

Summary and Conclusion

Food consumption pattern is defined as the consumption of specific food items and their combinations as dishes and meals. India has a diverse food consumption pattern across the country as well as within the states. The increase in income lead to induced diet diversification and resulted in people moving away from nutritionally superior cereals such as ragi, jowar and bajra and moved towards grains such as wheat and rice. These lead to the deficiency of micronutrients otherwise known as hidden hunger. Among the deficiency of the micronutrients, the most affecting ones are the iron deficiency and zinc deficiency. Deficiencies of trace minerals such as iron and zinc are widespread among the global population. According to the reports of International as well as National agencies, about two billion people worldwide, suffers from these deficiencies.

Bioavailability of iron and zinc from the diets are influenced by several factors such as presence of inhibitors or enhancers of absorption, nutrient interactions or the micronutrient malnutrition could be multiple ranging from poor bioavailability of these nutrients from plant based diets, lack of purchasing power, lack of knowledge of under exploited locally available nutrient dense foods, and in correct food preparation methods. Bioavailability of these minerals can be enhanced by household processing methods such as malting, roasting, fermentation, drying etc, which will enhance the bioavailability of these micronutrients.

Though India is the first country in the world to initiate the National Nutritional Anaemia Prophylaxis Programme (NNAPP), around 50 per cent of the Indian populations are suffering from different grades of anaemia. Except the national food surveys by National Nutrition Monitoring Bureau (NNMB), National Sample Surveys Organization (NSSO), there are only a very few up-to-date assessments of regional Indian diets. The data on the impact of different processing methods and cooking in the form of regional diets on the

bioavailability of micronutrients especially iron and zinc are not available in India. Hence, the need for the present study.

The specific objectives of the study are to assess the consumption pattern of the regional diets by the households of selected districts in Tamil Nadu and evaluate the nutrient potential as well as the bioaccessibility of iron and zinc from the regional diets and to assess the *invivo* bioavailability of iron and zinc from the Ready To Eat (RTE) food among adolescent girls and assess the impact of interventions on the iron nutriture of adolescent girls.

For conducting the study, initially the investigator presented the proposal before the Institutional Human Ethics Committee of the Avinashilingam Institute for Home Science and Higher Education For Women, Coimbatore. After obtaining ethical approval, the present study was initiated. The approval number issued by the Institutional Human Ethics Committee for the present study was AUW/IHEC-13-14/FHP-03. The study was also registered under the Clinical Trial Registry of India (CTRI), Indian Council of Medical Research and received the number 005253. The methodology of the study was designed in six phases. 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 procedure.

Phase I

In Phase I, consumption pattern of regional diets from households of selected districts of Tamil Nadu were carried out by a community based survey. The locale selected for conducting the present study was Tamil Nadu. 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 the selected districts, two taluks consisting of around 100 to 110 households were selected on a random basis covering one urban area and one rural area of each district. Thus, for the present study, 427 households were surveyed to collect data on the socio-economic background of the households, frequency of food consumption pattern, regional diets prepared and consumed by the households during various occasions, cooking practices followed in the preparation of foods and to collect recipes of various food preparations.

A pretested and structured interview schedule was used to collect the details regarding personal, socio-economic characteristics such as age, type and size of family, caste and religion, sources and monthly income, details regarding family members and food expenditure pattern.

PHASE II:

In Phase II, nutritional evaluation of the regional diets and convenience foods were carried. From the 427 households surveyed among the four districts, the commonly consumed 40 regional diets were identified. It was classified as cereal preparations, pulses and legumes preparations, vegetable preparations, roots and tuber preparations, non-vegetarian preparations and milk and sweet preparations. These regional diets were subjected to nutritional evaluation for total iron and zinc content as per the AOAC procedure.

PHASE III:

In vitro bioaccessibility of iron and zinc from regional diets were carried out in this phase. In the present investigation, from the standardized regional diets and convenience foods, bioaccessibility of iron and zinc were assessed by *in vitro* method of Luten *et al* (1996) and by atomic absorption spectrophotometer. The total iron and zinc content of the convenience foods and regional diets were assessed using Atomic Absorption Spectrophotometer.

PHASE IV:

To combat the problem of anaemia, the simplest and the most effective method is food to food fortification. Incorporation of iron rich foods with suitable processing methods would enhance the iron content of a product when all these ingredients are used together in a recipe.

