EFFECT OF IRON AND VITAMIN SUPPLEMENTATION ON IRON PROFILE OF ANEMIC ADOLESCENT GIRLS

BY

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THESIS

submitted in partial fulfilment of the requirement

for the degree of

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1999

To my beloved teachers

Dr. L. Prema

&

Dr. R.S. Ayer

and

To All who are working seriously

for nutritional development

DECLARATION

I hereby declare that this thesis entitled, **"Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls",** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any associateship, fellowship or other similar title of any other university or society.

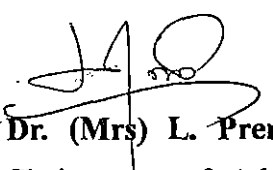
Vellayani

Date : 12-11-1999

KAVITA. M.S

CERTIFICATE

Certified that this thesis entitled, **"Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls",** is a record of research work done independently by Miss. Kavita M.S, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.



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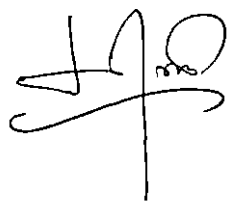

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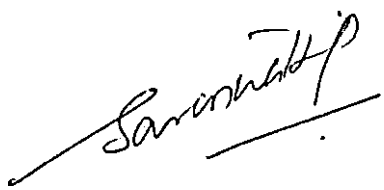

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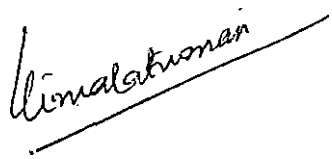

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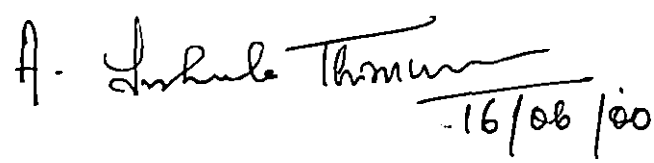

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KAVITA .M.S

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INTRODUCTION

INTRODUCTION

Among the micro nutrients iron has the longest and best described history. Iron is the fourth most abundant terrestrial element, comprising approximately 4.7 per cent of the earth's crust in the form of minerals, haematite, magnetite and siderite. Primordial iron compounds are possibly responsible for the catalytic generation of some of the atmospheric oxygen upon which most modern life forms depend (De Duve, 1990). Iron is an essential nutrient, for all the living organisms, with the exception of certain members of the bacterial genera, *Lactobacillus* and *Bacillus*. In all the other life forms, iron is an essential component of, or co-factor for hundreds of proteins and enzymes.

Despite its abundance in the earth's crust, iron deficiency is a serious health issue, in many parts of the world. Iron deficiency anemia is the most prevalent nutritional deficiency worldwide and over 90 per cent of affected individuals live in developing countries (ACC/SCN, 1997). Calculations using the most recent estimates of anemia prevalence from WHO suggest that 43 per cent of all women and 34 per cent of all men are anemic in developing regions (WHO/UNICEF/UNU, 1999). Estimating trends in anemia prevalence over time remains problematic. This would require representative longitudinal data (ACC/SCN, 1997). Most recent updated estimates on the prevalence of iron deficiency anemia indicated that women of reproductive age, pregnant women and pre school children were the vulnerable groups (ACC/SCN, 1997).

At the World Summit for Children in 1990, there was political commitment to reduce iron deficiency anemia in women of reproductive age to one third of 1990 levels by the end of the decade. Women of reproductive age formed the target group since they need more iron than men because of the super-imposed requirements related to reproduction - menustruation, pregnancy and lactation. During adolescence acceleration of growth, along with sexual maturation imposed increased requirements of iron primarily for the production of haemoglobin. A great majority (nearly 2/3) of the young adolescent girls in the countries of Indian subcontinent are anemic, and the considerable proportion of anemia is of moderate or severe degree (Gopalan, 1992).

There are a number of causes of anemia other than iron deficiency. According to Suharno and Muhilal (1996) deficiency of other micro nutrients, such as vitamin A, B_2 and C and folic acid which involve in the absorption and metabolism of iron in the body, can cause anemia. But this fact was not tested at the field level situation. Also, the prevalence of iron deficiency in relation to adolescent growth spurt and the associated socio economic, health and nutritional factors which underline the root causes of iron deficiency anemia have received little attention. Thus there are fewer models of how to deliver preventive nutrition services to adolescent girls. According to ACC/SCN (1997) there is a critical need to identify and test interventions that effectively reach female adolescents, including the appropriate role of nutrient dense dietary supplements.

The present study entitled, "Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls", is an attempt to reach not only the root causes of anemia in relation to socio economic, health and nutritional variables but also to search out the roles of other micronutrients viz., vitamin A, B_2 and C and folic acid on iron metabolism, iron status indicators and physical endurance.

Major objectives of the present study are:-

1. To assess the magnitude of iron deficiency anemia among adolescent girls.
2. To find out direct and indirect effects of the causative factors and
3. To evaluate the relative effect of supplementation of iron with vitamins on the iron status of anemic adolescent girls.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

There are two major disturbances of iron balance, iron deficiency and iron overload (Thomas,1995). Iron deficiency is the most widespread nutritional deficiency in the world. It affects more than a quarter of world's population (De Maeyer and Adiels,1985). Its victims number in hundreds or millions (Van and de Jong, 1992). Approximately one billion people suffer with iron deficiency anemia (INACG, 1987). Iron deficiency anemia affects principally infants, children and women in fertile age, particularly during pregnancy.

2.1. Prevalence and magnitude of nutritional anemia due to iron deficiency

On a global basis, an estimated 2,150,000,000 persons are anemic or iron deficient with women and children most likely to be affected (WHO, 1992). WHO statistics further indicated a worldwide prevalence of about 30 per cent with even higher figures in developing countries. Young children and pregnant women are the most affected groups, with an estimated global prevalence of 50 per cent each in 1987 (INACG, 1987) and about 40 per cent and 50 per cent respectively in 1989 (INACG, 1989). According to INACG (1985), 30 per cent of the world's population is anemic, with greater prevalence rate in developing countries. Iron deficiency appears to be the cause of anemia in 50 to 60 per cent of this population. While Mac Phail and Bothwell, (1992) have estimated that 1 billion of the world's 5 billion

inhabitants suffer from nutritional iron deficiency anemia. In developing countries iron deficiency anemia is the most common and widespread nutritional problem (WHO, 1993) or public health concern, with the prevalence between 500 to 600 million (Thomas, 1995) and estimated to be responsible for 20 per cent of maternal deaths (Vijayaraghavan, 1994).

Prevalence of iron deficiency may be as high as 60 to 70 per cent in pregnant women in developing countries (Bothwell *et al.*, 1979, Simons and Gurney, 1980). Some survey data are at least 20 years old but current estimates confirm that 60 to 70 per cent of the most vulnerable individuals in some countries are still affected despite 40 years of research (INACG, 1990., Mac Phail and Bothwell, 1992).

It was found that prevalence of mild or moderate anemia among school age girls was 65 per cent while that among pregnant women was 90 percent in India (UN-Subcommittee on nutrition, 1991). Haemoglobin surveys among pregnant women revealed that as many as 87.5 per cent were anemic (Hb < 11g per cent), about 13 per cent were severely anemic (Hb < 7g per cent) and 33.66 per cent were moderately anemic (Hb 7 to 10g per cent) (Vinodini *et al.*, 1993).

Multicentric studies conducted by ICMR showed that anemia is not conjured to pregnant women alone, but affects other segments of the population as well (ICMR, 1989). Prevalence of anemia is higher in rural

than in urban areas (Vinodini *et al.*, 1993). Among this about 95.1 per cent of the rural females from the age group of 15 to 24 years were anemic (Rao *et al.*, 1982).

According to Vijayaraghavan (1995) anemia due to iron deficiency is particularly common in women of the reproductive age group and young children. Surveys conducted by ICMR (1989) on haemoglobin levels of populations in different areas reveal that 88 per cent of pregnant women suffer from anemia and about 26 per cent have severe anemia. Severe anemia in pregnancy is associated with increased risk of maternal mortality causing an estimated 80,000 maternal deaths every year, along with a high incidence of premature delivery, low birth weight, parinatal mortality and foetal wastage (Vijayaraghavan,1995). UN (1991) found that the prevalence of anemia in pregnant women in developing countries is 56 per cent and that in developed countries is 18 per cent.

According to WHO (1992) the prevalence of anemia in pre school children is often similar to or greater than that seen in pregnant women. A great majority (nearly 2/3) of young adolescent girls in the countries of Indian subcontinent are anemic and in the considerable proportion of anemia is of moderate or severe degrees (Gopalan, 1992).

According to Chaturvedi *et al.* (1994) adolescence is a period of rapid growth and development. Adolescent girls are a neglected sector of population in India and are poorly fed members of the family (Akkamaha

Devi *et al.*, 1998). ICN (1992) identified that problems of care for adolescent girls often go unnoticed, yet these girls also constitute a nutritionally vulnerable group in need of care. Kapoor and Aneja (1992) identified, iron deficiency anemia as the major health problem in adolescent girls which indicates the need for iron supplementation along with health education. According to Kanani (1995) 65 to 75 per cent of the underprivileged adolescent girls of 10 to 18 years in India are anemic. Waselien and Steward (1994) was of opinion that poor nutritional status and hence iron deficiency anemia becomes apparent during adolescence with a delay in maturation which may have repercussion for subsequent ability of the biologically immature women to carry out pregnancy. Thus iron deficiency influence future productivity of adolescents primarily through its perment effects on mental development and cognition and later poor reproductive output. As per 1996 data (World Bank, 1996), the economic loss due to iron deficiency anemia in India was 1.27 per cent of GDP or 3761 million US dollars.

2.2. Socio economic factors affecting the magnitude of iron deficiency anemia

Malnutrition is an outcome of poverty. There is increased recognition that child malnutrition indexed by failure to grow is a cause of poverty (Reynaldo, 1996). Failure to grow in childhood, leading to stunted physique that is characteristic of people from many poor countries, is the most visible and widespread manifestation of malnutrition (Beaton *et al.*, 1990).

The determinants of malnutrition operate at household community and national levels, such as some micro-economic forces, identified as influencing the capacity of families and mothers to take care for children, are cash and food resources, that determine the amounts and types of foods used in meal preparation, labour demands and domestic work responsibilities that limit mothers' time to prepare meals and to feed children and, poor living conditions and deficient sanitation that bring on infections. (Pacey and Payne, 1985).

Nutritional stress brought about by disruptions in agricultural production, sharp rises in commodity prices, and/or socio political instability may have a relatively rapid onset, resulting in widespread malnutrition and mortality in a period of just a few months. Information systems that focus on detecting these types of short term problems are referred to as early or timely warning systems (Nancy *et al.*, 1993).

The important causes of iron deficiency are delayed and inadequate supplementation, frequent infections, avoidance of micro-nutrient rich foods due to ignorance as a result of high female illiteracy, poor bioavailability of iron and low purchasing power of the families (Vijayaraghavan, 1994).

The inequity in assets and income distribution among households in a typical community renders some segments of the population more vulnerable to changes in food system variables than others with a deterioration in nutrition

status sooner, perhaps, months or even years earlier than the general population (Nancy *et al.*, 1993). Kelly (1990) found that the highest correlation between cereal prices and nutrition status indicators were found with a time lag of only three months in Ethiopia.

Baker and De Maeyer (1979) found that the segments of population at risk from nutritional anemia are pre-school children and pregnant women. Prevalence of anemia in pregnancy (Hb level below 11g/dl and among girls of low income groups is very high (UNICEF, 1995).

It was found that the women of poor communities are anemic not only at the time of conception but earlier in their adolescence. Data on the haemoglobin status of adolescent girls in urban and rural areas indicated that 7 per cent of the girls in urban and 16 per cent of the girls in rural areas had haemoglobin levels of less than 10 per cent (NFI, 1997).

According to Leela (1990) mean haemoglobin levels of adolescent girls both urban slum and rural poor were not different and the overall incidence of anemia (Hb < 12 per cent) was round 25 per cent irrespective of urban, rural residence status.

Iron defficiency showed an increase with increasing age especially in those attained menarche (Piyasena, 1988). The reported prevalence of anemia in pregnancy ranges from 40 to 50 per cent in urban areas, 50 to 70 per cent in rural areas and nearly 90 per cent in those rural areas where Hookworm infestation is endemic (UNICEF, 1990).

The prevalence of nutritional deficiency conditions such as anemia, under nutrition, dry skin, angular stomatitis and conjuntival xerosis in the 0 to 5 year age group was greater among children of illiterate mothers than in the moderately literate and highly literate groups (Rajammal, 1994). It was also found that morbidity was higher for the children of illiterate mothers compared to those of moderately literate and highly literate mothers (Rajammal, 1994).

Visweswara Rao (1998) indicated an interaction between fertility, mortality and nutritional status with female literacy, income generating responses and health facilities.

Prema and Gouri (1993) revealed that nutrition messages could be integrated successfully into the ongoing functional literacy programmes and such an effort may lead to sustainable results in terms of family nutritional improvement status.

A study among adolescent girls revealed that nutrition education helped the girls to develop correct concepts on nutrition, which is the essential requirement for carry home impact and changes in dietary habits of family members (Varghese, 1993).

The chief immediate causes of malnutrition indexed by growth failure are inadequate child care and attention, inappropriate feeding practices leading to diets deficient in quantity and/or quality and high rates of infection (Beaton

et al., 1990). An underlying cause and fundamental constraint in solving micro-nutrient problem is that non-staple foods, particularly animal products tend to be the foods richest in bioavailable nutrients while the diets of poor consist mostly of staple foods, primarily cereals as sources of micro nutrients (Howarth, 1996).

Women prepare food for home consumption, while they produce much of the food, they eat less than what they need and consequently became malnourished. As for food distribution within the family, men are considered more valuable for economic well being and therefore are given maximum food from family's food basket (Rajammal, 1994).

2.3. Interventions to curb the magnitude of anemia

Interventions to curb iron deficiency anemia need to be mounted to improve iron intake and iron nutritional status in many countries and communities. The major interventions are supplementation, fortification, dietary modification and parasitic disease control (UN, 1991). In the past, most programmes to reduce anemia have been aimed only at women during pregnancy, and have involved mainly medicinal iron supplementation. Interventions including iron fortification of commonly eaten foods, nutrition education other than during pregnancy are all needed (Michael, 1993). In general, strategies have been based on one or more of the elements such as iron supplementation, iron fortification and reduction of iron loss (INACG, 1993).

Most South East Asian countries have introduced a national nutritional anemia control programme that is expected to deliver iron-folic acid tablets to pregnant women from early pregnancy till delivery or beyond (Subadra *et.al.*, 1994). According to INACG (1993) iron supplementation has the potential for producing a rapid improvement in iron status.

Under the national nutritional anemia prohylaxis programme of India, all the children between 6 months and 12 years of age, all pregnant and lactating women and family planning acceptors are to receive iron (60mg) and folic acid (0.5 mg) supplements for a period of 100 days every year (Rameshwar, 1993 and Subadra *et.al*, 1994).

Several intervention studies carried out in pregnant women have shown that supplements of iron and folic acid given for 2 months to 4 months during second half of pregnancy can sufficiently increase the haemoglobin levels and reduce the prevalence of anemia (Sood *et al.*, 1979, Charoenlarp *et al.*, 1988 and ICMR, 1992). Inadequate supply of iron supplements may arise from insufficient budgetary allocations to iron deficiency anemia (IDA) control due to overall governmental resources, low priority for health expenditure within the government, lack of awareness by policy makers of IDA as a problem, lack of knowledge of the prevalence and distribution of IDA, scepticism about the effectiveness of interventions for its control and limited exposure to evidence concerning the benefits of control as reported by United

Nations (1991). ICMR in 1989 showed that the programme had hardly any impact on the pregnant women due to inadequate coverage and/or poor compliance (Schultnik, 1993).

A study from the State of Gujarath, India revealed that at district level, 83 per cent of the target group were judged to be covered by supplement supply; at PHC level this proportion was 67 per cent, at subcentre level 61 per cent and finally at village level only 8 per cent of the target group were covered by the actual supply (United Nations, 1991).

Evaluating the information on nutritional iron deficiency gathered over the last 40 years has led most investigators to conclude that iron fortification of the diet is the only cost effective long term strategy for reducing the prevalence of iron deficiency in most developing countries (Cook and Reusser, 1983., Mac Phail and Bothwell, 1992). In developing countries, approaches to fortification will differ to those adopted in developed countries owing to a lower dietary iron bioavailability and fewer food items centrally processed (United Nations, 1991).

Prerequisites for effective fortification include long term commitment, a bioavailable iron source compatible (not chemically reactive) with suitable food vehicles, that confirms to existing regulations and a suitable food vehicle ie., one that is centrally processed, technologically and economically fortifiable with no change to taste, texture, appearance, acceptance and frequently used

by target or total population, made available through an effective distribution system (UN, 1991).

Food has been fortified with vital nutrients including iron in several Western countries, including United States, Canada, Sweden and the United Kingdom since the early 1940's (INACG, 1993). Other countries that require wheat flour to be fortified with iron include Chile, Denmark, Guiana, Kenya, Zambia and Nigeria (Barret and Ranum, 1985). Food vehicles for fortification included whole and white bread, salt, sugar, 26 per cent fat milk powder, infant formulae, cookies, curry powder, fish sauce, soya sauce and fruit flavoured drinks (United Nations, 1991).

Major cereal foods, wheat flour, corn meal (maize) and rice, lend themselves readily to iron fortification especially in countries where these grains are processed through centralized milling operations (INACG, 1977).

Many cereals and milk powder for infants are routinely fortified with various forms of iron. The bioavailability of such iron is strikingly improved when ascorbic acid is present (A ratio, by weight of at least 1:5 iron to ascorbic acid, is recommended). Many infant foods often contain ingredients such as barley flour, eggs and bananas which are known to discolor in the presence of certain iron salts (Sayers *et al.*, 1973).

In many countries, sugar appears to be suitable for iron fortification. But a major disadvantage to adding ionizable salts to sugar is the precipitation of tannins in tea (Disler *et al.*, 1975 and Layrisse *et al.*, 1976).

Crude cooking salts widely used in developing countries can be successfully fortified with ferric orthophosphate together with sodium hydrogen sulphate (NIN, 1973) or ascorbic acid (Sayers *et al.*, 1974).

One of the low cost and easy to adopt interventions to reduce the prevalence of anemia is dietary modification. Modifying people's diets may involve imparting new knowledge and changing attitudes and practices of individuals, especially behavioural modification. The three recommended modifications are increasing the intake of haemoglobin iron, usually from meat although this may not be economically / culturally acceptable, increasing the intake of vitamin C, along with foods which promote iron absorption (eg., acidic and fermented foods) and reducing the intake of inhibitors of iron absorption (eg., tannins in legumes, coffee and tea phytates in some cereals and polyphenols) (UN, 1991).

Two main strategies for reducing anemia prevalence are de-parasitisation (in general) and the reduction in the prevalence of hookworm infestation in particular. Hookworm infestation is a significant contributor to iron deficiency among certain populations. Two main recommendations to break its transmission are to keep faeces out of soil and to keep skin from contact with the soil (UN, 1991).

