc content but zinc absorption was comparable to non-fortified crops. Thus efforts are needed not only to increase the zinc content in the staple foods but also to enhance its absorption to satisfy the requirements in vulnerable segments of the population. In a double blind randomized controlled trial (RCT) among zinc-deficient 19 to 49 year old women (serum zinc  $\leq 70 \mu\text{g/dl}$ ), 50 and 100 ppm fortified bread was found to improve zinc status compared to non-fortified bread. The dose of 100 ppm was found to improve phytic acid-zinc molar ratio leading to enhancing zinc bioavailability from moderate to high without bringing unacceptable organoleptic changes.

Thus, the result of this phase proves that, with selection of nutrient dense foods, suitable processing methods adopted convenience foods can be developed. These foods will serve as a vehicle for improving the micronutrient status of the vulnerable groups. Hence, hidden hunger can be mitigated from household itself.

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**PHASEV**

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**E. Assessment of *in vivo* bioavailability ready to eat iron food and imparting nutrition education to adolescent girls and assessing the impact of interventions**

From different areas of Coimbatore district, 140 adolescent girls (16 to 18 years) were selected randomly and the details regarding socioeconomic and dietary pattern were assessed. For the *in vivo* study 67 adolescent girls (33 anaemic and 34 non-anaemic) were selected based on inclusion and exclusion criteria. They were grouped into four- experimental group I and II were anaemic, experimental group III and Control group were non-anaemic. Every week the investigator used to supplement the ready to eat food to experimental group I (anaemic adolescent girls) and group III (non-anaemic adolescent girls). All the four groups nutrition education on alternate weeks. The interventions were given for four months. The intervention period is for four months. Nutritional status assessment in terms of anthropometry, biochemical. Clinical and dietary assessments were carried out before and after the interventions. “t” test was done to find the significant difference between initial and final biochemical parameters as well as Knowledge, attitude and practice. Pearson’s correlation was done to assess the association between increase in hemoglobin and serum ferritin levels. The results of interventions are given below.

**1. Socio-economic background of the adolescent girls (16-18 years)**

Socio-economic factors have a role on the prevalence of anemia. The major factors that influence the nutritional status of an individual are socio-economic and personal characteristics like age, religion, educational status and family income.

In the present study, one hundred and forty respondents of 16-18 years were chosen from four areas of Coimbatore district and details regarding their personal and socio-economic and dietary characteristics were collected using interview schedule. Personal and socio-economic characteristics of the respondents were assessed in order to elicit information regarding age, religion, caste, type and size of the family, educational status, occupation of parents

and total family income monthly. Table XXX shows the background information of the adolescent girls.

**TABLE - XXX****BACKGROUND INFORMATION OF THE ADOLESCENT GIRLS****N - 140**

<b>Details</b>	<b>No.</b>	<b>Per cent</b>
<b>Age in years</b>		
16	43	30.71
17	61	43.58
18	36	25.71
<b>Educational Level</b>		
+1	37	26.43
+2	49	35.00
Degree 1 <sup>st</sup> Year	31	22.14
Degree 2 <sup>nd</sup> Year	23	16.43
<b>Type of family</b>		
Nuclear	96	68.57
Joint	26	18.57
Extended	18	12.86
<b>Size of Family</b>		
1 - 4 members	89	63.57
5 - 7members	38	27.14
> 8 members	13	9.29
<b>Religion</b>		
Hindus	86	61.43
Christian	35	25.00
Muslim	19	13.57
<b>Caste</b>		
Forward	9	6.43
Most Backward Caste	99	70.71
Schedule Caste	32	22.86
<b>Total family income (Rs)*</b>		
<3300	17	12.14
3301 – 7300	70	50.00
7301 – 14500	39	27.86
> 14501	14	10.00
<b>Educational status of Fathers</b>		
Primary School	34	24.29
High School	50	35.71
Higher secondary School	33	23.57
Graduates	23	16.43

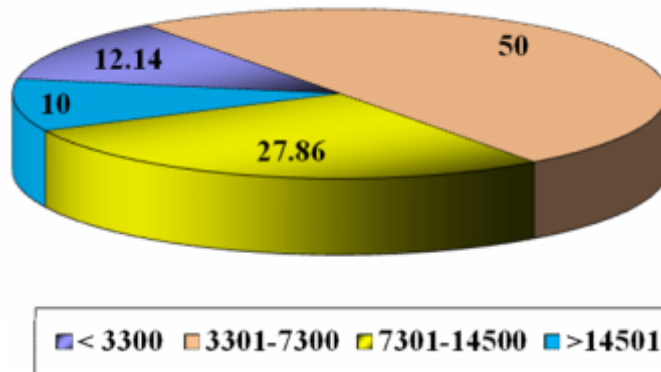
<b>Details</b>	<b>No.</b>	<b>Per cent</b>
<b>Occupation of Fathers</b>		
Agricultural labours	30	21.43
Daily wage earners	60	42.85
Own Business	23	16.43
Private employees	21	15.00
Government employees	6	4.29
<b>Educational status of Mothers</b>		
Primary School	36	25.71
High School	52	37.14
Higher secondary School	34	24.29
Graduates	18	12.86
<b>Occupation of Mothers</b>		
Home makers	47	33.57
Daily wage earners	42	30.00
Agricultural labours	14	10.00
Own Business	20	14.29
Private employees	15	10.71
Government employees	2	1.43