In the present study, a bioavailable ready to eat iron rich food supplement was formulated. Four variations were developed of the food was developed. The ingredients were malted bajra, green gram, roasted Bengal gram, ground nut in the ratio 65:20:10:5 g respectively. This mix formed the standard. In variation 1, 5 per cent shade dried drumstick leaves were incorporated, in variation 2, 10 per cent and in variation 3, 15 per cent shade dried drumstick leaves were added respectively. Ready to eat foods were developed from the four mixes and were

subjected to sensory evaluation, nutritional evaluation, *in vitro* iron and zinc bioaccessibility, shelf life evaluation and costs were calculated.

PHASE V:

For the present study, in order to assess the *in vivo* bioavailability of iron and zinc, adolescent girls in the age group of 16 to 18 years were selected. Prior permission was obtained from the parents to conduct the study. The adolescent girls and the parents were informed about the need for the study by showing them information sheet and consent was obtained from each of them for carrying out the interview as well as the intervention. Based on the inclusion and exclusion criteria, 140 adolescent girls were selected randomly from different areas of Coimbatore district. The personal and socio-economic characters, food habits were studied. For the conduct of intervention studies, 67 adolescent girls were selected, out of which 33 were anaemic and 34 were non anaemic. Sixty seven adolescent girls were divided in to four groups based on heamoglobin level and the interventions received. experimental group I were moderately anaemic (Hb level 7 to 9.9 g/dl) received ready to eat food supplement and nutrition education. experimental group II were also moderately anaemic (Hb level 7 to 9.9g/dl) received nutrition education alone. experimental group III were non - anaemic (Hb level > 11.5g/dl) received ready to eat food supplement and nutrition education. Non anaemic adolescent girls with Hb level >11.5g/dl formed the control group of the study were received nutrition education alone. A ready to eat food in the form of ladoo (50g) made of the variation 1 (consisting of 5g shade dried drumstick leaves powder) was supplemented to experimental group I (moderately anaemic) and experimental group III (Non – anaemic) adolescent girls for a period of 120 days. The ready to eat foods were supplemented weekly in sealed pouches. Nutrition status assessments were done. Biochemical status was done before and after interventions. Knowledge, Attitude and practice of the adolescent girls were assessed before and after nutrition education, Clinical examination was also carried out. After four months of the interventions, the body mass index and the biochemical parameters such as heamoglobin, total iron binding capacity, serum iron, ferritin and zinc was assessed.

PHASE VI:

The data collected was subjected to suitable statistical analysis using the Statistical analysis Package for Social Sciences (SPSS). Descriptive statistics were computed using standard methods like frequencies and percentages for men and women individually. Means and Standard deviations were calculated for all the parameters and were presented in the tables. 't'-test was used to compare hematological parameters between experimental and control groups. $P > 0.05$ was set for significance.

Salient Findings of the Study

The salient findings of the present study entitled "**Bioavailability of iron and zinc from regional diets**" are presented:

PHASE I

- Demographic profile of the households revealed that among the four districts surveyed, majority of the males as well as females were in the age group of 20 to 59 years. Majority of the households belonged to Hindu religion of backward caste. More than 70 per cent of the households of the four districts had nuclear family type with a family size of four members.
- Most of the adult male members were educated up to graduation and a majority were employed in private sector. Most of the adult female members were educated up to higher secondary.
- As per the 11th five year plan, around 40 to 50 per cent of the households of the four districts were from middle income group with income range of Rs.7301 – 14500 /-
- Food habits revealed that out of the 427 households surveyed about 80.33 per cent of the households were non vegetarians.
- Frequency of consumption of food items revealed that among cereals, rice was consumed daily among the households of all the districts, micronutrient rich millets were consumed by minority only. The consumption of fruits, green leafy vegetables and meat were weekly once only.

- During minor diseases, the foods consumed were, rice kanji, dry ginger tea, milk with turmeric, pepper rasam rice while the foods avoided were curd, milk based preparations and fried foods etc.
- One day's diet of the four districts were identified. The food intake of the adolescent girls revealed that consumption of all food groups were lower when compared to RDA (2010).

PHASE II

- In this phase around, 40 commonly consumed regional diets were analysed for iron and zinc content using AOAC procedures. 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.
- 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.
- 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. The iron content of the vegetarian side dishes ranged between 3.4 to 6.5 mg while the zinc content of the diets ranged from 1.7 to 3.6 mg.
- Iron contents 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 contents 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.
- The iron content in roots and tuber preparations ranged between and 1.36 to 4.80g, with highest of 4.80g in vegetable kuruma and the total

zinc content, vegetable kuruma had 2.8 mg/ 100g respectively. The total iron content of non -vegetarian preparations was in the range of 8.15 mg to 3.87 and zinc content was 1.21 to 4.12 mg/ 100 g.