Concerning the overall effect of general infections on iron status, diarrhoea, per se does not impair iron absorption, although repeated or chronic infections can impair iron utilization. So any intervention to curb the prevalence

of nutritional anemia should also be aimed to improve the general health status of the individual (UN, 1991).

2.4. Aetiology of anemia

Major aetilogical features of iron deficiency are iron losses such as basal iron losses, menstrual losses, losses due to pregnancy and lactation, pathologic blood losses and inadequate absorption of iron from the diet. If adequate nutrition is to be maintained the amounts absorbed from the diet must at least match the average daily losses from the body. In normal women, these losses can be divided into the basal obligatory iron excretion and those extra losses incurred as a result of menstruation, pregnancy and lactation (INACG, 1981).

In normal men the daily loss is less than 0.1mg in the urine, 0.2 to 0.3 mg from the skin and 0.6 mg in the faeces. Only about 0.14 mg daily of the iron lost in the faeces is derived from bile and desquamated epithelial cells. Since the haemoglobin content of erythrocytes makes intestinal blood loss much more significant, it is apparent that any increase in the amount of blood loss have a profound effect on iron balance (Green *et.al.*, 1968).

Excess menstrual blood losses have been estimated as a cause of iron deficiency anemia with wide variation in the iron loss but with least individual variation (Hytten *et al.*,1964).

Menustrual blood loss is reported to have positive correlations with parity and with body size. The heavy loss is attributed to endometrial abnormalities or fibroids as reported by Rybo (1973) in 40 per cent of women studied.

Modern contraceptive practices are also observed to reduce significantly menustrual blood losses even to 12.7ml level (Cole *et al.*, 1971) but increased to an average of over 50ml, when intra uterine devices are used (Guillebaud *et al.* 1976).

During pregnancy there is a continuous drain of iron and this is greater in teenage mothers due to natural increase in blood volume. With each pregnancy and child birth, the iron loss is reported to enhance along with lactation loss (Antia, 1989).

Basal iron losses in women can be affected by a number of pathologic conditions, in the gastrointestinal tract, and by hookworm infestation (Miller, 1979). Frequent blood donation produces iron deficiency in woman unless adequate iron supplements are administered (Bernard *et al.*, 1967).

Poor absorption of iron from the diet is one of the causes of anemia. The behaviour of the intestinal mucosa, the amount of iron ingested and its bioavailability determine the amount of iron absorbed from the diet (INACG, 1981). In countries such as India, Haiti, West Pakistan and Bangladesh, malabsorption of iron associated with bowel disease is common (Russel *et al.*, 1966)

Pica or eating of non-food material may lead to iron deficiency depending on the substance consumed. (Fairbanks *et al.*, 1971) Pica has been recognised in many parts of the world including India (Halsted, 1968). It has been observed by him in both sexes and is most prevalent among pregnant women from lower socio economic strata.

2.5. Absorbtion of iron from foods

Iron deficiency is the result of inadequate absorption owing to the body's inability to extract all the iron needed from many foods, while meals with a large meat component are excellent sources of iron, many cereal and vegetable foods contain large quantities of phytate, polyphenols and other constituents that bind iron, rendering it unavailable for absorption (Antia, 1989., INACG, 1993). According to Narasingha Rao *et al.*, (1983) iron absorption from Indian diets based on cereals and millets is quite low, the absorption being highest from rice based diets and lowest from diets based on millets like ragi. For an adult male, iron absorption is 5 from rice, 2 from wheat and millets and 3 per cent from mixed cereal diets. For recommending dietary intake of iron, an average figure of 3 for absorption from mixed cereal diets is used (ICMR 1992).

According to Hurrell (1990) the food components responsible for the inhibitory effect of cereals are thought to be phytate, dietary fibre, polyphenol and saponins. Phytate and protein are observed to play a similar role in soya; calcium, phosphorus and protein in cow's milk; and polyphenols in tea.

Iron enters the body as heme and non-heme iron (Hallberg, 1981). Heme iron, derived primarily from haemoglobin and myoglobin in meat, is transferred to the intestinal cells as the intact porphyrin complex, from which iron is released by heme oxygenase. According to Charlton and Bothwell (1983) heme iron is virtually always well absorbed (20 to 25 per cent) and is little affected by other elements of the meal in which it is eaten.

The non-heme iron has a heterogenous origin, being derived from vegetable foods, inorganic contaminant iron, meat, iron that is not in the form of heme and inorganic iron fortificants added to the diet. The absorption of iron from all these sources requires prior solubilization in the lumen of the upper gastro intestinal tract (Monsen, 1988). Non-heme iron absorption is strongly influenced by the composition of the diet. Some foods such as cereals, soya, cow's milk and tea inhibit iron absorption, where as others such as fruits, some vegetables and meat enhance it (Hurrel, 1990).

Iron absorption mainly takes place in duodenum and upper jejunum which promotes iron absorption during iron deficiency (Schumann *et al.*, 1990). According to Conrad *et al.* (1994), surgical removal of any part of duodenum and upper jejunum or the presence of factors that increase erythrocyte turnover, decreases iron absorption and also malabsortion syndrome such as steatorrhoea and tropical sprue while hypoxia is observed to increase iron absorption independently of erythropoiesis (Raja *et al.*, 1988)

The amount of iron absorbed depends on mucosal behaviour in the intestinal wall and on the presence of ligands in the meal, which either promote or depress iron absorption from the pool. Ascorbic acid and animal tissues act as promoters while polyphenols, phytate, calcium and protein act as inhibitors of iron absorption (Cook, 1990). Hallberg *et al.* (1991) has observed that one consequence of consuming more calcium especially at mealtime or with multivitamin or mineral supplements, is an inhibition, approximately by half, of iron absorption.

Bioavailability is dependent both on the amount of meat or heme iron in the diet and on the balance between promoters of non-heme iron absorption (ascorbic acid and meat) and iron inhibitors (phytate, polyphenoles etc) (Thomas, 1995). Of the fortificants available, iron EDTA is most resistant to common inhibitors, except polyphenols in tea, bush teas and coffee. Hence consuming these beverages along with meals is observed to inhibit severely the absorption of iron present in any form (Richard, 1990).

The two major factors that affect iron absorption are the size of iron stores and the rate of erythropoiesis (Bothwell *et al.*, 1988). Baynes *et al.* (1987) has observed slow rise in absorption, as stores decline from high levels to lower levels and a steep rise in absorption when depletion is reached.

At physiologic levels iron uptake is reported to be mediated by a series of receptors and binding proteins. In this manner, heme iron is also

processed in a manner analogous to non-heme iron and transferred to binding proteins within the lumen (John *et al.*, 1996). Stremmel *et al.* (1987) had observed specific transporters for non-heme iron binding proteins on the luminal surface of erythrocytes.

Heme is soluble in an alkaline environment. Hence no binding proteins are necessary for its luminal absorption (John *et al.*, 1996). After entering the cell, heme is degraded to iron, carbon monoxide and bilirubin IXA by the enzyme hemoxygenase. This enzyme is not induced by iron deficiency and its distribution in the intestine is identical to the areas of maximal heme iron absorption (Rosenberg and Kappas, 1989).

2.6. Biochemical transport of iron in the living pool and storage and factors associated

Transferrin, the most significant iron transport molecule, is found to be responsible for the delivery of iron from the basolateral surface of enterocytes to peripheral tissues, but it is also responsible for redistribution of iron to various body compartments and protection of iron from glomerular filteration (John *et al.*, 1996).

Transferrin is reported to be identified in a family of proteins viz., ovotransferrin, lacto transferrin (P97 antigen) and a newly described protein hemiferrin (Stallard *et al.*, 1991).

Transport of absorbed iron through the enterocytes may also involve a transferrin like protein such as mobilferrin. It is a homologue of calreticulin and can also bind Ca, Cu and Zn (Conrad *et al.*, 1993). It has been proposed that ceruloplasmin is the protein responsible for oxidation of iron, which is necessary for its binding to transferrin at the basolateral membrane (Wollenberg *et al.*, 1990).

Iron that is not transferred to the plasma is stored either as ferrition or lost when the enterocyte disintegrates (John *et al.*, 1996) or as hemosiderin in liver, spleen and bone marrow as reported by Peter (1981).

Peter (1981) has also reported that the total amount of iron in the body, is about 3.5 mg per kilograms of body weight and 70 per cent of this is contained in haemoglobin and is influenced by age and gender as observed by Hunt and Groff (1990). Selden *et al.*, (1980) had stated that accumulation of hemosiderin in the liver is at 10 times the rate of ferritin. As reported by Peter (1981),they constitute a reserve for the production of haemoglobin and other iron compounds that serve physiologic functions. Cook and Skine (1982) have stated that, theoretically upto 4500 ferric atoms can be stored in ferritin, even though ferritin with less iron content (1200 to 1400 molecules) was observed to be the most efficient in the acquisition or release of iron and they further observed that generally *in vivo* ferritin is found to be only 20 per cent saturated with (800 out of 4500) iron sites. A study on the structure and composition of the mineralized core has revealed that it is analogous to

a polymer of ferrhydrite ($5Fe_2O_3$. $9H_2O$) with a variable amount of phosphate (Crichton and Ward, 1992).

Ferric iron core formation was further explained by Crichton and Ward (1992). According to them, ferrous iron enters the protein through specific channels and iron is oxidised either at various sites within the protein or on the core surface. De Silva and Aust (1992) had found that ceruloplasmin is responsible for iron oxidation and subsequent incorporation into ferritin.

Iron is rapidly released from ferritin by reduction of the iron core. The identity of the reductant is unknown however *in vitro* studies of iron oxidation sometimes use ascorbic acid to mobilize iron from iron loaded ferritin (Herbert *et al.*, 1996).

Ferritin is degraded by lysosomal proteases to form hemosiderin, an insoluble iron storage protein. In this process, the protein shell of ferritin is particularly degraded so that upto 40 per cent of the mass of hemosiderin consists of iron (Weir *et al.*, 1984). The type of iron stored in hemosiderin is observed to depend on the sources and conditions under which it was obtained. These forms of iron include amorphous ferric oxide, ferrhydrite and goethite which are less chemically reactive than those found in ferritin and may be less available for mobilization (Crichton and Ward, 1992).

Most cellular iron acquisition occurs via transferrin uptake through transferrin receptor which is a glycoprotein (Jing and Trowbridge, 1987).

Therefore, the regulation of cellular iron uptake is mediated by altering the number of transferrin receptors present on the cell surface. Their number can be increased either by immediate translocation of cytoplamic receptors to the surface or by *de novo* synthesis (Young *et al.*, 1984). The number of receptors present in the cell surface is a function of intracellular iron status, cell proliferative status and metabolic need such as production of haemoglobin and myoglobin (Iacopetta *et al.*, 1982).

After iron is removed from transferrin (Tf), the iron containing portion of the endosome separates from the compartment containing Transferrin Receptor (TfR) complex as observed by Richardson and Baker in 1992. Iron in the endosomal compartment is found to be transported across the membranes to the cytosol where it appears either to enter a pool of low molecular weight iron chelates or attach to an intracellular iron binding protein (Richardson and Baker, 1992). The participation of protein pump (H^+-ATPase) in the transport of iron from the endosome to cytosol was observed by Li *et al.* (1994).

The endosomal portion containing the TfR - apo - Tf complex travels to the Golgi apparatus, where it is packaged along with newly synthesized receptors and is translocated to the cell surface (Pan and Johnstone, 1984). As observed by Chitambar *et al.* (1991), the complete cycling of TfR to Tf occurs in about 10 minutes and can occur repeatedly about 100 times before either Tf or TfR is degraded.

2.7. Effects of vitamin A, B_2, folic acid and C on iron metabolism

Vitamin A and its derivatives are important not only for normal functioning of the eye but also for normal differentiation of several tissues (Martin *et al.*, 1989). Retinol and retinoic acid have different actions on bone cells in culture, suggesting that both have functions in normal bone development. Retinol inhibits collagen synthesis, while retinoic acid stimulates the synthesis of non-collagen bone proteins (Dickson *et al.*, 1989). Blackley *et al.*, (1991), found that vitamin A is involved in the regulation of iron transport from the liver.

According to Martin *et al.*, (1989), vitamin A deficient subjects showed a reduction in haemopoietic cells in the bone marrow and have evidenced hemosiderosis in the liver and spleen. They further reported anemia, in man and animals, deprived of vitamin A.

Vitamin A deficiency and anemia often co-exist and there are significant associations between serum retinol and biochemical indicators of iron status (Mejia and Arroyave, 1982). As indicated in intervention trials in vitamin A deficiency endemic areas, a direct association between vitamin A supplementation and increased blood haemoglobin levels observed. (Suhano *et al.*, 1993). However the mechanisms by which vitamin A influences iron metabolism are still unclear (Annet *et al.*, 1995).

Riboflavin deficiency is associated with hypochromic anemia as the result of secondary iron deficiency. The absorption of iron is impaired in

riboflavin deficient animals, with a greater proportion of a test dose retained in the intestinal mucosal cells bound to ferritin, and hence lost in the faeces, rather than being absorbed (David, 1992).

The mobilisation of iron bound to ferritin in either intestinal mucosal cells or the liver, for transfer to transferrin, requires oxidation of Fe^{2+} to Fe^{3+}, a reaction catalyzed by NAD - riboflavin phosphate oxidoreductase (Adelakan and Thurnham, 1986).

In developing countries, where iron deficiency is widespread, folate and Vitamin B_{12} deficiency do not manifest, inspite of their low intakes presumably due to reduced requirement of these two vitamins in iron deficiency (Narasingha Rao, 1993).

Serum folate below 7 nmol/l or erythrocyte folate below 320 nmol/l indicates negative folate balance and early depletion of body reserves. At this stage the first changes in bone marrow are detectable (Bailey, 1990). A decrease in haemoglobin concentration and an increase in plasma ferritin concentration were observed in vitamin B_{12} and folic acid deficiency (Leggett *et al.*, 1990)

Folic acid deficiency, if prolonged and severe leads to abnormal haemopoiesis leading to megaloblastic anemia which readily responds to the administration of the vitamin (ICMR, 1992). Iron deficiency anemia may mask megaloblastic anemia.

According to Colman (1981), erythrocyte folate levels are used as an index of prolonged folate deficiency and of depleted body reserves of vitamin. Folate deficiency is observed to occur frequently in non-pregnant, pregnant and lactating women (Anderson and Talbot, 1981).

Vitamin C (Ascorbic acid) is one of the factors that enhance iron absorption (Nirmala *et al.*,1985).

Non-haem iron is absorbed as Fe^{2+} and ascorbic acid in the intestinal lumen maintains the iron in reduced state but chelates it to increase absorption (Bender, 1982). According to Hallberg (1981) ascorbic acid has a dose-related enhancing effect on non-heam iron absoption. A dose of 25 mg of Vitamin C taken together with a semisynthetic meal is found to increase the absorption of iron to 65 per cent and 1g dose resulted in nine fold increase in absorption. However, as noted by Bender (1982) neither intravenous administration of vitamin C nor supplements several hours before the test meal has any effect on iron absorption. The same effect on iron absorption was observed by Brise and Hallberg, in 1962, in foods with endogenous vitamin C. Nirmala *et al.*, (1985), have also reported that meat extract and ascorbic acid increase the absolute available iron of foods. However the overall effect depends on the interplay between ascorbic acid and inhibitory factors present in the diet (Thomas, 1995). Similar observations were made by Cook *et al.*, (1991) in a two year study among normal volunteers when large doses of ascorbic acid in meals had no effect on serum ferritin, probably because of inhibitory factors.

Ascorbate is also active in the reduction of Fe^{3+} in the plasma transport protein, transferrin to Fe^{2+} for storage in ferritin in the liver or haem synthesis. (Mazur *et al.*, 1960)

2.8. Iron status indicators

Over and above the biochemical variables, Ferguson et al. (1992), had observed that the methods of iron status assay may vary considerably in their sensitivity and selectivity. The choice of the iron status indicators and their methods of assay depends on the purpose of the survey, the degree of iron deficiency in the population, the anticipated occurence of non-nutritional causes of anemia such as malaria or sickle cell anemia, the type of environment and facilities available to the investigator. Because of economic constraints which exist in many developing countries, preference has been given to mannual and techniques that do not require complex and costly instrumentation (James *et al.*, 1985).

The assessment of iron status has traditionally centred around quantitative measurements of the concentrations of circulating red cells and haemoglobin because they are the only means of detecting anemia associated with serum iron deficiency (James *et al.* 1985).

Usually a battery of measurements, rather than a single diagnostic measure, are important to assess iron status. These include. serum ferritin, erythrocyte sedimentation rate (ESR), mean corpuscular volume, transferrin

saturation and serum transferrin receptor concentration (Inelmen *et al.*, 1994). Besides these methods, Herbert (1987) has further suggested dietary intake, haematocrit, haemoglobin (Hb), mean cellular Hb, erythrocyte mean index, free erythrocyte porphyrin, bone marrow iron stain, serum iron and total iron binding capacity, as methods to assess iron status.

National Health and Nutrition Examination Surveys (NHANES) and Hispanic Health and Nutrition Examinations Surveys of USA were utilising certain hematological variables, such as, red cell count, mean cell haemoglobin concentration and red cell distribution width additionally to indicate iron status (Anne *et al.*, 1995). Among these variables, Hb and hematocrit were observed to give significant false positive indications as indices of iron status (Borel *et al.*,1991).

Haemoglobin concentrations are observed to alter in/by polycythemia, dehydration, cigarette smoking, chronic inflammation, chronic infection, hemorrhage, protein energy malnutrition, Vitamin B_{12} deficiency, folic acid deficiency, hemoglobinopathies and pregnancy, as reported by Gibson (1991).

Hematocrit or packed cell volume is a measure of the ratio of the volume occupied by red cells to the volume of whole blood in a sample of capillary or venous blood (James *et al.*, 1985).

A long term negative iron balance eventually leads to a depletion of the storage iron pool, leading to dramatic declines in plasma ferritin

concentrations. The most realistic tool to date in a non-clinical setting for assessment of the size of the storage pool is the measurement of serum or plasma ferritin concentrations (Macaron and Macaron, 1985).

In iron deficiency anemia, serum ferritin concentrations are less than 12 mg/litre while in both transfusional and hereditary forms of iron overload, values of several thousand mg/litre may be seen. Elevated ferritin concentrations also occur in liver disease, malignancy and infections, but in these conditions, the serum ferritin concentration may not accurately reflect the level of storage iron (Worwood, 1980).

Once storage iron pool is depleted due to a prolonged or acute negative iron balance, there is a decline in the transferrin saturation (Hueberts and Finch, 1984). People in this stage of iron depletion have a transferrin saturation below 15 to 16 per cent (Siimes *et al.*, 1980).

The measurement of transferrin receptor concentration in plasma has diagnostic value for the assessment of iron deficiency anemia and ineffective erythropoiesis. (Thorstensen and Romslo,1993). It is a new measure that reflects the iron status and the rate of erythropoiesis in adults (Beguin *et al.*, 1993).

According to Skikne *et al.* (1990), tissue iron requirements are more important determinants of the serum transferrin receptor levels than increases in erythropoiesis.