As per the above Table, around 43.58 per cent of the adolescent girls were in the age of 17 years. About 35 per cent of the adolescent girls were undergoing +12 class. Regarding the type of family, 68.57 per cent of the adolescent girls were from nuclear family and 63.57 percent were having a family size of four.

On assessment of the religion, it was found that, 61.43 per cent of the adolescent girls were Hindus, 25 per cent were Christians and 13.57 per cent were from Muslim community. Majority (70.71 per cent) of the adolescent girls in the present study were from most backward caste.

As per the 11<sup>th</sup> 5 year plan (2012), about half of the adolescent girls had a family income between Rs.3301–7300/-. Around 27.86 per cent had income between, Rs. 7301- 14500/-. Only 10 per cent had income above Rs.14501/- and 12.14 per cent of the adolescent girls were having family income less than Rs. 3300/-. Figure XX shows the classification of respondents based on monthly income

**FIGURE XXI**  
**CLASSIFICATION OF RESPONDENTS BASED ON MONTHLY INCOME**



Regarding the education status of the fathers, majority of them were educated upto high school and primary school. Only 23.57 per were educated upto high secondary school and only 6.43 per cent were graduates. Education status of the mothers revealed that, 37.41 per cent were upto high school and 25.71 per cent upto primary school. Only 24.29 per were educated upto high secondary school and only 12.86 per cent were graduates.

Assessment of occupational status revealed that, 42.85 per cent were daily wage earners, 21.43 per cent were agricultural labourers. Around 16.43 per cent were having own business while 15 percent were employed in private sectors. Only 4.29 per cent of the father's were government employees. While, the assessment of the occupational status of mothers revealed that, 33.57 per cent were homemakers, 30 per cent were daily wage earners, 10 per cent of them were agricultural labourers. Around 14.29 per cent had own business, 10.71 per cent were employed in private sectors and only 1.43 per cent were government employees.

## 2. FOOD HABITS OF ADOLESCENT GIRLS

Dietary habits of the adolescent girls were assessed using the structures schedule. The assessment of dietary habits includes food habit, habit of skipimng meals and frequency of consumption of fast foods.

TABLE XXXI

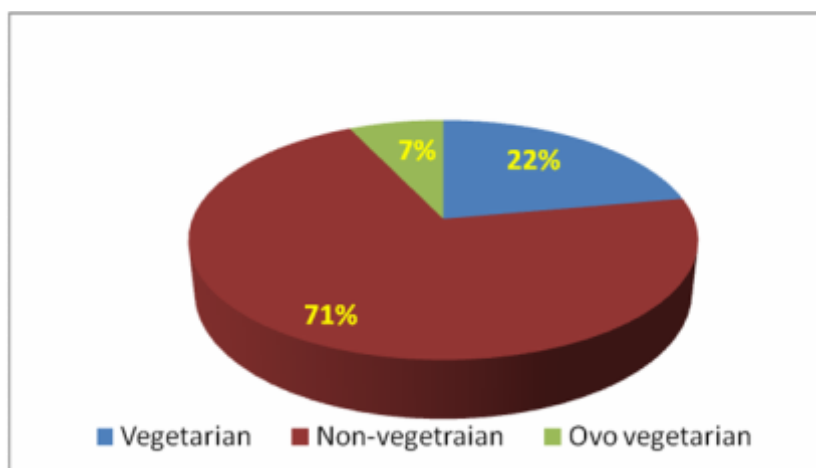
## FOOD HABITS OF ADOLESCENT GIRLS (N=140)

Criteria	No.	Per cent
Vegetarian	31	22.14
Ovo vegetarian	10	7.14
Non vegetarian	99	70.72
<b>Habit of Skipping Meals</b>		
Yes	67	47.86
No	73	52.14
<b>Skipping</b>		
Breakfast	96	68.57
Lunch	26	18.57
Dinner	18	12.86
Yes	129	92.14
No	11	7.86

From the above Table-, it can be inferred that 70.72 per cent of the adolescent girls in the present study were non vegetarians while only 22.14 per cent of the adolescent girls were vegetarians and 7.14 were ovo vegetarians Figure XXII shows the classification of adolescent girls based on food habit

FIGURE XXII

## CLASSIFICATION OF ADOLESCENT GIRLS BASED ON FOOD HABIT



**a. Meal skipping pattern**

The food skipping pattern of the adolescent girls revealed that, nearly 47.86 per cent of the adolescent girls had the habit of skipping meals. About 52.14 per cent of the adolescent girls usually didn't skip any meals during the past one month. Around 18.57 per cent of the adolescent girls revealed that lunch and 12.86 per of the adolescent girls skipped dinners due to various reasons. The meal skipping pattern of the adolescent girls showed that, 69 per cent of the adolescent girls responded that, they used to skip breakfast of the day in school days.