- One day's diet of the adolescent girl was analysed in the lab for total iron and zinc content as per AOAC (2004) procedures. The iron intake met only 60.96 to 65.92 per cent of the RDA. The per cent RDA met for zinc was only 56.54 to 61.36.

PHASE III

- *In vitro* bioaccessibility of iron and zinc from regional diets were carried out by Luten *et al* (1996), the results revealed that the highest iron bioaccessibility was observed in lime rice with 22.38 per cent. Fermented cereal and pulse based products such as dosa and idli also had iron bioaccessibility of 19.05 to 21.05per cent respectively
- 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 per cent respectively.
- Mung bean dhal masial had 10.88 per cent bioavailability whereas spinach kottu and cabbage kottu with 10.59 per cent and 10.1 percent iron bioavailability respectively. The average oxalate content of recipes varied between 0.13 to 5.57 g per cent.
- The total iron content of the three salads namely vegetable salad, vegetable salad with lime and sprouted salad with lime 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. A meal of rice with sambar has an iron content of 5.79 mg/ 100g, and the bioaccessibility of iron was 5.58 per cent dosa with sambar had bioaccessibility of 19 per cent.

PHASE IV

- The nutritional evaluation of formulated ready to eat foods had energy content (calculated) 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/ 100g. Micronutrient contents of the ready to eat foods increased on adding dried drumstick leaves. 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.
- 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. The ready to eat food formulated had iron bioaccessibility ranged between 3.6 per cent to 9.5 per cent and zinc bioaccessibility ranged between 1.42 per cent to 2.12 per cent. Even though, anti-nutritional factors such as phytate and oxalate increased by the incorporation of drumstick leaves.
- The appearance of variation 1 had a 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 ± 0.86 to 1.86 ± 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.

PHASE V

- Around 43.58 per cent of the adolescent girls were in the age of 17 years. 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. Majority 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. 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. On assessment of the BMI revealed that majority of the respondents in the study were having BMI ranging from 18.5 to 23.5 showing that, they are normal. Only 15.78 per cent of the control group and 26.67 per cent of the experimental group III had BMI above 23.5 showing that they are slightly overweight.

- Initially, all the biochemical parameters were less than normal for the anaemic adolescent girls. The mean haemoglobin level ranges from 9.10g/dl in anaemic adolescent girls of experimental group I to 12.12g/dl in the non anaemic adolescent girls of control group. Similarly, the mean serum iron was in the range of 53.11µg/L to 64.26µg/L, mean serum ferritin was 10.33ng/ml to 14.01ng/ml, mean TIBC was 308.84µg/dl to 254.77µg/dl and mean serum zinc was 66.87µg/dl to 77.98µg/dl among the anaemic and non anaemic adolescent girls respectively. The clinical picture of the respondents proved that they were suffering from micronutrient malnutrition.
- The results proved that supplementation of foods rich in bioavailable iron and nutrition education significantly increased the haematological 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 haematological parameters. The increment in haematological parameters of experimental group III who were non anaemic were not significant and the non anaemic control group who received nutrition education were not significant
- After four months, Knowledge attitude and practicescores 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.

Results of the present study supported the strategy of food based intervention which addresses the root causes of iron and zinc deficiency. It also concluded that dietary intervention is at par when compared to the elemental form. The dietary interventions had the advantages of feeding and nourishing the households in both short term and long term resources with suitable processing techniques and locally available resources.

From the foregoing results, it may be concluded that regional diets contribute to iron and zinc in the dietaries of population in Tamil Nadu. Various traditional processing and cooking methods may enhance the availability of iron and zinc in the diet. Further, the impact of dietary intervention using a ready to eat convenience food to anaemic girls improved their iron nutritional status. This proved the promising results of dietary diversification as a long term strategy.

RECOMMENDATIONS FOR FUTURE RESEARCH

- Database generation on nutrient potentials and in vitro bioaccessibility of iron and zinc from the regional diets of Tamil Nadu.
- Compilation of recipes of different regions and standardisation as per cultural practice.
- Phytochemical screening of regional diets.
- Formulation and shelf life evaluation of ready to eat convenience food rich in micronutrients using under exploited foods.
- Studies on regional diet consumption, cultural practice and its relation to immunity and morbidity.
- Long term dietary supplementation of iron and zinc among different segments of population
- Impact of traditional and novel food technology practices on bioavailability of iron and zinc from dietaries.
- In depth studies on dietary diversification using micronutrient rich foods and life style disorders.
- Imparting nutrition education to all masses coupled with raising kitchen gardens or community gardens which would serve as a sustainable strategy to combat micronutrient malnutrition.