Plasma transferrin concentrations increase even in mild iron deficiency of recent onset (Carriaga *et al.*, 1991). The amount of the receptor increases

soon after signs of iron deficiency appear, the rise reflecting the paucity of available tissue iron. In advanced iron deficiency, the mean serum tranferrin receptor concentration increases to approximately three times the normal mean (Ferguson *et al.*, 1992). The plasma concentration of transferrin receptor is also increased in b-thalassemia autoimmune hemosis, HbH disease, polycythemia vera, secondary polycythemia, myelofibrosis and chronic lymphocytic leukemia (Cook *et al.*, 1993). The plasma transferrin concentration is decreased in hemochromatosis, aplastic anemia - bone marrow ablation, post transplantation anemia and chronic renal failure. (Beguin, 1992).

Erythyocyte protoporphyrin accumulates in increased amounts in red blood cells when there is insufficient iron available to combine with protoporphyrin to form heme. Erythrocyte protoporphyrin is elevated in iron deficiency and also in cases of lead poisoning. Thus, it has been used to screen infants and young children in urban and low income areas where both conditions are common (Centre for Disease Control, 1985).

2.9. Deleterious effects of iron deficiency anemia

All the available evidence indicates that both severe and mild forms of iron deficiency are associated with several deleterious effects in man (Narasingha Rao, 1981).

The important physical manifestations of iron deficiency are glossitis, angular stomatitis, koilonychia (spoon nails), blue sclera, oesophageal webbing and anemia (John *et al.*, 1997).

The overt physiologic manifestations of iron deficiency are noted in immune function, cognitive performance and behaviour, thermoregulatory performance, energy metabolism and exercise or work performance (Dallman, 1986). With a few exceptions depletion of iron pool is generally without influence on physiologic function (Tucker *et al.*, 1982). Iron deficiency also produce histological changes in various tissues such as oral and pharyngeal mucosae and the nails. Widespread ultrastructural abnormalities also occur in the mitochondria of a number of different body cells (Baker, 1978).

Iron needs increase significantly during pregnancy because of growth of foetus and placenta and expansion of the mothers blood volume. Women frequently enter pregnancy with inadequate iron stores, and thus the increased demands associated with pregnancy result in anemia and severe anemia is associated with an increased risk of primature delivery and increased foetal and maternal morbidity. Milder degrees of anemia may also be detrimental and have been shown to be associated with premature delivery, lower birth weight, placental hypertrophy and increased maternal estiol excretion (Baker, 1978). In a report published by INACG (1989), association of maternal anemia with low birth weight subsequent infant morbidity and mortality and increased parinatal mortality has been stated. According to Levin *et al.* (1993), anemic women bled more during delivery and are less able to cope with severe blood loss.

Anemic women are less tolerant of blood loss at delivery, particularly when haemoglobin levels fall below 8.0 g/dl. Circulatory decompensation

becomes apparent in severe cases of anemia. Women experiences breathlessness and increased cardiac output at rest and even a blood loss of 100 ml can cause circulatory shock and maternal death (Charlton and Bothwell, 1981).

Growth failure is most commonly used indicator of child nutrition (Reynaldo, 1996). It was found that by oral iron supplementation, anemic, underweight children improved their weight, appetite and psychomotor and mental development (Idjradinata and Pollitt, 1993).

Impact of iron deficiency anemia on growth rate and appetite depressions has also been shown through carefully controlled animal studies of rats, pigs and bovines (Reddy *et al.*, 1987).

Studies on iron deficient childern had found that anemia leads to impaired learning (Lozoff *et al.*, 1991), apathy, irritability, difficulty in concentrating and impairment in psychomotor and mental development as well as in academic achievement (INACG, 1987). Iron deficient infants treated with iron were observed to improve their performance on scales of mental and motor development after iron treatment (Aukett *et al.*, 1986).

Studies conducted by Ernesto (1991) on anemic children, indicated that they, did not learn concepts of identity and differences nor perform as well at school as children with repleted iron stores.

Sheard (1994) found that, iron deficiency anemia in infants causes developmental delays and the effects of iron deficiency anemia on mental and

motor performance in this age group are completely reversible with adequate iron treatment.

In iron deficiency decreased resistance to infections has been reported which may be related to diminished function of the immune system (INACG, 1987 and 1989).

Anemia with haemoglobin concentrations below 11 g/dl is observed to be associated with decreased work capacity (INACG, 1989). Similar findings were reported by Baker (1978), who found that mild anemia and possibly even iron deficiency in the absence of anemia can reduce the maximum level of work. He has further observed that, severe anemia limits the oxygen carrying capacity of the blood which in turn limit the work output.

According to Vijayalakshmi *et al.*, (1987), anemia and work output are inversely related and that iron supplementation may conserve energy, as a result the work output is increased after supplementation. Tucker *et al.*, (1982), have noted correlations between electroencephalogram asymmetry (a central nervous system abnormality) and plasma ferritin within the iron adequate range.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study entitled, "Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls", comprises a documentation of systematic investigations on a macrosample of 225 anemic adolescent females and on a micro sample of 35 moderately anemic (Hb 7-10 g/dl) adolescent females. The materials and methods used in this study are presented under:

3.1. Locale of the experiment

3.2. Selection of subjects

3.3. Investigations on macro sample (n=225)

3.4. Investigations on micro sample (n=35)

3.5. Tools formulated for the experiments

3.6. Mode of data collection

3.7. Conduct of the study and

3.8. Analysis of collected data

3.1. Locale of the experiment

The locale of the experiment was limited to Neyyattinkara, Nedumangadu and Trivandrum Taluks of Trivandrum district of Kerala state, India, since indepth metabolic experiments need constant and frequent contacts with the subjects.

3.2. Selection of subjects

Two hundred and twenty five adolescent females suffering from iron deficiency anemia (with haemoglobin level of $\leq$ 12 g/dl) formed the

macrosample for the study. They were identified from a population of 462 adolescent females through physical examination and rapid assessment technique of hemoglobin level by using Sahli's haemoglobinometre.

For the detailed metabolic experiment, to assess the effect of iron and vitamin supplementation, a micro sample of 35 adolescent females were selected based on the following criteria:

a. Females from the age group of 12 to 18 years

b. Those who are healthy but moderately anemic (Hb7-10 g/dl) and

c. Residents of boardings where uniform food is cooked and served.

3.3. Investigations on macro sample (n = 225)

Investigations on macro sample comprised of:

a. A haemoglobin survey to ascertain the prevalence and magnitude of iron deficiency among adolescent females of 12 to 18 years of age.

b. A socio economic, nutritrional and health survey to identify the variables responsible for the development of anemia.

c. A 24 hour recall survey to ascertain the actual food intake of the respondents.

d. Anthropometric and clinical tests to assess the general nutritional profile of the respondents.

3.4. Investigations on micro sample (n = 35)

Investigations on micro sample comprised of a metabolic experiment of two months duration. Thirty five adolescent females, selected, for the experiment were classified into 7 groups of five females each, in order to find out the influence of selected nutrients viz., Vitamin A, B_2 and C on their iron profile. Following battery of treatments were administered on the selected subjects to reach the above objective:

Treatments	Particulars
T_0 (control)	Basal diet (BD) alone
T_1	BD + 60mg Fe + 500µg folifer
T_2	BD + 60mg Fe + 500µg folifer + 600µg equivalent vitamin A
T_3	BD + 60mg Fe + 500µg folifer + 1.2mg equivalent vitamin B_2
T_4	BD + 60mg Fe + 500µg folifer + 40mg equivalent vitamin C
T_5	BD + 60mg Fe + 500µg folifer + 600µg equivalent vitamin A + 1.2mg equivalent vitamin B_2 + 40mg equivalent vitamin C.
T_6	BD + supplementary foods rich in iron, folate, vitamin A, B_2 and C

Since it was evident that the primary nutritional macrocytic anemia is due to folic acid deficiency eventhough iron deficiency may also be associated with the condition, RDA of folic acid (500µg) for adolescents were also supplied along with each treatment. It was assured that the iron rich supplementary food given was contained adequate amounts of folic acid.

Two institutions were selected for the metabolic experiment and the cyclic menu of these institutions were made uniform, with reference to food constituents and methods of preparation and nutrient content during the experimental period, to form the basal diet. The vegetarian basal diet was expected to meet the RDA of nutrients for adolescent girls. Inclusion of vitamins in the diet was ensured by administering vitamins in tablet forms along with the basal diet.

Bioavailability of iron from the basal diet as well as from the supplementary food, was done by using *in vitro* technique of Rao and Prabhavati (1978). For this the food was digested first at gastric pH (1-2) in the presence of pepsin followed by incubation at pH 7.5, centrifugation, filtration and assay of total iron using thiocyanate method (Wong, 1928).

Further investigations done on the micro sample were:

a. Composition of diets consumed by the subjects before the experiment
b. Nutritional status of the subjects
c. Pre and post experimental haematological profile of the subjects with reference to iron and

d. Pre and post experimental physical endurance and work capacity of the subjects.

3.5. Tools formulated for the experiments

Internationally accepted tools based an earlier studies (Karuna, 1993., Sujatha, 1990., Suja, 1989) were selected for data collection in the present study.

3.5.1. Tools selected for data collection from macro sample

a. Questionnaire

Oral questionnaire method was used to conduct surveys among the anemic adolescent females to find out the socio economic, health and nutritional variables responsible for the development of anemia.

Schedules, formulated had appropriate questions for obtaining required data relating to the various possible socio economic, nutritional and health variables that reported to affect the incidence of anemia in the respondents, as evidenced from relevant literature. Interview schedule thus formulated was circulated among a group of experts and necessary modifications were made to avoid ambiguity and redundance in the questions in the schedules.

b. Teacher type test

In order to asses the knowledge of the respondents about anemia, teacher type test was administered. For this, a total of 100 statements on

various aspects of nutritional anemia were prepared from relevant literature. These statements were edited for the subject content and circulated among the experts. According to the scores obtained, highly ranked fifty five statements were selected statistically by their frequency of distribution. These statements, were a mixture of positive and negative statements, and were pretested among a group of non-respondent women population (n=20) prior to administration and most reliable 33 statements which were correctly identified by the non-respondent population were selected.

Each statement was provided with two response categories namely, "True" or "False" with a score of `2' for correct answer and `1' for wrong answer. The scores were added up to get the score for each respondent. The maximum score for the test developed was 66.

The Schedules formulated for the above prescribed data collection their score sheets are presented in Appendices I to V, as listed below:

i. Schedule to elicit information on the social status of the families (Appendix I)

ii. Schedule to assess the knowledge of the respondents regarding anemia(Appendix II)

iii. Schedule to ascertain economic status of the families of the respondents (Appendix III)

iv. Schedule to elicit information on the nutritional variables leading to anemia (Appendix IV) and

v. Schedule to elicit information on health variables responsible for the development of anemia (Appendix V).

c. Twenty four hour dietary recall survey

Twenty four hour dietary recall method was used to estimate the respondents' daily dietary intake. Schedule for 24 hour dietary recall survey is given, along with the schedule to elicit information on nutritional variables responsible for the incidence of anemia, in Appendix IV.

d. Anthropometry

Major anthropometric measurements elicited in the study are:

i. Height or length

ii. Weight

iii. Mid Upper Arm Circumference (MUAC)

iv. Arm Muscle Circumference (AMC) by using a Tanner - Holtain Caliper

v. Waist and hip

Schedule used to assess anthropometric measurements is presented, along with the schedule to elicit information on the health variables responsible for the incidence of anemia, in Appendix V.

e. Clinical examination

Clinical examination of the respondents were conducted with the help of qualified medical practitioners to estimate changes, that can be seen or felt

in superficial epithelial tissues viz., skin, eyes, hair, bucal mucosa or in organs near the surface of the body as detailed by Whitehead (1965).

The schedule for recording clinical signs is given, along with the schedule to elicit information on the nutritional variables responsible for the development of anemia, in Appendix IV.

In order to find out the grade of anemic condition in respondents, hemoglobin level was tested by rapid assessment method.

3.5.2. *Tools formulated for micro sample (n=35)*

a. Food weighment method

Food weighment method was administered to ascertain the actual quantity of food consumed by each subject in a day, using the schedule presented in Appendix VI.

b. Physical endurance tests

Physical endurance and work capacity of the respondents was tested at the beginning and at the end of the metabolic experiment. For this, aerobic (cardiovascular endurance) and anaerobic (muscle endurance) fitness were assessed by Sharkey's Forestry step tests (Sharkey, 1977).

The equipments used for Forestry step test are given in Table.1

Table 1. Equipments used for Forestry step test

Physical endurance parameters	Instruments used
Basic data	
Weight (kg)	Platform scale
Height (cm/or m)	Wall measure
Ergometric	
Step Ergometre (cm/or m)	Step of height 33cm (13")
Timing	
Minutes: Seconds (min:sec.s)	Stop watch
Metronome	Audio recording of candence

Details of the conduct of the test for aerobic fitness are presented from plate I to IV. To ascertain aerobic fitness the pre and post test pulse rate for 15 Sec.s were recorded and the non-adjusted value of maximal oxygen consumption or aerobic fitness was found out from the standard tables evolved by Sharkey (1984).

Details of the conduct of the test for anaerobic fitness are given in plates V and VI. Measurements taken during the anaerobic fitness test were the weight of the subject, number of steps taken and the timing of the test.

Plate 1. Step I of aerobic fitness test

Plate 2. Step II of aerobic fitness test

Plate 3 Step III of aerobic fitness test

Plate 4. Step IV of aerobic fitness test

Plate 5. Step I of anaerobic fitness test

Plate 6 Step II of anaerobic fitness test

The Anaerobic power (Anp) was calculated by using the formula:

$$\text{Anp (watts)} = \frac{[(FxD)/t] \times 1.33}{6.12} \quad \text{Watts}$$

where, Anp = Anaerobic power

F = Force, the weight of the subject in kg

D = 0.33m x Number of steps taken per minute

t = 1 minute

c. Iron profile determination

Table 2 gives the details regarding the variables used to assess the iron profile of the subjects before and after the metabolic experiment, by using internationally accepted analytical methods.

Table 2. Variables used to assess the iron profile of the subjects

Variables	Reference for analytical method
PCV	-
RBC Count	-
Haemoglobin	ICSH, 1967
Serum Iron	Ramsay, 1957
TIBC	Ramsay, 1975
Serum Feritin	Worwood, 1980

3.6. Mode of the data collection

Interview method was selected in the study, for collecting details regarding socio economic characteristics and nutritional and health variables responsible for the incidence of anemia, using suitably structured schedules. Same method was also administrated for dietary assessments, anthropometic and clinical studies and also to assess the knowledge of the respondents regarding anemia.

3.7. Conduct of the study

3.7.1. *Conduct of the survey (n = 225)*

As a preliminary attempt, a pilot survey was conducted in schools identified in the locale selected for the study. Since adequate number of adolescent females were not available, free medical camps were conducted in selected areas in the locality. In these camps qualified physicians graded adolescent females into anemic and non-anemic based on physical examination. The females identified as anemic were further tested for their haemoglobin levels and details regarding the socio economic, nutritional and health variables were collected. Details of medical camps conducted were given in Table 3.

Subjects for the micro sample and institutions for the metabolic study were also selected after the above camps.

Table 3. Details of medical camps conducted

Place of camp (Taluk)	Date	Number of adolescent females	
		Identified as anemic	Tested & confirmed as anemic
1. Kanjiramkulam (Neyyattinkara)	26/2/1997	50	15
2. Kanjiramkulam (Neyyattinkara)	27/2/1997	50	20
3. Kanjiramkulam (Neyyattinkara)	28/2/1997	20	10
4. Kanjiramkulam (Neyyattinkara)	1/3/1997	30	20
5. Bharaniyam (Neyyattinkara)	2/3/1997	35	24
6. Konni (Nedumangadu)	3/3/1997	30	9
7. Poovachal (Nedumangadu)	5/3/1997	30	19
8. Kuttichal (Nedumangadu)	7/3/1997	36	18
9. Muthiyavila (Nedumangadu)	14/3/1997	38	20
10. Vilappilsala (Trivandrum)	30/4/1997	50	20
11. Vilappilsala (Trivandrum)	1/5/1997	43	28
12. Kanjiramkulam (Neyyattinkara)	8/5/1997	50	22
	Total	462	225

50

3.7.2. Conduct of the metabolic experiment (n = 35)

Females in the age group of 12 to 18 years residing in two institutions were screened for their haemoglobin levels and those having moderate degree of anemia were selected for the study.

Prior to the experiment, stools from the subjects were collected and tested for worm infestation. Then they were dewormed by using Albendazol.

Menu of the basal diet in the institutions, where the subjects residing, were made uniform with reference to food constituents included in the main meals and methods of preparation during the experimental period. Prior to the experiment, the actual quantity of food consumed by the subjects were collected by three day food weighment method. The quantity consumed by the subjects was equalised so that the basal diet should meet Recommended Dietary Allowances (RDA) for adolescent females.

Haematological profile, nutriional status, physical endurance and work capacity of the subjects were assessed prior to the experiment. The selected females were divided into seven groups of five each, and among these, one group formed the control group and the rest formed the experimental groups. Control group was given only the basal diet and the experimental groups were given iron and vitamin supplements and supplementary foods rich in iron, folic acid, Vitamin A, B_2 and C. Iron and vitamin supplements were given along with dinner since it was the suitable time for administration as

managed by institutional personnel. Supplementary food was administered along with breakfast, lunch, evening tea and dinner. The subjects were persuaded to consume the entire quantity of the supplementary food served.

3.7.3. Development and Standardisation of Supplementary foods

The following steps were taken in order to develop and standardise the supplementary foods rich in iron, folate, Vitamin A, B_2 and C.

i. A list of locally available food articles, rich in nutrients under study, was prepared from Nutritive Value of Indian foods (NIN, 1991).

ii. Fourteen recipes were formulated, with food articles included in the list. Care was taken so that the recipes should follow traditional South Indian cooking practices. The formulated recipes are given in Appendix VI.

iii. To standardise the developed recipes, they were prepared and evaluated on the basis of method, ingredient proportion, cost, skill and overall suitability for the experiment.

iv. The selected recipes viz., Amaranth Soyabean pugath, Gingelly balls, Rice flakes and Ladies finger fry, were further tested, for their acceptability, by the subjects and feasibility of including the same in their daily menu.

The portion size of the recipes were adjusted so that they should contain approximately 60 mg iron, 500 µg folic acid, 600 µg equivalent vitamin A, 1.2 mg equivalent vitamin B_2, 40 mg equivalent vitamin C, when all the servings were taken together.

3.8. Analysis of collected data

3.8.1. *Data collected from macro sample (n = 225)*

a. Development of "Quality of Life Index" (QLI) based on selected socio economic variables

Certain variables like socio economic status and other related variables were selected, from the data collected, to develop quality of life index as suggested by Dhanasekharan (1991) and Karuna (1993). The selected variables included caste, educational status of the respondents, occupational status of the head of the family, family income, per capita income, expenditure on food as percentage of monthly income and calorie and protein requirements of the respondents. Each of the variables were rated by giving scores. The scores given for each parameter ranged from 1 to 6 depending on the intrafamily variations. The different variables and their corresponding scores given to find out QLI are given in Appendix VII.