**b. Frequency of consumption of fast foods during the past one month**

Frequency of consumption of fast foods during the past one month was recorded using the interview schedule. Table XXXII shows the frequency of consumption of fast foods.

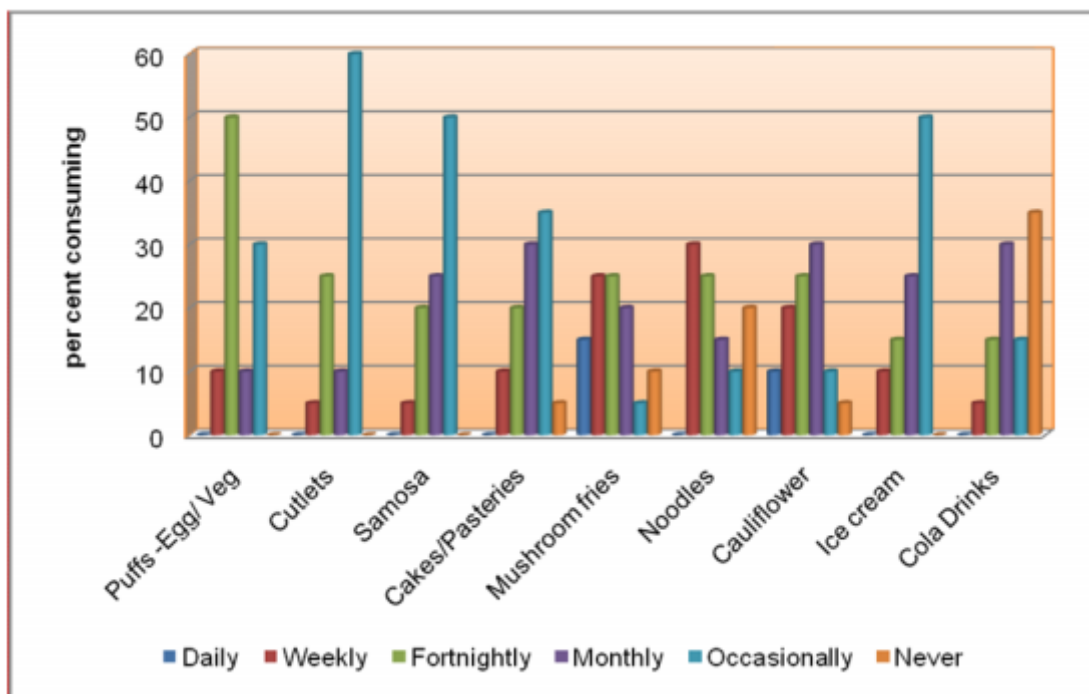
**TABLE XXXII**  
**FREQUENCY OF CONSUMPTION OF FAST FOODS**  
(per cent)

Food items	Frequency of consumption*					
	Daily	Weekly	Fortnightly	Monthly	Occasionally	Never
<b>Puffs – Egg /Veg</b>	0.0	10	50	10	30	0.0
<b>Cutlets</b>	0.0	5	25	10	60	0.0
<b>Samosa</b>	0.0	5	20	25	50	0.0
<b>Cakes</b>	0.0	10	20	30	35	5
<b>Mushroom</b>	15	25	25	20	5	10
<b>Cauliflower</b>	10	20	25	30	10	5
<b>Ice cream</b>	0.0	10	15	25	50	0.0
<b>Cola Drinks</b>	0.0	5	15	30	15	35

\*Multiple responses

In the present study, 92.14 per cent of the adolescent girls were having the habit of consuming fast foods while 7.86 per cent of the adolescent girls were not consuming fast foods regularly. The commonly consumed fast foods among adolescents were Puffs Egg /Veg , Cutlets, Samosa, Cakes, Mushroom, Cauliflower, Ice cream, Cola Drinks. From the above table, it can be observed that, 10 per cent of the adolescent girls were consuming puffs weekly once, 50 per cent fortnightly, 10 per cent monthly and 30 per cent occasionally. Frequency of consuming cutlets were weekly once by 5 per cent of the adolescent girls, fortnightly once by 25 per cent, 10 per cent monthly and 60 per cent occasionally. Samosa was consumed by 50 per cent of the adolescent girls occasionally only. Mushrooms and cauliflower was consumed daily by 15 per cent and 10 per cent of the adolescent girls respectively. Around 10 per cent of the adolescent girls never had mushrooms, while 5 per cent never has cakes and cauliflower. Regarding cola drinks, 35 per cent of the adolescent girls never had, while 30 per cent had monthly once, 15 per cent had fortnightly and occasionally and only 5 per cent had cola drinks weekly once. FigureXXIII shows the frequency of consumption of fast foods.

**FIGURE XXIII**  
**FREQUENCY OF CONSUMPTION OF FAST FOODS**



### 3. IRON NUTRITURE STATUS OF THE ADOLESCENT GIRLS

For the conduct of the intervention study, 67 adolescent girls were selected based on the inclusion and exclusion criteria. Experimental group I, were moderately anaemic (Hb 7 to 9.9g/dl) received supplementation and nutrition education; experimental group II were moderately anaemic (Hb 7to9.9 g/dl) received only nutrition education; experimental group III were non-anaemic (Hb>12 g/dl) received supplementation and nutrition education and control group were also non anaemic received only nutrition education. The result are presented and discussed here.

#### a. Classification of adolescent girls (16-18 years) based on Body Mass Index

Body Mass Index (BMI) is the most practical and widely used tool to ascertain an individual's body fat mass. TABLE XXXIII shows the classification of adolescent girls based on body mass index.

**TABLE XXXIII**  
**CLASSIFICATION OF ADOLESCENT GIRLS BASED ON BMI**

n=67

BMI Classification*	Experimental -I (n=16)		Experimental - II (n=17)		Experimental -III (n=15)		Control - II (n=19)	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
<18.5 Under weight	3	18.75	5	29.41	3	20.00	2	10.53
18.5 -23.0 Normal	13	81.25	12	70.58	8	53.33	14	73.68
23.0 – 25.0 Over weight	0.0	0.00	0.0	0.00	4	26.67	3	15.78
<b>Total</b>	<b>16</b>	<b>100.00</b>	<b>17</b>	<b>100.00</b>	<b>15</b>	<b>100.00</b>	<b>19</b>	<b>100.00</b>

Table XXXIII shows the BMI classification of the adolescent girls showed that majority of the respondents in the study were having BMI normal ranging from 18.5 – 23.0. Only 15.78 percent of the control group and 26.67 per cent of the experimental group III had BMI above 23.0 showing that they are slightly overweight. Around 18.75 per cent of experimental group I, 29.41 per cent of experimental group II, 20 per cent of the experimental group III and 10.53 per cent of the control group respectively had BMI less than 18.5, showing that, they were under weight.

#### **b. Biochemical profile of the adolescent girls**

Study of biochemical parameters enables us to detect the deficiencies before the symptoms are clinically evident and thereby giving the early chance of rectifying the deficiency diseases. The biochemical parameters assessed for the present study includes, hemoglobin, serum iron, ferritin, zinc, total iron binding capacity and transferrin saturation. The results are presented as mean  $\pm$  SD and compared with reference values. Table XXXIV shows the biochemical profile of the adolescent girls.

**TABLE XXXIV**  
**BIOCHEMICAL PROFILE OF THE ADOLESCENT GIRLS**

Biochemical parameters	*Ref. Range	Experimental –I (n=16)	Experimental –II (n=17)	Experimental –III (n=15)	Control (n=19)
		Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Haemoglobin* (g/ dl)	$\geq 12$	9.10 $\pm$ 0.21	9.28 $\pm$ 0.12	12.11 $\pm$ 0.12	12.12 $\pm$ 0.13
Serum iron $\mu\text{g/L}$	60 –180	53.11 $\pm$ 1.67	53.26 $\pm$ 1.72	63.03 $\pm$ 2.14	64.26 $\pm$ 1.93
Serum ferritin ng/ml	$\geq 12$	10.33 $\pm$ 0.63	10.35 $\pm$ 0.60	13.96 $\pm$ 1.11	14.01 $\pm$ 1.09
TIBC $\mu\text{g/dl}$	250–450	308.84 $\pm$ 7.45	307.51 $\pm$ 6.19	254.77 $\pm$ 7.78	255.29 $\pm$ 9.18
Transferrin saturation %	30–40	17.20 $\pm$ 0.64	17.32 $\pm$ 0.61	24.76 $\pm$ 1.23	25.19 $\pm$ 1.12
Serum zinc# $\mu\text{g/dl}$	$\geq 74$	67.11 $\pm$ 1.67	66.87 $\pm$ 1.21	77.98 $\pm$ 1.59	77.63 $\pm$ 1.16

\*International Nutritional Anaemia Consultative Group (1984)