Scores assigned for each parameter for a family were summed up to give the total score for that family which represents the quality of life index of that particular family. The maximum score that can be obtained by this

calculation was 43.

Based on the variation in Physical Quality of Life Index (PQLI), the selected respondents for the study were classified into 4 groups of poverty levels, such as destitutes, very very poor, very poor and poor. (Dhanasekharan, 1991).

b. Knowledge Score

The knowledge score of the respondents was calculated by using the formula:

$$\text{Knowledge score} = \frac{\text{Number of correct answers}}{\text{Total number of questions}} \times 100$$

(Singh and Singh, 1974)

c. Food use frequency score

Frequency of use of different food groups would give an indication to the adequacy of the family diet pattern. Food use frequency was measured on a five point scale. On the basis of the frequency of use, the foods were classified into 5 groups and scored as occasionally used foods (score 1), foods used once in a week (score 2), foods used twice in a week (score 3), foods used thrice in a week (score 4) and foods included in daily dietaries (score 5).

The total score for each of the food group was calculated (Reaburn *et al.*, 1979). Based on the percentage score obtained, the food articles were further classified into four groups viz, most frequently, moderately, less frequently and least frequently used foods.

d. Developing Calorie Consumption Index (CCI)

In order to find out the adequacy of the calorie intake of the respondents with reference to a well fed population, Calorie Consumption Index (CCI) was calculated as a fraction of calorie intake of adolescent girls in developed countries such as USA (2150 kcal).

e. Developing Nutritional Status Index (NSI)

In order to develop nutritional status index, Haemoglobin level, height, weight, arm muscle circumference, waist, hip, mid upper arm circumference, triceps skinfold thickness,body mass index, waist to hip ratio and calorie consumption index were taken into consideration as reported by Ottesen *et al.* (1989).

The NSI was worked out by using the formula

$$N_i = \sum_{w_i}^{k} xij$$

where, i = 1,2,3,..... ..N

N = 225

k = number of variables

w_i = $1/S_i^2$, S_i^2 being the variance of i^{th} variable based on sample of N size. OR the information supplied by the sample with respect to i^{th} character.

xij = Observation corresponding to the j^{th} respondent with respect to the i^{th} variable.

Nutritional Status Index obtained for each individual was classified as given below:

Mean - SD	= Low
Between mean ± SD	= Medium
Mean + SD	= High

3.8.2. *Data collected from micro sample (n = 35)*

a. Percentage of RDA met from daily dietaries

The percentage of RDA met from daily dietries and available nutrients were assessed from food weighment data.

b. Red cell indices

From the estimated values of haemoglobin, RBC count and PVC the following indices were calculated:

i. Mean Corpuscular Volume (MCV)

$$\text{MCV in femto liters (fl)} = \frac{\text{PCV}}{\text{RBC count}} \times 100$$

ii. Mean Corpuscular Haemoglobin (MCH)

$$\text{MCH in pg} = \frac{\text{Haemoglobin}}{\text{RBC count}} \times 100$$

iii. Mean Corpuscular Haemoglobin Concentration (MCHC)

$$\text{MCHC (per cent)} = \frac{\text{Haemoglobin}}{\text{PCV}} \times 100$$

c. Transferrin Saturation

Transferrin Saturation (TS) was calculated by using the formula

$$\text{TS (per cent)} = \frac{\text{Serum Fe}}{\text{TIBC}} \times 100$$

where, TIBC is the Total Iron Binding Capacity

3.8.3. *Statistical analysis*

a. Statistical analysis of the data collected from macro sample (n = 225)

i. Socio economic data

The food intake and food habit of a population is greatly influenced by socio economic status. Further, socio economic variables determine the quality of food prepared and served in the family and hence indirectly influence the incidence of nutritional disorders especially micro nutrient deficiencies such

as iron deficiency. So the correlation between the socio economic variables (independent variables) and the incidence of anemia (dependent variable) was worked out.

ii. Data on nutritional variables

The correlation between the nutritional variables and incidence of anemia was found out by using the data on nutrirional variables. The relationship between selected socio economic variables and nutritional variables was also assessed.

iii. Data on health variables

Relationships between health variables and various socio economic and nutritional variables, and haemoglobin level were assessed.

Chi-square (χ^2) test was conducted to assess the inter dependency of selected socio economic, health and nutritional variables. While computing χ^2 test of independence, classes were pooled if the frequency happens to less than 5.

b. Statistical analysis of data collected from micro sample (n = 35)

Inter relationships between nutrient and food intake, anthropometric measurements, aerobic and anaerobic fitness were worked out.

Analysis of variance (ANOVA) was conducted to find out the effect of iron and vitamin supplementation on different experimental groups and the difference between bioavailability of basal dinners when tested along with iron and vitamin supplements.

RESULTS

RESULTS

The present study was conducted to assess the effect of iron and vitamin supplementation on iron profile of anemic adolescent girls. Three Taluks viz., Neyyattinkara, Nedumangadu and Trivandrum in Trivandrum district, Kerala were selected for the study.

The study included documentation of the prevalence of anemia and the associated socio economic, nutritional and health variables and an indepth study on the effect of iron and vitamin supplementation on haematological profile. Data collected were statistically analysed and the results are presented under the following headings:

4.1. Prevalence and magnitude of iron deficiency anemia among adolescent girls

4.2. Socio economic variables responsible for iron deficiency anemia

4.3. Nutritional variables responsible for iron deficiency anemia

4.4. Health variables responsible for iron deficiency anemia and

4.5. Metabolic experiments on the effect of iron and vitamin supplementation on haematological profile.

4.1. Prevalence and magnitude of iron deficiency anemia among adolescent girls

Table 4 depicts the prevalence of anemia among adolescent girls selected from Trivandrum, Nedumangadu and Neyyattinkara Taluks.

Table 4. Prevalence of anemia among the adolescent girls

Name of Taluk	Number of girls screened for anemia	Number of anemics detected	Rate of prevalence (in percentage)
Trivandrum	93	48	52
Nedumangadu	134	66	49
Neyyattinkara	235	111	47
Total	462	225	49*

From the Table, it was revealed that 47 to 52 per cent of the adolescent girls tested were anemic. Among the three Taluks surveyed, the highest prevalence rate of 52 per cent was observed in Trivandrum followed by Nedumangadu (49 per cent) and Neyyattinkara (47 per cent). A comparison of the magnitude of anemia among these three locations revealed that it was not significantly different from each other (SE = 1.45, CV = 5.1). The overall prevalence rate was found to be 49 per cent.

4.2. Socio economic variables responsible for iron deficiency anemia

Social status of the respondents, details of their families, educational and economic status of the families were the major variables considered for studying their involvement in the prevalence of iron deficiency anemia.

4.2.1. Social status of the respondents

Location of the house, religion, caste, type of the family, family size,

family income and source of the income are the major factors which determine the social status of an individual.

The respondents surveyed were from rural (84.89 per cent), coastal (8.00 per cent) and suburban (7.11 per cent) households (Table 5). Among the rural households nuclear families were more common (72.44 per cent) than joint (6.67 per cent) and extended families (5.78 per cent). Families surveyed from the coastal region as well as from the suburban areas of Trivandrum district were of nuclear type. It was found that, there was significant relationship between the type of family and location of house (χ^2 = 8.43) at 1 per cent level of significance.

Compared to the families located in suburban and rural areas, majority of the families surveyed in coastal region were of larger size. Chi-square analysis of the data showed family size was not influenced by the location of the house (χ^2 = 0.53).

About 16 per cent of the respondents had a family income of ≤1000 rupees per month and were residing in rural areas. 17.78 per cent of the families had an income ranging from 1001 to 1500 rupees per month and of these 2.22 per cent were from coastal areas and 15.56 per cent were from rural areas. 24.45 per cent of the families fell into the income range from Rs. 1501 to 2000 per month. Among them 17.78 per cent, 3.56 per cent and 3.11 per cent were respectively from rural, suburban and coastal regions.

The income range of 28.45 per cent of the families was from 2001 to 2500 rupees per month. 22.22 per cent, 2.67 per cent and 3.56 per cent of the families categorised in this group were respectively from rural, coastal and suburban regions. About 3.11 per cent of the respondents, who were from rural areas had a monthly income of 2501 to 3000 rupees per month and that of 10.22 per cent of the respondents, from rural households, were with an income above Rs 3000/- per month. Family income of the respondents had a significant association with the location of the house (χ^2=30.42) at 1 per cent level of significance.

Regular employment was the major source of income in 41.28 per cent of the families. Among them 35.50 per cent and 5.78 per cent, of the respondents, were respectively from rural and suburban regions.

The families depended on other sources such as agriculture, fishing, and fish vending, coolie work and petti business for an income, formed 58.72 per cent. All the respondents from coastal region, 49.33 per cent and 1.33 per cent of the respondents belonging to rural and suburban regions, depended on the above mentioned other sources of income. The major source of income of the family had no influence on the location selected for the house as per χ^2 analysis (χ^2 = 0.1590).

Majority of the families (67.11 per cent) believed in Hinduism while 29.34 and 3.55 per cent of the families were Christians and Muslims respectively.

Table 5. Social status of the families surveyed

Variable	Type of family			Family size		Family income (Rs)						Source of income		Total
	Nuclear	Joint	Extended	<5	≥5	≤1000	1001-1500	1501-2000	2001-2500	2501-3000	≥3001	Regular employment	Other sources	
1. Location of the house														
a. Coastal	18 (8.00)	-	-	8 (3.56)	10 (4.44)	-	5 (2.22)	7 (3.11)	6 (2.67)	-	-	-	18 (8.00)	18 (8.00)
b. Rural	163 (72.44)	15 (6.67)	13 (5.78)	102 (45.33)	89 (39.56)	36 (16.00)	35 (15.56)	40 (17.78)	50 (22.22)	7 (3.11)	23 (10.22)	80 (35.56)	111 (49.33)	191 (84.89)
c. Suburban	16 (7.11)	-	-	12 (5.33)	4 (1.78)	-	-	8 (3.56)	8 (3.56)	-	-	13 (5.78)	3 (1.33)	16 (7.11)
χ^2 values	$\chi_1^2 = 8.43^{**}$			$\chi_1^2 = 0.53^{ns}$		$\chi_4^2 = 30.42^{**}$						$\chi_1^2 = 0.16^{ns}$		225 (100)
2. Religion														
a. Christian	61 (27.12)	-	5 (2.22)	30 (13.33)	36 (16.00)	13 (15.78)	12 (5.33)	22 (9.78)	13 (5.78)	-	6 (2.67)	28 (12.44)	38 (16.89)	66 (29.34)
b. Hindu	128 (56.89)	15 (6.67)	8.0 (3.56)	91 (40.44)	60 (26.67)	23 (10.22)	28 (12.44)	33 (14.67)	43 (19.11)	7 (3.11)	17 (7.56)	63 (28.00)	88 (39.11)	151 (67.11)
c. Muslim	8 (3.55)	-	-	1 (0.44)	7 (3.11)	-	-	-	8 (3.56)	-	-	2 (0.89)	6 (2.67)	8 (3.56)
χ^2 values	$\chi_2^2 = 58.50^{**}$			$\chi_2^2 = 9.78^{**}$		$\chi_4^2 = 14.37^{**}$						$\chi_1^2 = 4.58^{*}$		225 (100)
3. Caste														
a. SC	7 (3.11)	-	-	4 (1.78)	3 (1.33)	-	-	2 (0.89)	4 (1.79)	-	1 (0.44)	7 (3.11)	-	7 (3.11)
b. OBC	172 (76.44)	11 (4.89)	6 (2.67)	110 (48.89)	79 (35.11)	26 (11.56)	36 (16.0)	45 (20.0)	60 (26.67)	-	22 (9.78)	79 (35.11)	110 (48.88)	189 (84.00)
c. Forward	18 (8.0)	4 (1.78)	7 (3.11)	8 (3.56)	21 (9.33)	10 (4.44)	4 (1.78)	8 (3.56)	-	7 (3.11)	-	7 (3.11)	22 (9.78)	29 (12.89)
χ^2 values	$\chi_2^2 = 24.43^{**}$			$\chi_2^2 = 9.52^{**}$		$\chi_3^2 = 10.49^{**}$						$\chi_1^2 = 3.95^{*}$		225 (100)

*Numbers in parenthesis indicate percentage, * Significant at 5 per cent level, ** Significant at 1 per cent level , ns -* not significant

As revealed in Table 5, about 57.33 per cent of the families with Hindu religious background were nuclear type, whereas 6.67 and 3.11 per cent, respectively, were from joint and extended families. All the Muslim families were of nuclear type whereas 27.12 per cent and 2.22 per cent of the families with Christian background were respectively of nuclear and extended types. Religion of the respondent significantly influenced the type of the family in which she was living (χ^2 = 58.50) at 1 per cent level.

Among the families surveyed 45.78 per cent of them had a family size of $\geq$ 5. Of them 16 per cent belong to Christian, 26.67 per cent Hindu and 3.11 per cent Muslim families. About 54.21 per cent of the families, surveyed, were with a family size of < 5. Among them 13.33 per cent were Christians, 40.44 per cent were Hindu and 0.44 per cent were Muslims. It was found that there was significant relationship between family size and religion (χ^2 = 9.78) at 1 per cent level.

The eight Muslim respondents had a family income range of 2001 to 2500 rupees per month. Among the 16 per cent of the families with an income of $\leq$ 1000 rupees, 5.78 per cent were Christians and 10.22 per cent were Hindus. 5.33 per cent of Christians and 12.44 per cent of Hindu families were found to have an income range of 1001 to 1500 rupees per month and those falling under the income range of 1501 to 2000 rupees were also found to belong to Christian (9.78 per cent) and Hindu (14.67 per cent) communities. 5.78 and 19.11 per cent of the respondents, from Christian and

Hindu families, surveyed had an income range of 2001 to 2500 rupees per month. Only 3.11 per cent of families belonging to Hindu religion were observed to have an income ranging between 2501 and 3000 rupees per month. About 2.67 and 7.56 per cent of families belonging to Christian and Hindu religion respectively were found to have an income of $\geq$ 3001 rupees per month. Statistical analysis of the data revealed a significant association between family income and religion (χ^2 = 14.37) at 1 per cent level.

Of the 41.33 per cent of the families who were depending on regular employment as major source of income, 12.44 per cent were Christians, 28.00 per cent were Hindus and 0.89 per cent were Muslims while in the remaining families, Christian (16.89 per cent), Hindu (39.11 per cent) and Muslim (2.67 per cent) families, were observed to rely on sources other than regular employment as major source of income.

Statictical testing revealed an association between the source of income and religion (χ^2 = 4.58) at 5 per cent level of significance.

Castewise distribution of the respondents revealed that about 3.11 per cent of the respondents were from scheduled caste, 84 per cent OBC and 12.89 per cent were from forward communities. Nuclear type families were common among the families belonging to different castes. However, statistically significant influence was observed between caste and type of family (χ^2 = 24.43) at 1 per cent level.

Family size of ≥ 5 was cited in 1.33 per cent 35.11 per cent and 9.33 per cent of families respectively of SC, OBC and forward communities while 1.78, 48.89 and 3.56 per cent of the families respectively belonging to SC, OBC and forward communities were with a family size < 5. Caste and family size were significantly interrelated at 1 per cent level (χ^2 = 9.52).

Of the 3.11 per cent of SC families, 0.89 per cent had a family income of 1501 to 2000 rupees per month, while that of 1.79 and 0.44 per cent families had Rs 2001 to 2500 and ≥ 3001 rupees respectively. Among 84 per cent of respondents, who belonged to OBC category, 11.56, 16.00, 20.00, 26.67 and 9.78 per cent fell under the income ranges of ≤ 1000 rupees, Rs 1001 to 1500, Rs 1501 to 2000, Rs 2001 to 2500 and Rs ≥ 3001 per month respectively. While 12.89 per cent of the respondents falling under the category of forward communities, 4.44, 1.78, 3.56 and 3.11 per cent showed an income range of ≤ 1000 rupees, Rs 1001 to 1500, Rs 1501 to 2000, Rs 2501 to 3000 per month respectively.

Statistical treatment of the data revealed a significant influence on family income by caste (χ^2 = 10.49 at 1 per cent level).

All the respondents (3.11 per cent) from SC community relied on regular employment as major source of income, while 48.88 per cent and 9.78 per cent of the families from OBC and forward communities depended on other sources of income as mentioned earlier. 35.11 per cent and 3.11 per

cent of the respondents from OBC and forward communities relied on regular employment as major source of income. Source of income from regular employment or otherwise was also observed to be influenced significantly by the caste to which the respondent belonged (χ^2 = 3.95) at 1 per cent level.

4.2.2. Influence of type of employment on family composition

Influence of type of employment on the composition of the families with reference to number of children, adults and sex ratio were ascertained. Table 6 gives the details regarding the composition of the families surveyed.

Total number of children in the families ranged from 1 to ≥ 5. Irrespective of the occupation of the family head many families (56.89 per cent) had only 1 to 2 children. About 36.44 per cent of the families had 3 to 4 children. In these families, only 16.89 per cent of the family heads had regular employment. 6.67 per cent of the families surveyed had ≥ 5 children. Among them 3.11 per cent of the family heads had regular employment as well as income from agriculture as a major source. The average number of children in the families was found to be 3.

Statistical analysis of the data indicated that the type of employment of the family head had a significant influence on the total number of children (χ^2 = 14.33) at 1 per cent level.

89.33 per cent of the families who had one or two adolescent girls

Table 6. Composition of the families surveyed

Occupation of the head of the family	Number of Children			Number of adolescents				Number of adults		Distribution of males in the family				Distribution of females in the family					Total
				Girls		Boys@		Total number											
	1-2	3-4	≥5	1-2	3-4	1-2	3-4	3	≥4	Only 1	2	3	4	Only 1	2	3	4	5	
Regular employment	38 (16.89)	38 (16.89)	2 (0.89)	67 (29.78)	11 (4.89)	46 (20.44)	2 (0.89)	1 (0.44)	77 (34.22)	1 (0.44)	26 (11.56)	45 (20.00)	6 (2.67)	1 (0.44)	1 (0.44)	20 (8.89)	56 (24.89)	-	78 (34.67)
Regular employment & agriculture	18 (8.00)	15 (6.67)	7 (3.11)	36 (16.00)	4 (1.78)	26 (11.56)	3 (1.33)	4 (1.78)	36 (16.00)	5 (2.22)	7 (3.11)	27 (12.00)	1 (0.440	- -	5 (2.22)	7 (3.11)	28 (12.45)	-	40 (17.78)
Agriculture	2 (0.89)	1 (0.44)	-	3 (1.33)	-	1 (0.44)	-	-	3 (1.33)	-	1 (0.44)	1 (0.44)	1 (0.44)	-	1 (0.44)	1 (0.44)	1 (0.44)	-	3 (1.33)
Coolie work	6 (2.67)	5 (2.22)	4 (1.78)	7 (3.11)	8 (3.56)	7 (3.11)	3 (1.33)	-	15 (6.67)	-	2 (0.89)	12 (5.33)	1 (0.44)	-	1 (0.44)	1 (0.44)	13 (5.78)	-	15 (6.67)
Fishing & fish vending	1 (0.44)	-	-	1 (0.44)	-	1 (0.44)	-	-	1 (0.44)	-	-	1 (0.44)	-	-	1 (0.44)	-	-	-	1 (0.44)
Petti business	63 (28.00)	23 (10.22)	2 (0.89)	87 (38.67)	1 (0.44)	59 (26.22)	1 (0.44)	9 (4.00)	79 (35.11)	5 (2.22)	33 (14.67)	37 (16.44)	13 (5.78)	5 (2.22)	3 (1.33)	21 (9.33)	54 (24.00)	5 (2.22)	88 (39.1)
χ^2 values		χ^2_2 = 14.33**		χ^2_2 = 141.53**		χ^2_2 = 116.10**		χ^2_2 = 156.02**				χ^2_2 = 29.20*					χ^2_2 = 69.43**		225 (100)

@ Families without boys = 76 (33.78)
Numbers in parenthesis indicate percentage
* *Significant at 5 per cent level*
** *Significant at 1 per cent level*

were depending on petti business (38.67 per cent) or regular employment (29.78 per cent). Major source of income for 10.67 per cent of the families, with 3 to 4 adolescent girls, was regular employment (4.89 per cent) and coolie work (3.56 per cent). The average number of girl children in the families was 2.