# International Zinc Nutrition Consultative Group). 2004

As observed the initial biochemical parameters of the anaemic and non anaemic adolescent girls selected for the intervention study. Measurement of iron stores is considered as a sensitive index of the iron status of individuals. The level of serum ferritin reflects the iron status in the body. The mean haemoglobin level ranges from 9.10g/dl in anaemic adolescent girls of experimental group I to 12.12g/dl in thenon anaemic adolescent girls of control group. Similarly, the mean serum iron was in the range of 53.11 $\mu\text{g/L}$  to 64.26 $\mu\text{g/L}$ , mean serum ferritin was 10.33ng/ml to 14.01ng/m, mean TIBC was 308.84 $\mu\text{g/dl}$  to 254.77 $\mu\text{g/L}$  and mean serum zinc was 66.87 $\mu\text{g/dl}$  to 77.98 $\mu\text{g/dl}$  among the anaemic and non anemic adolescent girls respectively. All the biochemical parameters of the anaemic adolescent girls were less than normal.

### c. Clinical Examinations

Clinical examination of the subjects was done by a qualified physician for the incidence of clinical signs and symptoms of the deficiency diseases. Table XXXV shows the clinical symptoms of adolescent girls

**TABLE XXXV**

**CLINICAL SYMPTOMS OF ADOLESCENT GIRLS**

**N=67**

Clinical symptoms	Experimental - I n = 16		Experimental - II n = 17		Experimental - III n = 15		Control - I n = 19	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
Free from clinical signs of deficiency diseases	5	31.25	6	35.29	9	60.00	12	63.16
Lusterless hair	2	12.50	3	17.65	0.0	0.0	0.0	0.0
Easily pluckable hair	5	31.25	2	11.76	1	6.67	0	0.0
Angular stomatitis	3	18.75	4	23.53	1	6.67	0	0.0
Magenta tongue	2	12.50	1	5.88	0.0	0.0	0.0	0.0
Mottled enamel	2	12.50	4	23.53	0.0	0.0	1	5.26
Spongy bleeding gums	3	18.75	4	23.53	1	6.67	2	10.52
Pellagrous dermatitis	1	6.25	3	17.65	2	13.33	2	10.52
Dental caries	2	12.50	2	11.76	3	20.00	3	15.78
Koilonychia	2	12.50	1	5.88	0.0	0.0	0.0	0.0
Fatigue	6	37.50	4	23.53	0.0	0.0	0.0	0.0

From the above table, it can be found that, 60 per cent of the adolescent girls in experimental group III and 63.16 per cent of the control group are free from clinical signs of deficiency diseases. Both these groups were non anaemic adolescent girls. It may be the reason of majority of them being free from the clinical signs of deficiency diseases.

Angular stomatitis, dermatitis, mottled enamel, dental caries etc were present in the four groups. Fatigue was observed among 37.50 per cent of group I and 23.53 per cent of group II respondents. Koilonychia was present in 12.50 per cent of group I and 5.88 per cent of group II respondents respectively. The reason behind fatigue as well as koilonychia may be the result of anaemia. In the study also, it is present among anaemic subjects only. Thus, the clinical

picture of the respondents proved that they were suffering from micronutrient malnutrition. In the present study, the biochemical parameters of the majority of the adolescent girls of group I and group II (Anaemic ) were low and which could be the reason for the clinical signs of fatigue, pale face among the adolescent girls.

#### **d. Morbidity pattern of the respondents**

The prevalence of morbidities such as fever, diarrhoea, dysentery and acute respiratory infections (ARI) during the preceding 30 days showed that about 6 per cent of the adolescents had morbidities such as fever (3.5 per cent), ARI (2.9 per cent) and diarrhoea (0.2 per cent).

#### **e. Frequency of use of various food items by the respondents**

Frequency of use of various food items by the respondents were assessed using food frequency questionnaire. Table XXXVI shows the frequency of use of various food items by the respondents.

**TABLE XXXVI**  
**FOOD FREQUENCY SCORES OBTAINED FOR VARIOUS FOOD ITEMS**

<b>Food Items</b>	<b>Average Scores</b>	<b>Per cent of total Scores</b>
<b>Cereals</b>	7.00	100.00
<b>Pulses</b>	5.90	84.23
<b>Other vegetables</b>	5.95	85.00
<b>Green leafy vegetables</b>	3.80	54.23
<b>Roots and tubers</b>	4.55	65.00
<b>Fruits</b>	2.75	39.23
<b>Milk and its products</b>	6.75	96.43
<b>Fat and oils</b>	7.00	100.00
<b>Nuts and oilseeds</b>	6.8	97.14
<b>Sugar</b>	7.00	100.00
<b>Spices and condiments</b>	7.00	100.00
<b>Egg</b>	2.80	40.00
<b>Fish</b>	2.55	36.43
<b>Meat</b>	3.95	56.43
<b>Beverages(Tea/Coffee)</b>	6.75	96.43

<b>Baked foods</b>	1.95	27.86
<b>Processed foods</b>	2.05	29.23

**i. Frequency of use of food groups**

Based on the percentage frequency scores, food groups included in the daily dietaries of the respondents in this study was classified as most frequently used (percentage score above 80), medium frequently used (percentage score between 50-80), less frequently used (percentage score between 30-50) and least frequently used (percentage score below 30). Table XXXVII shows the frequency of use of food groups

**TABLE XXXVII**

**FREQUENCY OF USE OF FOODS GROUPS**

<b>Most frequently used</b>	<b>Medium frequently used</b>	<b>Less frequently used</b>	<b>Occasionally used</b>
Cereals	Roots and tubers	Egg	Processed foods
Fat and oils	Meat	Fish	Baked foods
Nuts and oilseeds	Green leafy vegetables	Fruits	
Sugar			
Spices and condiments			
Other vegetables			
Beverages (Tea/Coffee)			
Milk and its products			
Pulses			

The most frequently used foods by the adolescent girls were cereals, other vegetables, pulses, fats and oils, nuts and oilseeds, sugar, spices and condiments, milk and its products and tea and coffee. The items like fats and oils, nuts and oilseeds, sugar, spices and condiments, are frequent as they are indispensable ingredients in the dietaries. Though they are frequently using pulses and other vegetables, the mean intake is low when compared with RDA. Regarding the use of milk and its products, for preparing tea/ coffee milk and

added. Other products like curd, buttermilk, yoghurt, butter, ghee etc., are used occasionally. Meat is consumed weekly once and fish fortnightly. Adolescent girls in the present study mostly prefer egg puffs rather than taking other than preparations like boiled egg, egg curry omelet etc.

According to Patted *et al* (2010) to low consumption of green leafy vegetables results in lower intake of micronutrients which can be the reasons for mineral deficiencies including iron and zinc in particular, among the adolescents girls.

#### **4. Impact of interventions on the iron nutriture and KAP of the adolescent girls**

Initially the mean haemoglobin level of the experimental group I was 9.10 and II was 9.28 g/dl, both groups were moderately anaemic. Non anemic groups, experimental group III and control group had haemoglobin 12.11 g/dl and 12.12 g/dl respectively. After four month of supplementation with 50 g of the ready to eat iron rich food and nutrition education, the haemoglobin level of all groups increased. The intervention period was 120 days, after 120 days (four months) the final assessment of biochemical parameters were carried out and the results are presented below. Table XXXVIII shows the impact of interventions on the iron nutriture of the adolescent girls

*Results and Discussion*

**TABLE XXXVIII**

**IMPACT OF INTERVENTIONS ON THE IRON NUTRITURE OF THE ADOLESCENT GIRLS**

Biochemical parameters		Experimental- I (n = 16)	Experimental - II (n = 17)	Experimental - III (n= 15)	Control - I (n= 19)	Total (n=67)
Heamoglobin (g/ dl)	Initial	9.10 ± 0.21	9.28 ± 0.12	12.11 ± 0.12	12.12 ± 0.13	10.68± 1.47
	Final	9.88 ± 0.25	9.52 ± 0.13	12.40 ± 0.11	12.34 ± 0.10	11.0 ± 1.35
t value		4.53**	1.48 <sup>ns</sup>	2.67*	1.28 <sup>ns</sup>	0.56 <sup>ns</sup>
Serum Iron µg/L	Initial	53.11 ± 1.67	53.26 ± 1.72	63.03 ± 2.14	64.26 ± 1.93	58.53±5.58
	Final	53.42 ± 1.61	53.28 ± 1.72	63.44± 2.11	64.28 ± 1.92	58.71±5.57
t value		0.403 <sup>ns</sup>	0.062 <sup>ns</sup>	0.185 <sup>ns</sup>	0.015 <sup>ns</sup>	0.206 <sup>ns</sup>
Serum Ferritin ng/ml	Initial	10.33 ± 0.63	10.35 ± 0.60	13.96 ± 1.11	14.01 ± 1.09	12.18±2.02
	Final	10.68 ± 0.61	10.61 ± 0.58	14.46 ± 1.01	14.07 ± 1.05	12.47±1.98
t value		0.573 <sup>ns</sup>	0.638 <sup>ns</sup>	0.815 <sup>ns</sup>	0.063 <sup>ns</sup>	0.437 <sup>ns</sup>
TIBC µg/dl	Initial	308.84 ± 7.45	307.51 ± 6.19	254.77 ± 7.78	255.29 ± 9.18	281.23 ± 27.57
	Final	301.64 ± 8.10	301.04 ± 7.11	253.47 ± 6.33	252.42 ± 8.69	276.69± 25.28
t value		1.168 <sup>ns</sup>	0.946 <sup>ns</sup>	0.472 <sup>ns</sup>	0.074 <sup>ns</sup>	0.269 <sup>ns</sup>
Transferrin Saturation %	Initial	17.20 ± 0.64	17.32 ± 0.61	24.76 ± 1.23	25.19 ± 1.12	21.19 ± 3.97
	Final	17.73 ± 0.68	17.71 ± 0.62	25.04 ± 1.12	25.49 ± 1.17	21.56±3.89
t value		1.571 <sup>ns</sup>	0.056 <sup>ns</sup>	0.367 <sup>ns</sup>	0.258 <sup>ns</sup>	0.782 <sup>ns</sup>
Serum Zinc µg/dl	Initial	67.11 ± 1.67	66.87 ± 1.21	77.98 ± 1.59	77.63 ± 1.16	72.47 ± 5.56
	Final	67.39 ± 1.66	67.01 ± 1.17	78.13 ± 1.61	77.65 ± 1.13	72.61 ± 5.50
t value		0.244 <sup>ns</sup>	0.647 <sup>ns</sup>	0.326 <sup>ns</sup>	0.018 <sup>ns</sup>	0.169 <sup>ns</sup>