About 62.22 per cent of the families had one or two adolescent boys and 4 per cent had 3 or 4 adolescent boys while 12.44 per cent of the families had no adolescent boys at all. The average number of boys in these families was 1.

The total number of adults in the families surveyed ranged from 3 to $\geq$ 4. Majority of the families (93.78 per cent) had $\geq$ 4 adults, while 6.22 per cent had three adults in the family.

Many families (54.67 per cent) had 3 adult males in the family while in 30.67 per cent families the number was found to be reduced to 2. Only one male member was found in 4.89 per cent of the families and 9.78 per cent families had four adult males. The average number of adult males was three while the average number of adult females was four.

57.56 per cent of the families had a total number of 4 adult females, while 22.22 per cent had only 3 adult females per family, in 5.33, 2.67 and 2.22 per cent of the families were found to be having 2, 1 and 5 female members respectively.

The average size of the families surveyed was found to be 5 with 2:3 as male to female ratio.

Majority of the families (90.24 per cent) were male headed and only 7.56 per cent of them were female headed. 1.33 per cent of the families were headed by relatives.

4.2.3. Educational status of the respondents and their families

Table 7 details the educational status of the respondents and family members.

Table 7. Educational status of the respondents and parents

Educational status	Father	Mother	Respondent
Illiterate	0	7 (3.11)	5 (2.22)
Literate	6 (2.67)	15 (6.67)	13 (5.78)
Lower primary	11 (4.89)	7 (3.11)	15 (6.67)
Upper primary	50 (22.22)	26 (11.56)	23 (10.22)
High School	153 (68.00)	108 (48.09)	130 (57.78)
College level	5 (2.22)	62 (27.55)	39 (17.33)
Total	225 (100)	225 (100)	225 (100)

Data regarding the educational status of the father of the respondents showed varying degrees of education ranging from literate (2.67 per cent), Lower Primary (4.89 per cent), Upper Primary (22.22 per cent), High school (68 per cent) and College level (2.22 per cent) education. Illiterate mothers formed 3.11 per cent while 6.67 per cent, 3.11 per cent, 11.56 per cent, 48.00 per cent and 27.50 per cent of the mothers had literacy education, Lower Primary, Upper Primary, High School and College level education respectively. Even among respondents 2.22 per cent were illiterate while remaining were either literate (5.78 per cent) or had education upto Lower Primary (6.67 per cent), Upper Primary (10.22 per cent), High school (57.78 per cent) and College level (17.33 per cent).

College level education was considered as the highest qualification. In 60.44 per cent of the families, there were 5 or more members with College level education, while in 36.89 per cent of the families, there were 4 members with College level education. 1.33 per cent of the families had no highly educated members upto College level, while in 1.33 per cent had only one member educated upto college level.

4.2.4. Economic status of the families surveyed

Economic status of the families surveyed is presented in Table 8. As revealed from the table, 16 per cent of the families were with a monthly income of ≤ 1000 rupees per month. Among these families the per capita

Table 8. Economic status of the families surveyed

Family income (Rupees per month)	Per capita income (Rs/month)						Total	Types of domestic animals and birds possessed by the families.						
	≤ 100	101-200	201-300	301-400	401-500	≥501		Cow	Buffalo	Sheep	Total	Chicken	Turkey	Total
≤1000	3 (1.33)	18 (8.00)	9 (4.00)	6 (2.67)	-	-	36 (16.00)	12 (5.33)	5 (2.22)	9 (4.00)	26 (11.55)	17 (7.56)	-	17 (7.56)
1001-1500	-	-	22 (9.78)	11 (4.89)	3 (1.33)	4 (1.78)	40 (17.78)	12 (5.33)	1 (0.44)	4 (1.78)	17 (7.55)	27 (12.00)	2 (0.88)	29 (12.88)
1501-2000	-	4 (1.78)	9 (4.00)	1 (0.44)	16 (7.11)	25 (11.11)	55 (24.44)	9 (4.00)	-	6 (2.67)	15 (6.67)	24 (10.67)	-	24 (10.67)
2001-2500	-	-	-	6 (2.67)	12 (5.33)	46 (20.44)	64 (28.44)	23 (10.22)	-	11 (4.89)	34 (15.11)	31 (13.78)	-	31 (13.78)
2501-3000	-	-	-	-	-	7 (3.11)	7 (3.11)	3 (1.33)	2 (0.88)	-	5 (2.21)	17 (7.56)	-	17 (7.56)
≥3001	-	-	-	-	-	23 (10.22)	23 (10.22)	9 (4.00)	-	1 (0.44)	10 (4.44)	7 (3.11)	-	7 (3.11)
Total	3 (1.33)	22 (9.78)	40 (17.78)	24 (10.67)	31 (13.77)	105 (46.67)	225 (100)	68 (30.21)	8 (3.54)	31 (13.78)	107 (47.53)	123 (54.68)	2 (0.88)	125 (55.56)
χ^2values	$\chi^2_2 = 37.40^{**}$							$\chi^2_2 = 9.00^{**}$				$\chi^2_3 = 1.70$		

Numbers in parenthesis indicate percentage

*** Significant at 1 per cent level.*

income of 1.33 per cent was ≤ 100 rupees, while that of 8.00, 4.00 and 2.67 per cent were 101 to 200, 201 to 300 and 301 to 400 rupees respectively per month.

17.78 per cent of the families had income ranging from 1001 to 1500 rupees per month. Among them, 9.78, 4.89, 1.33 and 1.78 per cent, of the respondents, had per capita income ranging from 201 to 300, 301 to 400, 401 to 500 and ≥ 501 rupees respectively per month. 1.78 per cent of the families with a family income between Rs 1501 to 2000 had per capita income ranging from Rs 101 to 200 per month while that of 4.00, 0.44, 7.11 and 11.11 per cent were Rs 201 to 300, 301 to 400, 401 to 500 and ≥ 501 respectively.

Families with an income range of Rs 2001 to 2500, contributed about 28.44 per cent of the total macrosample. Among them 2.67 per cent had a per capita income ranging from Rs 301 to 400 per month and that of 5.33 and 20.44 per cent were Rs 401 to 500 and ≥ 501 respectively.

An income range of Rs 2501 to 3000 per month was found in 3.11 per cent of the families. Their per capita income was found to be ≥ 501 rupees. 10.22 per cent of the families had a family income of ≥ 3001 rupees with a per capita income of ≥ 501 rupees. From the table, it was also revealed that majority of the respondents (46.67 per cent) had per capita income of ≥ 501 rupees.

Chi-square test brought out the fact that per capita income depended on family income (χ^2 = 37.40) at 1 per cent level of significance.

Among the families, 47.53 per cent depended on domestic animals such as cow (30.21 per cent), buffalo (3.54 per cent) and sheep (13.78 per cent) and 55.56 per cent depended on poultry keeping as secondary sources of income. The major domestic birds kept by them were chicken (54.68 per cent) and turkey (0.88 per cent). It was found that family income was influenced by the type of domestic animals and birds possessed by the families (χ^2 = 8.99 and χ^2 = 1.70 at 1 per cent level of significance).

4.3. Nutritional variables responsible for iron deficiency anemia

The major nutritional variables considered to be responsible for the incidence of anemia among adolescent girls were their food habits, food expenditure pattern of the respondents' families, frequency of use of different food items, People's Quality of Life Index (PQLI), food habits of the families surveyed, food and nutrient intake of the respondents, Calorie Consumption Index (CCI), and knowledge of respondents regarding anemia.

4.3.1. Food habits of the respondents

Majority (97.11 per cent) of the respondents were non vegetarians. The major staple foods in their daily dietaries were found to be cereals especially rice, and roots and tubers mainly tapioca. 2.89 per cent of the families were vegetarians.

4.3.2. Monthly expenditure on food by the respondents' families

Food expenditure pattern of the families based on their monthly income is given in Table 9.

Majority of the families (49.78 per cent) spent more than or equal to 91 per cent of their monthly income on food. Of them 29.46 per cent of the families had a family income of Rupees ≤ 1000, while 26.79 per cent, 24.11 per cent and 19.64 per cent of them had family income, ranging from Rupees 2001 to 2500, 1501 to 2000 and 1001 to 1500 rupees respectively.

81 to 90 per cent of the family income was spent on food by 13.34 per cent of the respondents surveyed. In this category, respondents with a family income of rupees 2001 to 2500 were 80 per cent and with Rupees 1501 to 2000 were 20 per cent.

15.98 per cent of the respondents expended 71 to 80 per cent of their income on food. Among them 33.33 per cent, 2.78 per cent, 19.44 per cent, 13.98 per cent and 5.56 per cent fell under the income categories of rupees 1501 to 2000, 2001 to 2500, 2501 to 3000, 1001 to 1500 and ≥ 3001 rupees per month respectively.

The respondents who spent 61 to 70 per cent of their family income on food formed 16.44 per cent of the total sample size. Total family income range of these respondents were rupees ≤ 1000 (2.70 per cent), Rs. 1001 to

Table 9. Food expenditure pattern of the families based on their monthly income

Family income	Percentage of expenditure on food					Total
	≥ 91	81-90	71-80	61-70	≤ 60	
≤ 1000	33 (29.46)	-	-	1 (2.70)	2 (20.00)	36 (16.00)
1001-1500	22 (19.64)	-	5 (13.98)	11 (29.73)	2 (20.00)	40 (17.78)
1501 -2000	27 (24.11)	6 (20.00)	12 (33.33)	5 (13.51)	5 (50.00)	55 (24.44)
2001 - 2500	30 (26.79)	24 (80.00)	10 (2.78)	-	-	64 (28.44)
2501-3000	-	-	7 (19.44)	-	-	7 (3.11)
≥3001	-	-	2 (5.56)	20 (54.05)	1 (10.00)	23 (10.22)
Total	112 (49.78)	30 (13.34)	36 (15.98)	37 (16.44)	10 (4.44)	225 (100)

Numbers in parenthesis indicate percentage of respondents under each category

$\chi_2^2 = 71.76^{**}$

1500 (29.73 per cent), Rs. 1501 to 2000 (13.51 per cent) and Rs ≥ 3001 (54.05 per cent).

The expenditure incurred for food by 4.44 per cent of the subjects was found to be ≤ 60 per cent of the total family income. Among them, respective family income ranges of ≤ 1000 and 1001 to 1500 rupees per month were obtained for 20 per cent each of the category of income range, while family income ranges of Rupees 1501 to 2000 and ≥ 3001 rupees formed 50 per cent and 10 per cent respectively of the respondents.

Statistical analysis of the above data revealed that the percentage of expenditure on food was significantly influenced by family income at 1 per cent level (χ^2 = 71.76).

Results regarding the percentage of expenditure on food against total monthly expenditure of the family is given in Table 10.

Among the families surveyed 35.11 per cent of the families had expended ≥ 91 per cent of their total monthly expenditure for food. This expenditure rate was observed in income ranges of Rupees ≤ 1000 (44.30 per cent), 1001 to 1500 (17.73 per cent) and 1501 to 2000 (37.97 per cent) rupees per month.

In 14.22 per cent of the families, the expenditure on food was found to form 81 to 90 per cent of the total monthly expenditure as depicted by

Table 10. Food expenditure pattern of the families against their total monthly expenditure

Monthly expenditure	Percentage of total monthly expenditure					Total
	≥ 91	81-90	71-80	61-70	≤ 60	
≤ 1000	35 (44.30)	1 (3.13)	-	-	-	36 (16.00)
1001-1500	14 (17.73)	1 (3.13)	11 (27.50)	10 (15.88)	4 (36.36)	40 (17.78)
1501-2000	30 (37.97)	12 (37.50)	13 (32.50)	32 (50.79)	-	87 (38.67)
2001-2500	-	18 (56.25)	14 (35.00)	-	-	32 (14.227)
2501- 300	-	-	-	-	7 (63.64)	7 (3.11)
≥ 3001	-	-	2 (5.00)	21 (33.33)	-	23 (10.22)
Total	79 (35.11)	32 (14.22)	40 (17.78)	63 (27.99)	11 (4.89)	225 (100)

Numbers in parenthesis indicate percentage of respondents under each category

χ_3^2 = 1.70 NS

families with a monthly income of Rs ≤ 1000 (3.13 per cent), 1001 to 1500 (3.13 per cent), 1501 to 2000 (37.50 per cent) and 2001 to 2500 (56.25 per cent) rupees.

17.78 per cent of the families was observed to incure 71 to 80 per cent of their total monthly expenditure on food. Of them 35.00 per cent, 32.50 per cent, 27.50 per cent and 5.00 per cent fell respectively under the income range of Rupees 2001 to 2500, 1501 to 2000, 1001 to 1500 and ≥ 3001 rupees respectively.

61 to 70 per cent of the total monthly expenditure was for food as reported by 27.99 per cent of the families surveyed. The monthly income range of these families was found to be rupees 1001 to 1500 (15.88 per cent), 2001 to 2500 (50.79 per cent) and ≥ 3001 rupees (33.33 per cent) per month. It was also found that for 4.89 per cent of the families surveyed, about ≤ 60 per cent of the total monthly expenditure was on food. These families were found to be in the monthly income range of rupees 1001 to 1500 (36.36 per cent) and 2501 to 3000 (63.64 per cent).

As indicated in the Table 11, all the families, with a per capita income of ≤ 100 rupees and rupees 100 to 200, the percentage of expenditure on food was found to be ≥ 91 per cent. But in the families with a per capita income of rupees 201 to 300, monthly expenditure on food was found to be ≥ 91, 71 to 80 and 61 to 70 per cent of the total monthly expenditure for 55.00, 17.50 and 27.50 per cent of the respondents respectively.

Table 11. Monthly expenditure on food as percentage of total monthly expenditure against per capita income

Per capita income (Rs)	Percentage of expenditure on food					Total
	≥ 91	81-90	71-80	61-70	≤ 60	
≤ 100	3 (100)	-	-	-	-	3 (1.33)
101-200	22 (100)	-	-	-	-	22 (9.78)
201-300	22 (55.00)	-	7 (17.50)	11 (27.50)	-	40 (17.78)
301-400	8 (33.33)	7 (29.77)	5 (20.83)	4 (16.67)	-	24 (10.68)
401-500	12 (38.71)	2 (6.45)	4 (12.90)	13 (41.94)	-	31 (13.76)
≥501	12 (11.43)	23 (21.90)	24 (22.86)	35 (33.33)	11 (10.48)	105 (46.67)
Total	79 (35.11)	32 (14.22)	40 (17.78)	63 (28.00)	11 (4.89)	225 (100)

Numbers in parenthesis indicate percentage of respondents under each income group.

$\chi_4^2 = 70.26$

The percentage of expenditure on food against total monthly expenditure was found to be ≥ 91, 81 to 90, 71 to 80, 61 to 70, and ≤ 60 per cent respectively for 33.33, 29.17, 20.83 and 16.67 per cent of the respondents having a per capita income of rupees 301 to 400.

Families with a per capita income of rupees 401 to 500 expended

≥ 91 (38.71 per cent), 81 to 90 (6.45 per cent), 71 to 80 (12.90 per cent and 61 to 70 (41.94 per cent) per cent of the total monthly expenditure on food. 11.43 per cent, 21.90 per cent, 22.86 per cent, 33.33 per cent and 10.48 per cent of the respondents having per capita income of ≥ 500 rupees about ≥ 91, 81 to 90, 71 to 80, 61 to 70 and ≤ 60 percentage of their monthly expenditure was for food.

Statistical analysis of the data revealed that percentage of expenditure on food was found to depend on per capita income of the family (χ^2 = 70.26), which was significant at 1 per cent level.

Significant relationship was observed among the socio economic variables, such as family size (r = 0.2341), number of highly educated members (r = 0.2864) and family income (r = 0.6865) at 1 per cent level and number of employed persons in the family (r = 0.1593) at 5 per cent level and expenditure on food by the respondents' families.

4.3.3. People's Quality of Life Index (PQLI) of the respondents

From among the various socio economic characteristics of the families of the adolescent girls collected, few indicators like caste, educational status of the respondents, occupational status of the head of the family, family income, per capita income, expenditure on food as percentage of monthly income and calorie and protein requirements of the adolescent girls were selected for developing an index to ascertain physical quality of life. Each

parametre was rated by giving, "scores". Scores obtained for each parametre in the case of each respondent was summed up to obtain the "total score". Maximum score that can be obtained was 43.

In the families surveyed, the maximum score obtained was 32 and the minimum was 7. Scores obtained for each family is presented in Appendix.VII.

Dhanasekharan (1991) had evolved an index to ascertain poverty levels based on the quality of life of rural areas of Tamil Nadu. Based on the classification of Dhanasekharan (1991), the scores obtained by the families in the present study were divided into four groups such as destitutes, very very poor, very poor and poor and the details are furnished in Table. 12.

Table 12.. Poverty level based on Quality of Life Index (QLI)

Levels of poverty *	Score range	No. of families	Mean score	SD	CV (%)
Destitute	<4	-	-	-	-
Very very poor	4-14	16 (7.11)	11.81	2.48	21.02
Very poor	15-25	191 (84.89)	19.15	3.00	15.68
Poor	26-39	18 (8.00)	27.78	1.63	7.48
Total	-	225 (100)	19.32 (n=225)	4.25 (n=225)	22.00 (n=225)

* *Source : Dhanasekharan (1991)*
Numbers in parenthesis indicate percentage

The distribution of the families with respect to various levels of poverty showed that 7.11 per cent of the families surveyed were classified as very very poor, 84.89 per cent as very poor and 8.00 per cent as poor. Thus all the families surveyed were poverty stricken.

4.3.4. Frequency of use of different food items by the families surveyed

Frequency of use of different food items in the daily diet of the respondents is presented in Table 13.

Foods like cereals, nuts and oil seeds (coconut), fats and oils, sugar and jaggery and beverages like coffee or tea were used daily by all the families.

Majority of the families (77.78 per cent) used pulses in their daily diet. Vegetables also had a place in the daily dietaries of 56.88 per cent of the families, whereas roots and tubers were daily used by 48.88 per cent.