\*\* - Significant at 1% level; \* - Significant at 5 % level ns –Not significant

After four months supplementation with the ready to eat food, there was a significant increase in the haemoglobin level of the groups supplemented. 't' test was performed to find the significance of the increase in biochemical parameters.

When 't' test was done, this increase in haemoglobin level was significant at 1 % level for the experimental group who were anaemic, received supplementation as well as nutrition education. Experimental group III (non anaemic) received supplementation as well as nutrition education had an increase in haemoglobin which was significant at 5 % level. Though the experimental group II and control group showed increment in haemoglobin levels that was not significant.

Review studies also pointed that, the absorption of iron from the body will be high during iron repletion and in iron depletion; the iron uptake will be low. The finding of the intervention also proves this.

Initially, mean serum iron level was in the range of 53.11 to 64.26 µg/dl for anaemic and non anaemic groups respectively. After four months interventions, though there was an increment in serum iron levels of four groups from 53.28 to 63.44 µg/dl. But the increase in serum iron after four months of interventions, the increase in serum iron among the four groups were not statistically significant.

According to WHO (2007), serum ferritin is the measure of the amount of iron stored in the body. If there is no concurrent infection; the concentration  $\geq 15$  ng/ml reflects us iron stores are present; higher concentrations reflect the size of the iron store; when the concentration is low ( $< 12-15$  ng/ml) then iron stores are depleted. In the present study, serum ferritin levels were in the range of 10.33 to 14.01 ng/ml. After four months supplementation, it arose to 14.46. When 't' test was performed, this increase in serum ferritin levels were not significant statistically.

Total Iron Binding Capacity, which indicates low iron stores (deficient) when the TIBC values are high and high iron values (normal or above) when the TIBC values are low. In the present study, initial TIBC ranged from 308 µg/dl for

anaemic girls and 254 µg/dl for non anaemic girls. After intervention, there was a reduction in TIBC, stating that, iron stores of the body increased. When 't' test was performed, the reduction in TIBC were not statistically significant.

After the four month of intervention, the increase Transferrin saturation per cent was low. Transferrin saturation reflects the quantity of iron in transit from the reticuloendothelial system to the bone marrow and gets decreased during iron deficiency. Percentage of transferrin saturation was calculated as the percentage of ratio of serum iron to TIBC. In the study, since TIBC as well as serum iron were not statistically significant, transferrin saturation was also not significant.

Assessment of serum zinc levels, revealed that, there was only a minor increment in the serum zinc level of the intervention groups. The increment was not statistically significant. Ingestion of foods containing provitamin A rich carotenoids from green leafy vegetables improves the total body vitamin A pool size and Hb concentration and thereby reducing anaemia.

#### **5. Impact of nutrition education on the knowledge, attitude and practice of adolescent girls**

Nutrition education is considered to be a major component of all the national nutrition programmes. After nutrition education Participants were able to tell out iron rich foods more promptly. Also they had a clear idea about hemoglobin, and hemoglobin values. The knowledge, attitude and practice of the respondents (quantified in terms of scores) before and after imparting nutrition education. Table XXXVIII shows the impact of nutrition education on the knowledge, attitude and practice of adolescent girls