Majority of the families occasionally or never used food items such as green leafy vegetables (70.66 per cent), fruits (68.00 per cent), egg (69.77 per cent), meat (60.88 per cent), fish (64.44 per cent) and commercially prepared foods (96.88 per cent). Milk and milk products were consumed daily by 24.89 per cent of the respondents, but only as an ingredient of tea or coffee.

Frequency of use of various food items was measured in a 5 point

Table 13. Frequency of use of various foods by the families

Food items	Number of families and frequency of use					Total
	Daily	Thrice in a week	Twice in a week	Once in a week	Occasionally or never	
Cereals	225 (100)	-	-	-	-	225 (100)
Pulses	175 (77.78)	6 (2.67)	5 (2.22)	6 (16.00)	3 (1.33)	225 (100)
Roots and tubers	110 (48.88)	6 (2.67)	3 (1.33)	33 (14.67)	73 (32.44)	225 (100)
Green leafy vegetables	3 (1.33)	9 (4.0)	8 (3.56)	46 (20.44)	159 (70.66)	225 (100)
Other vegetables	128 (56.88)	6 (2.67)	11 (4.89)	76 (33.77)	4 (1.78)	225 (100)
Fruits	10 (4.44)	3.0 (1.33)	9 (4.00)	50 (22.22)	153 (68.00)	225 (100)
Nuts and Oil seeds	225 (100)	-	-	-	-	225 (100)
Milk and milk products	56 (24.89)	3.0 (1.33)	13 (5.78)	68 (30.22)	85 (37.77)	225 (100)
Fats and oils	225 (100)	-	-	-	-	225 (100)
Sugar and jaggery	225 (100)	-	-	-	-	225 (100)
Egg	33 (14.67)	1.0 (0.44)	-	34 (15.11)	157 (69.77)	225 (100)
Meat	3 (1.33)	2.0 (0.88)	7 (3.11)	76 (33.77)	137 (60.88)	225 (100)
Fish	57 (25.33)	-	5 (2.22)	18 (8.00)	145 (64.44)	225 (100)
Beverages	225 (100)	-	-	-	-	225 (100)
Commercially prepared foods	-	-	-	7 (3.11)	218 (96.88)	225 (100)

Numbers in parenthesis indicate percentage of families

scale. Mean scores obtained for each item on the basis of frequency of use is given in Table 14.

Table 14. Food use frequency scores obtained for various food articles

Food items	Mean Score	Percentage score over the total score
Cereals	5.00	100.00
Pulses	3.77	75.40
Roots and tubers	3.21	64.20
Green leafy vegetables	1.40	28.00
Other vegetables	3.78	75.60
Fruits	1.52	30.40
Nuts and oil seeds	5.00	100.00
Milk and milk products	2.45	49.00
Fats and oils	5.00	100.00
Sugar and Jaggery	5.00	100.00
Egg	1.75	35.00
Meat	1.48	29.60
Fish	2.13	42.60
Beverages	5.00	100.00
Commercially prepared foods	1.03	20.60

As indicated in the Table, only five food items ie, cereals, nuts and oil seeds, fats and oils, sugar and jaggery and beverages were found to obtain a mean score of five. Mean percentage score over total score for these foods

was 100. Depending on the frequency of use, mean scores of various foods showed fluctuations.

Based on the percentage scores obtained, the food articles were further classified into four groups, ie., most frequently used foods, moderately used foods, less frequently used foods and least frequently used foods. The details are presented in Table 15.

Table 15. Classification of food items based on food use frequency scores

Food use frequency scores	Food items
Daily used foods (76-100)	Cereals, nuts and oil seeds (coconut), fats and oils, sugar and jaggery and beverages.
Moderately used foods (51-75)	Pulses, roots and tubers and other vegetables.
Less frequently used foods (26-50)	Green leafy vegetables, milk and milk products fruits egg, meat and fish.
Least frequently used foods (≤25)	Commercially prepared foods.

Cereals, nuts and oil seeds (coconut), fats and oils, sugar and jaggery and beverages formed most frequently used food items. Moderately used foods included pulses, roots and tubers and other vegetables, where as less frequently used food items were found to be green leafy vegetables, milk and milk

products, fruits, egg, meat and fish; while commercially prepared foods were the least frequently used food items in the families.

Relationship between selected socio economic variables such as family size, family income, number of employed persons in the family, number of highly educated members, educational status of the respondent and her mother, people's quality of life index (PQLI) and food use frequency were tested statistically and details are presented in Appendix. VIII.

It was found that among the cereals and cereal products, the food items such as maida, rice flakes and ragi, there was significant correlation with some of the selected socio economic variables. A negative correlation was observed between family income and frequency of use of maida ($r = -0.1394$), rice flakes ($r = -0.2763$) and ragi ($r = -0.2516$). Frequency of use of rice flakes and ragi was also negatively influenced by PQLI ($r = -0.1938$ for rice flakes and $r = -0.2840$ for ragi). The number of highly educated members in the families showed a highly significant negative correlation ($r = -0.2050$) with the frequency of use of ragi. Other cereals and cereal products had no significant correlation with selected socio economic variables.

Bengal gram, cow pea and black gram were the pulses which had significant correlation with selected socio economic variables. The frequency of use of bengal gram was positively correlated with number of employed persons in the family ($r = 0.1735$) while that of cow pea was negatively

correlated with family income (r = -0.1943), number of highly educated members (r = -0.1938) and PQLI (r = -0.2406). The consumption pattern of black gram was negatively influenced by family income (r = -0.1427), number of highly educated members (r = -0.1567) and educational status of the mother of the respondent (r = -0.2061) and was positively correlated with number of employed persons in the family (r = 0.1882).

Among the green leafy vegetables, frequency of use of chekkurmanis showed a significant negative correlation with family income (r = -0.2238) and PQLI (r = -0.1698).

A significant positive correlation existed between the consumption pattern of beetroot and number of employed persons in the family (r = 0.1750).

The number of employed persons in the family had significant influence on the frequency of use of other vegetables such as plantain (r = 0.1547), cucumber (r = -0.1949) and ladies finger (r = 0.1331). The family income negatively correlated with the frequency of use of cucumber.

A significant negative correlation was found between frequency of use of fruits and educational status of the respondent (r = -0.1736) while a positive correlation existed between family income and frequency of use of egg (r = 0.1437). Frequency of use of all the other food items showed no significant correlation with selected socio economic variables.

4.3.5. Dietary habits of the families surveyed

Meal pattern, foods given during special occasions and conditions including periods of illness and also cooking practices of the family were assessed to ascertain the food habits of the respondents.

4.3.5.1. Meal pattern of the families

Majority of the respondents (76.00 per cent) were in the habit of consuming four meals a day. 8.89 per cent of the respondents had 3 meals a day, 5.78 per cent had five meals and 3.56 per cent had six meals and more. 0.44 per cent of them had meals twice a day while 5.33 per cent had meals once in a day.

4.3.5.2. Nibbling habits of the respondents

Data collected regarding the habit of taking foods in between meals is given in Table.16.

Majority of the respondents (94.67 per cent) ate confectionaries at least once in a day 19.11 per cent of the respondents took lunch items, especially along with evening tea, in between their major meals and 13.78 per cent were in the habit of taking fruits in between their meals.

Table 16. Nibbling habits of the respondents

Nature of food	Number of times in a day					
	Nil	Once	Twice	Thrice	Four times and more	Total
Confectionaries	4 (1.78)	213 (94.67)	1 (0.44)	-	7 (3.11)	225 (100)
Fried foods	35 (15.56)	11 (4.89)	4 (1.78)	1 (0.44)	174 (77.33)	225 (100)
Nuts and oil seeds	214 (95.11)	2 (0.89)	1 (0.44)	-	8 (3.56)	225 (100)
Fruits	194 (86.22)	31 (13.78)	-	-	-	225 (100)
Lunch items	178 (79.11)	43 (19.11)	-	4 (1.78)	-	225 (100)
Sugar/Jaggery	219 (97.33)	4 (1.78)	-	2 (0.89)	-	225 (100)
Carbonated beverages	219 (97.33)	5 (2.22)	-	-	1 (0.44)	225 (100)

Numbers in parenthesis indicate percentage

4.3.5.3. Foods given during special occasions

The families surveyed generally celebrated occasions like festivals, visit of guests and also according to the desire of family members to make a day special by preparing special delicious foods like sweet dishes or snacks or meat based food products or a combination of these three.

It was found that majority (76.44 per cent) of the families preferred sweet preparations on festive occasions.

For 9.79 per cent of the families, it was sweets and fried foods along with meat preparations while 7.11 per cent and 6.22 per cent preferred sweets along with fried foods and meat preparations to celebrate festivals, 0.44 per cent of the families did not prefer to prepare special foods for festivals.

Visit of guests was celebrated by preparing either sweets (19.55 per cent) or sweets along with fried foods (45.33 per cent) or meat preparations (10.67 per cent) or with sweets, fried foods and meat preparations (10.67 per cent). 13.78 per cent of the families do not have the habit of making special foods to celebrate the visit of guests.

The choice of 23.11 per cent, 22.66 per cent, 18.22 per cent and 6.67 per cent of the families was sweets along with fried foods, meat preparations, sweets and fried foods and meat preparations respectively to make a day special according to the desire of the family members. 29.34 per cent of them did not prepare any special foods for the above purpose.

4.3.5.4. Foods given during special conditions

The special foods given during special conditions such as infancy, pre school and adolescent periods (Table 17) indicated that in majority of the families (86.67 per cent) breast milk was supplemented with cow's milk. Egg preparations (3.12 per cent), sugar based food items (2.22 per cent), green

leafy vegetables (0.44 per cent) and fish preparations (1.33 per cent) were introduced as additional foods during infancy. But 6.22 per cent of the families were not in the habit of giving any special foods to their children along with breast milk in their infancy period.

Table 17. Special foods used during special conditions

Type of food	Special conditions		
	Infancy	Pre-school	Adolescence
Sugar based food items	5 (2.22)	16 (7.11)	2 (0.88)
Green leafy vegetables	1 (0.44)	2 (0.89)	1 (0.44)
Egg	7 (3.12)	9 (4.00)	7 (3.12)
Milk	19.5 (86.67)	54 (24.00)	4 (1.78)
Fish preparations	3 (1.33)	96 (42.67)	6 (2.67)
Meat preparations	-	-	5 (2.22)
No special food	14 (6.22)	48 (21.33)	200 (88.89)
Total	225 (100)	225 (100)	225 (100)

Numbers in parenthesis indicate percentage

24 per cent of the families gave milk and 42.67 per cent gave fish preparations as supplementary foods during pre school period. The proportion of families who gave egg as special food was 4.00 per cent and green leafy vegetables was only 0.89 per cent. 7.11 per cent of the families gave sweet foods as special foods while 21.33 per cent of the families gave no special foods during pre school period.

Majority of the adolescent girls (88.89 per cent) were given only ordinary adult diet. It was found that egg (3.12 per cent), fish preparations (2.67 per cent), meat preparations (2.22 per cent), milk (1.78 per cent), sugar based food items (0.88 per cent) and green leafy vegetables (0.44 per cent) were given as additional foods during adolescence.

4.3.5.5. Dietary modifications made during disease conditions

Major dietary modifications made during some common disease conditions are given in Table 18.

It was found that majority of the respondents were given either liquid foods (34.22 per cent) or reduced quantity of food (23.12 per cent) during fever. But 23.55 per cent of the families made no such restrictions during fever, while 11.11 per cent of the families were in the habit of starving the sick persons if they were affected by fever. For common cold, 79.55 per cent families made no dietary modifications while 13.33 per cent modified their diet to liquid foods. 2.67 per cent either reduced their food intake or starved

Table 18. Dietary modifications made during some common disease conditions

Name of disease	Modifications made							Total
	Solid food	Liquid food	Saltless food	No restrictions	Reduced food	No food	Don't know	
Fever	18 (8.00)	77 (34.22)	-	53 (23.55)	52 (23.12)	25 (11.11)	-	225 (100)
Cold	2 (0.89)	30 (13.33)	2 (0.89)	179 (79.55)	6 (2.67)	6 (2.67)	-	225 (100)
Diarrhoea	5 (2.22)	173 (76.89)	7 (3.11)	18 (8.00)	4 (1.78)	11 (4.89)	7 (3.11)	225 (100)
Jaundice	-	13 (5.78)	102 (45.34)	23 (10.22)	2 (0.89)	1 (0.44)	84 (37.34)	225 (100)
Chicken pox	1 (0.44)	1 (0.44)	84 (37.34)	32 (14.22)	10 (4.44)	13 (5.78)	84 (37.34)	225 (100)
Chest infections	-	5 (2.22)	15 (6.67)	87 (38.67)	8 (3.56)	14 (6.22)	96 (42.66)	225 (100)

Numbers in parenthesis indicate percentage

during the condition. In diarrhoeal diseases liquid foods (79.89 per cent), normal food (8.00 per cent), starvation (4.89 per cent) were the usual ways of curbing such situation and 3.11 per cent of respondents did not know what dietary modifications were to be made in such situations.

Majority of the respondents (45.34 per cent) restricted salt intake, if affected with jaundice. 5.78 per cent modified their diet to liquid diet, 0.89 per cent reduced their food intake, 0.44 per cent took no food if they had jaundice. 37.34 per cent of the respondents didn't know about the kind of modifications to be made in their diet.

During chickenpox infection, restricted salt intake (37.44 per cent), unrestricted adult food (14.22 per cent), reduction in the quantity of food (4.44 per cent), starvation (5.78 per cent), solid foods (0.44 per cent), liquid foods (0.44 per cent) were the dietary modifications followed. 37.44 per cent of the respondents did not know about the kind of dietary modifications to be made during chicken pox.

42.66 per cent of the respondents did not know about the dietary modifications to be made during chest infections. 38.67 per cent of them did not make any modification in their dietaries, 6.67 per cent took saltless food and 6.22 per cent starved during chest infections.

4.3.5.6. Cooking methods practised by the families

Table 19 depicts the common cooking methods practised by the

Table 19. Cooking methods practised by the respondents' families

Cooking methods	Food items							
	Cereals	Pulses	Green leafy vegatables	Other vegetables	Roots & tubers	Flesh foods	Egg	Milk
Boiling and draining of excess water	225 (100)	59 (26.22)	3 (1.33)	8 (3.56)	201 (89.33)	-	-	-
Boiling	-	90 (40.00)	58 (25.78)	200 (88.89)	-	179 (79.55)	41 (18.23)	187 (83.10)
Simmering	-	-	23 (10.22)	-	-	-	-	-
Steaming	-	-	-	-	3 (1.33)	-	-	-
Pressure cooking	-	-	-	-	-	6 (2.67)	-	-
Soaking and boiling	-	38 (16.89)	-	-	-	-	-	-
Sprouting and boiling	-	29 (12.89)	-	-	-	-	-	-
Roasting	-	9 (4.00)	-	1 (0.44)	-	25 (11.12)	22 (9.78)	-
Frying	-	-	135 (60.00)	1 (0.44)	21 (9.34)	4 (1.78)	162 (71.99)	-
Stewing	-	-	6 (2.67)	8 (3.56)	-	10 (4.44)	-	-
Baking	-	-	-	7 (3.11)	-	1 (0.44)	-	-
Condensing	-	-	-	-	-	-	-	4 (1.78)
Boiling and fermenting	-	-	-	-	-	-	-	34 (15.12)
Total	225 (100)	225 (100)	225 (100)	225 (100)	225 (100)	225 (100)	225 (100)	225 (100)

Numbers in parenthesis indicate percentage

families. It was indicated that boiling and draining of excess water was the commonly adopted method by the majority of the families for cooking cereals (100.00 per cent) and roots and tubers (89.33 per cent).

In most of the families, the excess water, after cooking cereals was a drink taken along with meals or in between meals.

Boiling method was practised for cooking pulses (40.00 per cent), vegetables (88.89 per cent), flesh foods (79.55 per cent) and milk (83.10 per cent). Frying method was preferred for cooking green leafy vegetables (60 per cent) and egg (71.99 per cent).

Simmering was adopted for cooking green leafy vegetables (10.22 per cent) while 1.33 per cent of the families steamed roots and tubers. Pressure cooking was followed to cook flesh foods (2.67 per cent) while 16.89 per cent of the respondents used soaking and boiling and 12.89 per cent used sprouting and boiling to cook pulses. Roasting was the method adopted for cooking pulses (4.00 per cent), other vegetables, (0.44 per cent), flesh foods (11.12 per cent) and egg (9.78 per cent). 2.67 per cent, 3.56 per cent and 4.44 per cent of the families used steaming to cook green leafy vegetables, other vegetables and flesh foods respectively. Baking was the method used by 3.11 per cent and 0.44 per cent of the families respectively to cook other vegetables and flesh foods. 1.78 per cent of the families, used milk after condensing while 15.12 per cent of the families used boiled and fermented milk.

4.3.5.7. Mean food and nutrient intake of the respondents

Mean food and nurtient intake of 225 respondents was determined by 24 hour dietary recall method. The food intake of the individual respondents was recorded, and mean daily intake of different foods was compared with the quantity specified in a balanced diet.

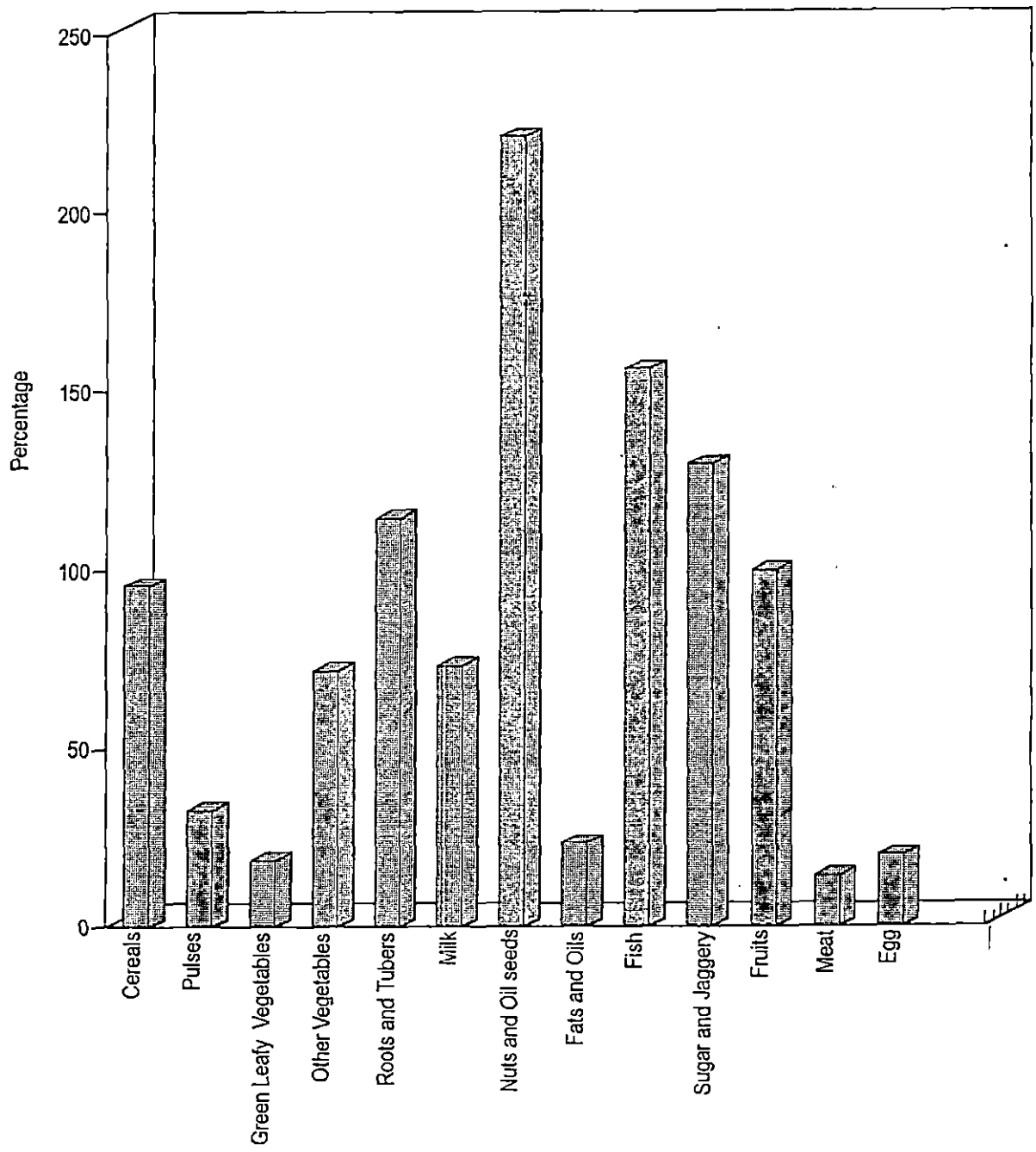
Table 20 and Figure 1 reveal that the diet consumed by the adolescents was not balanced. Intake of cereals was only upto 95.80 per cent of RDA.

Table 20. Mean daily intake of food (n=225)

Food item	Mean daily intake (g)	RDA* (g)	Percentage of RDA met
Cereals	335.29	350.00	95.80
Pulses	16.44	50.00	32.88
Green leafy vegetables	28.18	150.00	18.79
Other vegetables	35.93	50.00	71.86
Roots and tubers	114.44	100.00	114.44
Milk	110.02	150.00	73.35
Nuts and oil seeds (Coconut)	66.40	30.00	221.33
Fats and oils	9.40	40.00	23.50
Fish	46.91	30.00	156.37
Sugar and jaggery	38.96	30.00	129.87
Fruits	30.02	30.00	100.07
Meat	4.31	30.00	14.37
Egg	6.04	30.00	20.13

Source :- ICMR Nutrition Expert Group, 1981.

Fig 1. Food intake of adolescent girls as percentage of RDA



The intake of green leafy vegetables, fats and oils, meat and egg was too inadequate and the consumption rate was observed to be below 25 per cent of RDA. Intake of pulses was found to meet 32.88 per cent of the requirements as per RDA suggestions, while consumption of other vegetables and milk were found to meet 71.86 and 73.35 per cent of the RDA specifications respectively.

Consumption of nuts and oil seeds (coconut) was observed to be higher than the suggested level (Table 20). Similarly fish and sugar and jaggery were also found to be higher than that of RDA. Dietary intake of the respondents also indicated that requirements of roots and tubers were almost met, as specified in RDA.

The relationship between the dietary intake and socio economic factors were tested and the results are given in Appendix. IX.

A highly significant negative correlation was found to exist between family size and intake of cereals (r = -0.1834) and green leafy vegetables (r = -0.1972) and family income showed significant positive relationship with quantity of meat (r = 0.1816) consumed at 1 per cent level. Number of employed persons in the family was also observed to have a positive association with the quantity of roots and tubers consumed at 5 per cent level. As the number of highly educated members of the family increased the quantity of milk (r = 0.2674 at 1 per cent level), sugar and jaggery

(r = 0.1651 at 5 per cent level) and egg (r = 0.1411 at 5 per cent level) was found to increase. But the same variables were negatively associated with the intake of cereals (r = -0.1591) and fish (r = -0.1689) at 5 per cent level of significance. Educational status of the respondent was observed to have positive influence on the intake of fats and oils (r = 0.1323), sugar and jaggery (r = 0.1703) and egg (r = 0.1654) at 5 per cent level of significance, but it had a negative influence on the intake of fish (r = -0.2624) at 1 per cent level of significance.

A positive correlation was found to exist between educational status of the mother of the respondent and intake of other vegetables (r = 0.1915) and milk (r = 0.2083) at 1 per cent level and fruits (r = 0.1323) and meat (r = 0.1476) at 5 per cent level. While a negative correlation was observed between the above variable and intake of fish (r = -0.2427) at 1 per cent level of significance.

Nutrients present in the food items were calculated using Food composition tables from Nutritive value of Indian Foods (ICMR,1989) and the results are presented in Table 21 and Figure 2.

It was found that intake of nutrients, by many respondents, such as protein (77.44 per cent of RDA), carbohydrates (94.51 per cent of RDA), calcium (86.45 per cent of RDA) and riboflavin (76.67 per cent of RDA) was below the RDA specifications. Among the other nutrients, more than 50

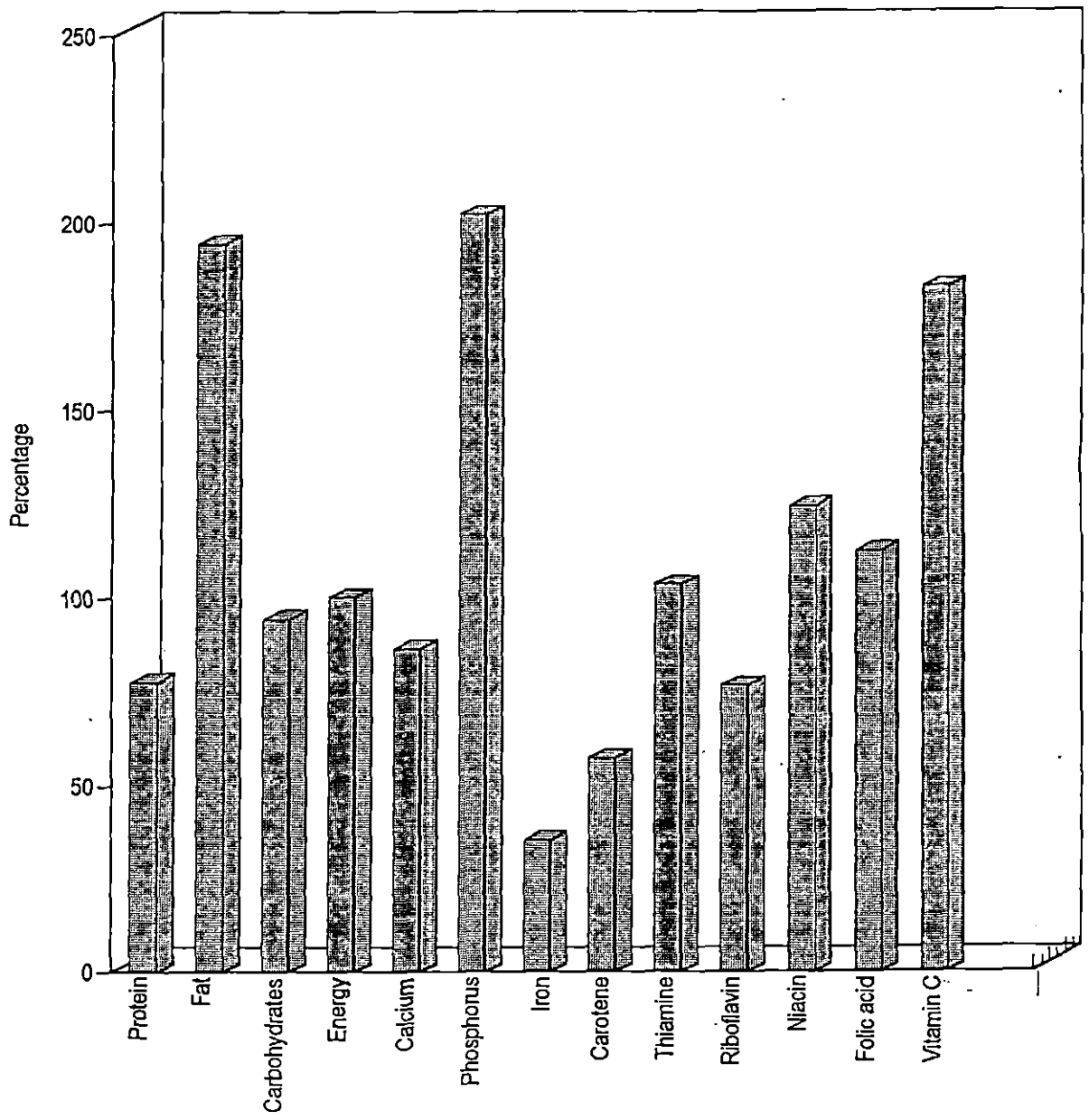
Table 21 . Average daily intake of nutrients

Nutrients	Average daily intake	RDA *	Percentage of RDA met
Protein (g)	48.010	62.00	77.44
Fat (g)	42.810	22.00	194.59
Carbohydrates (g)	380.390	402.50	94.51
Energy (kcal)	2061.710	2056.00	100.28
Calcium (mg)	475.450	550.00	86.45
Phosphorous (mg)	1112.800	550.00	202.33
Iron (mg)	10.630	30.00	35.43
Carotene (µg)	1377.460	2400.00	57.39
Thiamine (mg)	1.038	1.00	103.80
Riboflavin (mg)	0.920	1.20	76.67
Niacin (mg)	17.450	14.00	124.64
Folic acid (µg)	112.510	100.00	112.51
Vitamin C (mg)	73.190	40.00	182.98

* *Source : ICMR (1992)*
Number of respondents = 225

per cent of carotene was met from their diets. But the intake of iron was very poor since 35.43 per cent of RDA was met. Energy and thiamine contents in the diets were found to be adequate, while the intake of niacin and folic acid was higher than the prescribed RDA. Consumption of fat, phosphorus and vitamin C was also found to be sufficient but more than the quantity prescribed for RDA.

Fig 2. Nutrient intake of adolescent girls as percentage of RDA



4.3.5.8. Influence of family size and income on consumption pattern of iron rich foods

Table 22 depicts the details regarding the influence of family size and income on consumption pattern of iron rich foods. As indicated in the table, it was found that family size influenced the consumption of iron rich foods (χ^2 = 126.970) at 1 per cent level. Unlike other foods the quantity of intake of green leafy vegetables, was observed to be reduced with the increase in family size.

The quantity of iron rich foods consumed by the respondents depended on the income of the family (χ^2 = 899.996) at 1 per cent level of significance. It was also found from the table that the consumption pattern of cereals and their products showed a fluctuating tendency with increase in family income. The quantity of cereals and their products consumed by the income group of Rupees 1501 to 2001 was found to be very low when compared to other income groups. The respondents with a family income of Rupees 2501 to 3000 consumed the highest quantity (287.00 g) of cereals and their products, though the quantity was less than RDA of cereals and cereal products (350.00 g) specified for adolescent girls. The quantity of cereals and cereal products consumed by the respondents in the income range of Rupees ≥ 3001 was also found below RDA but almost similar to the quantity consumed by the respondents in the income range of 1001 to 1500 rupees per month.

Table 22. Influence of family size and income on consumption pattern of iron rich foods

Foods (g) (RDA)	Quantity of foods consumed (mean values in grams)							
	Family size		Family income(Rs.)					
	< 5	≥ 5	≤ 1000	1001-1500	1501-2000	2001-2500	2501-3000	≥3001
Cereals and products(350)	224.40 (64.11)	229.35 (65.53)	206.39 (58.97)	229.13 (65.47)	196.76 (56.22)	249.23 (71.21)	287.78 (82.22)	228.57 (65.31)
Pulses and legumes (50)	46.16 (92.32)	48.25 (96.50)	26.53 (53.06)	33.38 (66.76)	52.13 (104.26)	61.54 (123.08)	52.22 (104.44)	48.57 (87.14)
Leafy vegetables(150)	70.28 (46.85)	48.80 (32.53)	59.94 (39.96)	52.38 (34.92)	55.37 (36.91)	69.38 (46.25)	44.44 (29.63)	86.67 (57.78)
Roots and Tubers(100)	52.54 (52.54)	54.76 (54.76)	46.28 (46.28)	56.63 (56.63)	61.10 (61.10)	72.18 (72.18)	85.00 (85.00)	63.42 (63.42)
Other vegetables (50)	116.24 (232.48)	116.05 (232.10)	73.14 (146.28)	108.42 (216.84)	131.10 (262.20)	136.17 (272.34)	51.67 (103.34)	142.71 (285.42)
Nuts and oil seeds (30)	38.64 (128.80)	39.20 (130.67)	35.69 (118.97)	38.55 (128.50)	42.13 (140.43)	38.30 (127.67)	52.22 (174.07)	36.43 (121.43)
Fruits (30)	42.20 (140.67)	47.30 (157.67)	54.40 (181.33)	72.57 (241.90)	80.00 (266.67)	107.80 (359.33)	129.44 (431.47)	103.33 (344.43)
Fishes and other sea foods (30)	72.84 (242.80)	70.50 (235.00)	110.69 (368.97)	128.82 (429.40)	135.47 (451.57)	141.31 (471.03)	165.56 (551.87)	119.50 (398.33)
Meat and poultry(30)	59.24 (197.47)	55.65 (185.50)	57.39 (191.30)	71.21 (237.37)	82.62 (275.40)	80.30 (267.67)	87.50 (291.67)	66.67 (222.23)
χ^2values	χ^2_8 = 126.9737**		χ^2_{40} = 899.9957**					

Numbers in parenthesis indicates percentage of RDA met

*** Significant at 1 per cent level*

In the case of pulses, the quantity consumed increased according to the rise in family income upto the families in the income range of Rupees 2001 to 2500. Later, there was gradual decrease in the consumption of pulses (48.57 g) at ≥ 3001 Rupees. Consumption of pulses by the respondents in the income ranges of ≤ 1000, 1001 to 1500 and ≥ 3001 Rupees per month was below RDA levels.

The consumption pattern of green leafy vegetables was far below the RDA. About 29.63 to 57.78 per cent RDA of green leafy vegetables was met by the respondents. The consumption pattern of green leafy vegetables showed fluctuations with rise in family income. The highest quantity (86.67 g) was observed to be consumed among the respondents in the highest income range (≥ 3001 Rupees), while the respondents in the income group of 2501 to 3000 Rupees were observed to consume lesser quantity.

There was a sharp rise in consumption of roots and tubers with rise in family income upto 2501 to 3000 Rupees and at the next income range the decrease in consumption was observed to be 63.42 g. This trend was similar to the trend indicated in the consumption of fruits, fish and other sea foods.

The consumption of roots and tubers was far below RDA and the percentage of RDA met ranged from 46.28 per cent to 85.00 per cent.

For the income range of ≤ 1000 Rupees, the quantity of fruits

consumed was 54.40 g which was increased to 129.44 g among the respondents of 2501 to 3000 Rupees range and then, was observed to decrease to 103.33g in the case of respondents of ≥ 3000 Rupees income range.

The quantity of fish and other sea foods consumed by the respondents belonging to the income range of ≤ 1000 Rupees was 110.69g per day and this was observed to increase to 165.56 g among the respondents in the income range of Rupees 2501 to 3000 but a reduction to 119.50 g was observed among the respondents in the income range of ≥ 3001 Rupees.

Disparities in the consumption pattern with rise in income level was also indicated in the case of other vegetables. The highest quantity (142.71 g) was consumed by the respondents identified in the highest income range (≥ 3001 Rupees). However the quantity consumed by the respondents with 2501 to 3000 rupees income range was found to be lower (51.67 g) than that consumed by the families identified in the lowest income range (≤ 1000 Rupees).

Foods like nuts and oil seeds also showed similar trends either an increase or decrease in the quantity consumed with the rise in income level. Respondents belonging to the monthly income range of ≤ 1000 Rupees, were found to consume 35.69 g of nuts and oil seeds per day, which was gradually increased to 42.13 g among the respondents in the income range of rupees 1501 to 2000 Rupees, but observed to decrease to 38.30 g in the diets of respondents with a monthly income range of Rupees 2001 to 2500. But an

increase (52.22 g) in the consumption pattern of respondents at Rupees 2501 to 3000 range was observed and a decrease in consumption (36.43 g) at ≥ 3000 Rupees range.

Similar trend was also found in the consumption pattern of meat and poultry by the respondents. The daily consumption of respondents with ≤1000 rupees as family income was 57.39 g. This was increased to 82.62 g in the income range of Rupees 1501 to 2000 but decreased to 80.30 g in the income range of Rupees 2001 to 2500. An increase to 87.50 g was observed in the consumption pattern of respondents at Rupees 2501 to 3000 income range and further decrease to 66.67 g was also observed in the families identified in the income range of ≥ 3000 rupees.

The percentage of RDA met for other vegetables, nuts and oil seeds (coconut), fruits, fishes and other sea foods and meat and poultry were far above the quantities specified for recommended daily intake and the percentage of RDA met by above foodstuffs ranged respectively from 103.34 to 285.42 per cent, from 118.97 to 174.07 per cent, from 181.33 to 431.47 per cent, from 368.97 to 551.87 per cent and from 191.30 to 291.67 per cent.

Statistical analysis of the data (Table 23) showed that family income had an impact on the quantity of consumption of many iron rich foods and were positively correlated with family income. However, quantity of consumption of iron rich foods such as small onion and tapioca chips (dried) was negatively correlated with family income.

Table 23. Relationship between family income and quantity of iron rich foods consumed

Iron rich foods	Correlation coefficient
Whole wheat flour (Atta)	0.1944 **
Refined wheat flour (Maida)	0.2201 **
Bengal gram dhal	0.1633 **
Black gram dhal	0.1868 **
Green gram whole	0.2067 **
Chekkurmanis	0.2964 **
Curry leaves	0.1479 *
Beet root	0.2329 **
Carrot	0.2786 **
Small onion	-0.2330 **
Tapioca chips (dried)	-0.1417 **
Beans	0.2229 **
Broad beans	0.1440 *
Cauliflower	0.3414 **
Plantain green	0.1814 **
Water melon	0.1923 **
Seethaphal (custard apple)	0.1698 *
Sardine	0.1616 *

* *Significant at 5 per cent level*

** *Significant at 1 per cent level*

4.3.6. Knowledge of the respondents regarding anemia

Lack of knowledge of the dietary requirements and the nutritive value of different foods is the main contributory cause for the widespread occurrence of malnutrition among the vulnerable section of population in the developing countries.

Knowledge of the respondents was assessed by using teacher type test with 33 selected statements on iron deficiency anemia. From their response, knowledge score was worked out as the per cent of number of correct answers to the total score. Table 24 indicates knowledge of the respondents regarding anemia.