**TABLE XXXIX**  
**IMPACT OF NUTRITION EDUCATION ON THE KNOWLEDGE, ATTITUDE AND PRACTICE OF ADOLESCENT GIRLS**

Aspects	Experimental- I n = 16	Experimental – II n = 17	Experimental – III n = 15	Control - I n = 19
<b>Knowledge</b>				
Initial	6.44 ± 0.73	6.59 ± 1.06	7.60 ± 0.99	6.58 ± 1.07
Final	14.00 ± 1.03	12.94 ± 0.97	14.13 ± 0.74	13.63 ± 0.96
t value	19.45**	22.53**	31.45**	24.63**
<b>Attitude</b>				
Initial	6.44 ± 1.03	6.24 ± 0.97	7.60 ± 0.83	6.89 ± 0.99
Final	13.13 ± 0.72	12.88 ± 0.70	13.73 ± 0.80	13.05 ± 0.91
t value	30.40**	26.27**	23.15**	31.24**
<b>Practice</b>				
Initial	6.38 ± 0.96	6.18 ± 1.01	7.27 ± 0.96	6.74 ± 0.99
Final	13.19 ± 0.75	12.76 ± 0.75	13.67 ± 0.90	13.11 ± 0.81
t value	27.19**	21.62**	31.57**	25.73**

\*\* - Significant at 1% level

For evaluation of KAP of the four groups, a score of 15 was allotted for each Knowledge, Attitude and Practice respectively thus forming a total of 45. There was a significant increase in the KAP of the adolescent girls from the four groups after imparting the nutrition education for four months. From the above table, it can be inferred that, the knowledge of experimental group-I increased from a mean score of 6.44 to 14.00 and experimental group- III from 6.93 to 13.73 in four months, both groups received nutrition education and supplementation. The attitude of the adolescent girls improved after four months of the nutrition education. Initially the mean scores of attitude were in the range of 6.24 to 6.89. After four months, it increased from 12.88 to 13.73 in all groups. The gain in knowledge and attitude will influence the practices of individuals. In the present study also, the initial mean score for practice were 6.18 to 7.27 among the experimental groups and control group. After imparting four months of nutrition education, the scores increased from 12.76 to 13.67.

Earlier study done by Sajjan (2008) on adolescent girls also reported imparting nutrition education resulted in improvement of nutritional knowledge, attitude, practices as well as increase in the consumption of micronutrient rich foods. According to Kaur, *et al* (2011) increasing the awareness and knowledge among adolescent girls will help in enhancing the iron nutriture and thereby reducing anaemia in the long run.

Hence the results proved that supplementation of foods rich in bioavailable iron and nutrition education significantly increased the heamatological parameters of experimental group I who were anaemic. The experimental group II anaemic received interventions of nutritional education alone also had significant increase in the heamatological parameters. The increment in heamatological parameters of experimental group III who were non anemic were not significant and the non anaemic control group who received nutrition education were not significant.

**PHASE VI****Statistical Analysis and Interpretation of the Data****1. ASSOCIATION BETWEEN BLOOD HEAMOGLOBIN, SERUM FERRITIN AND IRON INTAKE**

**TABLE XXXX**  
**ASSOCIATION BETWEEN BLOOD HEAMOGLOBIN,**  
**SERUM FERRITIN AND IRON INTAKE**

<b>Variables</b>	<b>Experimental I (r value)</b>	<b>Experimental III (r value)</b>
<b>Heamoglobin vs iron</b>	0.385 <sup>ns</sup>	0.370 <sup>ns</sup>
<b>Serum ferritin vs iron</b>	-0.101 <sup>ns</sup>	0.094 <sup>ns</sup>

<sup>ns</sup>-Not Significant

From the above table, it can be inferred that though there positive correlation between heamoglobin increase in the heamoglobin levels and iron intake, for the experimental group I and II (received supplementation), the increment is not statistically significant.

**2. *In vitro* bioaccessibility versus *In vivo* bioavailability**

The *in vitro* bioaccessibility of ready to eat iron rich food was per cent and that of zinc was per cent. Ehen compared with the *in vivo* bioavailability of iron among adolescent girls it was found that the serum iron enhanced by percent, heamoglobin by per cent and serum zinc by per cent.

Therefore, it may be assumed that their *in vitro* bioaccessibility tested in this study may be compared with their *in vivo* bioavailability. Hence in future, it may be recommended that database can be generated for foods in terms of iron and zinc.

From the foregoing results, it is evident that the present study has thrown light on the consumption pattern of regional diets in selected districts of Tamil

Nadu. Further, the nutritional evaluation of selected regional diets proved the diets to be nutrient rich. The *in vitro* bioaccessibility of iron and zinc from the regional diets ranged from 2 to 22 percent. Though loss in zinc and iron content were evident on cooking and processing, the presence of heamatopoiteic factors, fermentation and addition of lime juice helped in enhancing the bioaccessibility of iron and zinc. Further, studies on supplementation of ready to eat convenience foods in the form of ladoo to the selected anaemic and non anaemic adolescent girls showed significant improvement in iron nutriture, the absorption of iron and zinc was higher in anaemic subjects. Long term studies are recommended to substantiate the outcome.