Table 24. Knowledge of the respondents regarding anemia

Knowledge score	Number of respondents (per cent)
Below 40 (Very poor)	10 (4.44)
41-50 (Poor)	10 (4.44)
51-60 (Average)	9 (4.00)
61-70 (Fair)	74 (32.89)
71-80 (Good)	80 (35.56)
81-90 (Very good)	8 (3.56)
91-100 (Excellent)	34 (15.11)
Total	225 (100)

Numbers in parenthesis indicate percentage

Majority of the respondents (35.56 per cent and 32.89 per cent respectively) scored good (score 71 to 80) and fair (score 61 to 70) grades for the 33 statements on anemia. 3.56 per cent of them scored very good grade (score 81 to 90) and 15.11 per cent had scored excellent grade (score 91 to 100). The performance of 12.88 per cent of the respondents were rated as average (4 per cent), poor (4.44 per cent) and very poor (4.44 per cent) with scores of 51 to 60, 41 to 50 and below 40 respectively. Knowledge scores worked out for the respondents were given in Appendix. X.

Relationship between the knowledge score obtained and educational status of the respondents was tested and found that there was a positive, though not significant relationship ($r = 0.0160$) between them.

4.3.7. Calorie Consumption Index (CCI) of the respondents

The amount of calories consumed by a population is often determined by food security and proper functioning of public distribution system and hence development of food industry of that community, which is comparable to a well developed country like USA by Calorie Consumption Index (CCI)

Assuming the calories consumed by the adolescent girls in a well developed country like USA as 1 and CCI was calculated as a fraction of it. According to Arnold and David (1995) calorie intake of adolescent girls in USA was 2150 kcals. Table 25 details the Calorie Consumption Index.

Table 25. Calorie consumption index (CCI) of the respondents

Classification of CCI *		Details of respondents	
		Number	Per cent
≥ 0.91	(Excellent)	142	63.11
0.81 - 0.90	(Better)	45	20.00
0.71- 0.80	(Good)	18	8.00
0.61 - 0.70	(Fair)	9	4.00
0.51 - 0.60	(Poor)	8	3.56
≤ 0.50	(Very poor)	3	1.33
Total		225	100

* *Source : National Research Council (1980) and Potti (1995)*
Classification in parenthesis indicate grade of household food secuity.

The calculated CCI ranged from (0.49 to 1.89). The mean CCI of the respondents was 0.96 ± 0.2080 (Mean ± SD), indicative of excellent food security in the families and excellent functioning of PDS in their communities.

From Table 25 it was found that majority of the respondents (63.11 per cent) had excellent food security in their families while food security in the families of 20 per cent, 8.00 per cent, 4.00 per cent, 3.56 per cent and 1.33 per cent were in the respective grades of better, good, fair, poor and very poor. Calorie consumption index worked out for the respondents was given in Appendix. XI.

4.4. Health variables responsible for the incidence of anemia

Major health variables, responsible for the incidence of anemia, considered, are the grade or severity of anemia among the respondents, the personal characteristics of the respondents such as age, birth order and spacing between the subjects and their siblings, details of their menstrual cycle, infectious diseases affected to the respondents' mothers when the respondent was in the womb, history of incidence of diseases affected to the respondents, nutrient deficiencies prevalent among the respondents, and nutritional status of the respondents. Results of the data collected on these variables are presented in this session.

4.4.1. Severity of anemia among the respondents

Data regarding the severity of anemia among the respondents were given in the Table 26.

Table 26. Severity of anemia among the respondents

Degree of anemia	Details of respondents	
	Number	Percentage
Severe (Hb < 7 g/dl)	-	-
Moderate (Hb 7-10 g/dl)	72	32.00
Mild (Hb > 10<13 g/dl)	153	68.00
Total	225	100

From the table it was found that, among many respondents (68.00 per cent), the stage of anemia was found to be of mild degree (Hb>10<13 g/dl) while in 32 per cent of them it was moderate degree of anemia.

Relationship between socio economic variables, and severity of anemia among the respondents, was worked out statistically. It was found that, among the socio economic variables studied, quality of life index (r = 0.1666) and the occupational status (r = 0.1702) of the family head showed significant positive correlations with haemoglobin level.

A highly significant positive correlation was observed between haemoglobin level and quantity of consumption of jack fruit seeds (r = 0.1940), fresh coconut (r = 0.2898) and dates (r = 0.2169).

Frequency of use per week, of rice flakes (r = 0.1870) and dates (r = 0.2002) at 1 per cent level and wheat semolina (r= 0.1442), black gram dhal (r = 0.1646), chekkurmanis (r = 0.1457), jack fruit seeds (r = 0.1707), fresh coconut (r = 0.1437), amla (r = 0.1727), bilimbi (r = 0.1973) and sapota (r = 0.1973) at 5 per cent level, showed positive correlations with haemoglobin level.

There exists a positive association between frequency of use per day, of rice flakes (r = 0.1383), amaranthus (r = 0.1350), bringal (r = 0.1718), amla (r = 0.1418) and sapota (r = 0.1714) at 5 per cent level and jack fruit seeds (r = 0.2898) and dates (r = 0.2002) at 1 per cent level of significance, and haemoglobin level.

Cooking methods practised by the respondents' families to cook other vegetables and egg showed negative correlations (r = -0.1418 and r = -0.2115, significant at 5 per cent and 1 per cent level respectively) with haemoglobin level.

4.4.2. Personal characteristics of the respondents

Data regarding the personal characteristics of the respondents were collected with regard to their age, spacing between the subjects and their siblings, details of menstrual cycle, maternal morbidity rates during the prenatal period of the respondents and history of incidence of diseases infected to the respondents. Table 27 details the agewise distribution of the respondents.

Table 27. Agewise distribution of the respondents

Age (years)	Details of respondents	
	Number	Per cent
13	7	3.11
15	11	4.89
16	61	27.11
17	94	41.78
18	52	23.11
Total	225	100

From the table, it was found that the age of the respondents ranged from 13 to 18 years. Many respondents (41.78 per cent) were of 17 years. 27.11 per cent of them were of 16 years and the age of 23.11 per cent of the respondents were 18 years. A negative relationship existed between age of the respondents and haemoglobin levels (r = -0.1786) at 1 per cent level.

Personal characteristics regarding the birth order of the respondents, number of siblings with them and spacing between siblings and the respondents are presented in Table 28.

It was found that many respondents (50.67 per cent) had one sibling for each with a birth order of eldest (31.11 per cent) or second (19.56 per cent). 30.67 per cent of them had 2 siblings in the birth order of eldest (7.11 per cent), second (10.67 per cent) and as third (12.89 per cent). 6.67 per cent of them had 3 siblings with 1.78 per cent as eldest or 4.89 per cent as third. 6.22 per cent of them had 4 sliblings either second (3.11 per cent) or third (0.89 per cent), or fourth (0.89 per cent) or fifth (1.33 per cent) birth order. 0.89 per cent had more than 5 siblings with second birth order. 4.89 per cent of the respondents had no sibling at all.

Data regarding the spacing between siblings and respondents showed that majority of the respondents were 2 years younger or older than their siblings.

Table 28. Distribution of the respondents based on birth order and sibling spacing

Birth order	Number of siblings							Spacing between siblings and respondent (years)				
	0	1	2	3	4	≥ 5	Total	0	1	2	≥ 3	Total
1	11 (4.89)	70 (31.11)	16 (7.11)	4 (1.78)	-	-	101 (44.89)	11 (4.89)	26 (11.56)	58 (25.78)	6 (2.67)	101 (44.89)
2	-	44 (19.56)	24 (10.67)	-	7 (3.11)	2 (0.88)	77 (34.22)	-	6 (2.67)	50 (22.22)	21 (9.33)	77 (34.22)
3	-	-	29 (12.89)	11 (4.89)	2 (0.88)	-	42 (18.67)	-	17 (7.56)	24 (10.67)	1 (0.44)	42 (18.67)
4	-	-	-	-	2 (0.88)	-	2 (0.88)	-	-	-	2 (0.88)	2 (0.88)
≥ 5	-	-	-	-	3 (1.33)	-	3 (1.33)	-	-	3 (1.33)	-	3 (1.33)
Total	11 (4.89)	114 (50.67)	69 (30.67)	15 (6.67)	14 (6.22)	2 (0.88)	225 (100)	11 (4.89)	49 (21.78)	135 (60.00)	30 (13.33)	225 (100)

Table 29 depicts the history of menarche of the respondents. It was revealed that majority (34.67 per cent) of the respondents had their menarche between 13 to 14 years of age, while the age at menarche of 31.11 per cent of the respondents was 11 to 12 years and that of 22.22 per cent of the respondents was more than 14 years. 12 per cent of the respondents had their menarche at an age of 10 years.

From the table, it was found that 83.11 per cent of the respondents had irregular menstruation. Chi square analysis revealed that age at menarche influenced the regularity of menstruation at 1 per cent level of significance (χ^2 = 26.42). Data regarding the nature of menstrual flow showed that 42.22 per cent of them had normal flow, 30.22 per cent had slightly heavy flow and 27.56 per cent had heavy flow during menstruation. Nature of menstruation was significantly influenced by age at menarche at 1 per cent level (χ^2 = 23.97).

It was found that the duration of menstrual flow of 51.11 per cent of the respondents was 5 to 6 days, while that of 46.22 per cent of them was less than 5 days. 2.67 per cent of them had menstrual flow for one week or more. Statistical analysis of the data revealed that duration of menstruation was influenced by the age at menarche at 1 per cent level (χ^2 = 27.50) of significance.

35.56 per cent of the respondents had normal menstruation, while 35.11 per cent of them had dysmenorrhoea or painful menstruation and 29.33

Table 29. Details of respondents based on their history of menarche

Age at menarche (years)	Details of menstruation														
	Regularity		Total	Nature of menstrual flow			Total	Duration (days)			Total	Complications			Total
	Regular	Irregular		Normal	Medium	Heavy		> 6	5-6	< 5		Menorr-hagia	Dysmen-orrhoea	Normal	
10	8 (3.56)	19 (8.44)	27 (12.00)	17 (7.56)	5 (2.22)	5 (2.22)	27 (12.00)	-	10 (4.44)	17 (7.56)	27 (12.00)	5 (2.22)	7 (3.11)	15 (6.67)	27 (12.00)
11-12	10 (4.44)	60 (26.67)	70 (31.11)	32 (14.22)	20 (8.89)	18 (8.00)	70 (31.11)	2 (0.89)	39 (17.33)	29 (12.89)	70 (31.11)	20 (8.89)	27 (12.00)	23 (10.22)	70 (31.11)
13-14	12 (5.33)	66 (29.34)	78 (34.67)	23 (10.22)	35 (15.56)	20 (8.89)	78 (34.67)	1 (0.44)	32 (14.22)	45 (20.00)	78 (34.67)	33 (14.67)	26 (11.56)	19 (8.44)	78 (34.67)
>14	8 (3.56)	42 (18.66)	50 (22.22)	23 (10.22)	8 (3.56)	19 (8.44)	50 (22.22)	3 (1.33)	34 (15.11)	13 (5.78)	50 (22.22)	8 (3.56)	19 (8.44)	23 (10.32)	50 (22.22)
Total	38 (16.89)	187 (83.11)	225 (100.00)	95 (42.22)	68 (30.22)	62 (27.56)	225 (100.00)	6 (2.67)	115 (51.11)	104 (46.22)	225 (100.00)	66 (29.33)	79 (35.11)	80 (35.56)	225 (100.00)
χ^2 values	$\chi^2_3 = 26.42^{**}$			$\chi^2_6 = 23.97^{**}$				$\chi^2_3 = 27.50^{**}$				$\chi^2_3 = 33.35^{**}$			

Numbers in parenthesis indicate percentage

** *Significant at 1 per cent level*

per cent of them had menorrhagia or heavy periods with pain. It was found that the complications during menstruation was significantly influenced by age at menarche at 1 per cent level (χ^2 = 33.35).

Many of the respondents' mothers (98.66 per cent) had no disease while carrying the respondents, while 1.33 per cent reported that they suffered from bacterial infections such as typhoid during prenatal period.

Table 30 details the current morbidity status of the respondents.

Table 30. Current morbidity status of the respondents

Type of disease	Nature of occurence	
	Occured during the last 3 months	Occured duing the last 2 years
Viral infections	115 (51.11)	157 (69.78)
Bacterial infecions	28 (12.44)	13 (5.78)
Diarrhoea	7 (3.11)	21 (9.33)
No history of occurence of diseases	75 (33.33)	34 (15.11)
Total	225 (100)	225 (100)

From the table, it was found that many respondents (51.11 per cent) had suffered from viral infections, when data related to this was collected by

recalling their health status for three months prior to the survey. 12.44 per cent of them had bacterial infections and 3.11 per cent had diarrhoea, three months prior to the survey. 69.78 per cent of the respondents recalled and reported that they had viral infections, 2 years prior to the study. 5.78 per cent had bacterial infections and 9.33 per cent had diarrhoea during this time period. It was reported that 33.33 per cent and 15.11 per cent of the respondents were free of any such pathological situation, neither in three months nor in 2 years prior to the survey.

Frequency of occurrence of the above infections during the last two years was observed to be varying among the respondents, as once in two years (26.22 per cent), once in a year (33.78 per cent), once in 6 months (23.56 per cent) and once in three months (1.33 per cent).

4.4.3. Prevalence of nutritional deficiencies present in the respondents

Nutritional deficiencies were assessed by conducting clinical examination among the respondents. Results of the clinical examination indicated that many respondents (57.78 per cent) had good general appearance while 34.22 per cent and 8 per cent of the respondents had fair to poor general physical appearance, respectively.

53.33 per cent had slight dental caries while 4.40 per cent had marked dental caries and 12.44 per cent of them had deficient adipose tissue quantity.

Details regarding the vitamin deficiency symptoms observed in respondents were given in Table 31.

Table 31. Vitamin deficiency symptoms observed among the respondents

Deficient nutrient	Organs affected	Deficiency symptoms observed	Details of respondents
Vitamin A	(i)Eyes	(a) Conjuctiva slightly dry on exposure for half a minute and lacks lustre	14 (6.22)
		(b) Slight discoloration of conjuctiva	2 (0.88)
		(c) Watery conjuctiva with excessive lachrymation	7 (3.11)
		(d) Slight dryness and diminished sensibility of cornea	10 (4.44)
		(e) Slight excoriation of eyelids	1 (0.44)
		(d) Few grannules on eyelids	116 (51.56)
		(e) *Angular conjunctivitis*	10 (4.44)
	(ii) Skin	Lustreless skin	13 (5.78)
	(iii) Hair	Lustreless hair	22 (9.78)
Vitamin B_2 or Riboflavin	(i) Mouth	(a) Mild angular stomatitis	112 (49.78)
		(b) Marked angular stomatitis	103 (45.78)
		(c) Stomatitis of buccal mucosa	8 (3.56)
	(ii) Eyes	Hazines and diminished transparency of cornea	2 (0.88)
Niacin	Tongue	Fissured tongue surface	18 (8.00)
Vitamin C	Gums	(a) Bleeding and/gingivitis	6 (2.67)
		(b) Pyrrhorea	1 (0.44)

Numbers in parenthesis indicate percentage.

Clinical signs of slight vitamin A deficiency were observed among 86.67 per cent of the respondents. Visible symptoms of riboflavin and niacin deficiency were observed in cent per cent and 8.00 per cent of the respondents respectively. Symptoms of vitamin C deficiency were also observed among 3.11 per cent of the respondents.

Details regarding, iron deficiency signs observed among the respondents are given in Table 32.

Table 32. Symptoms of iron deficiency observed among the respondents

Symptoms	Details of respondents	
	Number	Per cent
Pale coloured tongue	159	70.67
Anorexia	193	85.78
Diarrhoea	61	27.11

It was observed that most of the respondents exhibited one or more of the iron deficiency signs at a time. Iron deficiency symptoms such as pale coloured tongue, anorexia and diarrhoea were observed among 70.67, 85.78 and 27.11 per cent of the respondents respectively.

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General appearance of the respondents from a clinical point of view showed a highly significant positive correlation (r = 0.4006) with haemoglobin. level.

Among the nutritional deficiency symptoms, mild vitamin A deficiency indicated by discharge from the eyes and mild B complex deficiency indicated by the condition of lips and buccal mucosa showed significant negative correlations (r = -0.3246 and r = -0.2787 repectively at bold face type and r = -0.1350 at Roman type) with haemoglobin levels.

4.4.4. Nutritional status of the respondents

Anthropometry deals with the comparative measurements of the body. This is one of the most frequently used methods for assessing nutritional status. Parametres like height, weight, BMI, somatic circumferences viz., Mid Upper Arm Circumference (MUAC), Arm Muscle Circumference (AMC), waist, hip and body fat measurements such as triceps skinfold thickness were taken into consideration under this study.

The height and weight of the respondents were measured and are presented in Table 33. Mean height and weight of the respondents identified, under five groups, were found to be below the ideal height for age and weight for age suggested for adolescents. The height of the respondents of different age groups (13 to 18 years) ranged from 142.63 cm to 153.46 cm and their mean was found to be below the mean worked out for ideal heights for different age groups (159.00 cm). Height of the respondents

Table 33. Mean height and weight of the respondents compared to Indian standards for different age groups

Age (years)	Height (cm)		Weight (kg)	
	Mean	Standard*	Mean	Standard*
13	142.63	148.00	38.00	38.70
15	147.76	159.00	39.27	48.00
16	149.17	161.00	40.95	51.40
17	152.39	163.00	42.73	54.00
18	153.46	164.00	43.50	54.40
Mean	149.08 (± 6.42)	159.00	40.89 (± 4.37)	49.30

* *NCHS (1987)*
Numbers in parenthesis indicate SD values

showed a significant positive relationship (r = 0.1508) with haemoglobin level (at 5 per cent level of significance).

The weight for age of different age groups of the respondents ranged from 38.00 kg to 43.50 kg which was much below the mean of ideal weight for age ie., 49.30 kg. A highly significant positive relationship (r = 0.2075) was found to exist between haemoglobin levels and weight of the respondents.

Body Mass Index (BMI) of the respondents according to ICMR classification was worked out and the details are presented in Appendix XII. BMI according to ICMR classification is presented in Table 34.

Table 34. Body Mass Index (BMI) of the respondents according to ICMR classifcation

BMI class	Presumptive diagnosis	Details of respondents	
		Number	Per cent
< 16.0	CED Grade III (Severe)	14	6.22
16.0-17.0	CED Grade II (Moderate)	25	11.11
17.0-18.5	CED Grade I (Mild)	76	33.78
18.5-20.0	Low weight normal	84	37.33
20.0-25.0	Normal	26	11.56
Total		225	100

It was found that 6.22 per cent of the respondents suffered from severe energy deficiency, while 11.11 per cent and 33.78 per cent were identified as moderate and mild chronic energy deficiency (CED) respectively, 37.33 per cent of the respondents, though classified as normal, were found to have lower body weight when compared to standards. 11.56 per cent of the subjects were reported to be normal as per the BMI classification.

The mean somatic circumference and body fat measurements of the respondents are given in Table 35. From the table, it was found that the mean upper arm circumference of the respondents was 20.87 cms, which was 19.72 per cent less than the standard value. The mean arm. muscle circumference was found to be 21.86 cm while that of waist and hip was 23.68 and 30.36 inches respectively.

Table 35. Mean somatic circumference and body fat measurements of the respondents

	Measurements	Mean ± SD	Standard
(a)	**Somatic circumferences**		
	Mid Upper Arm Circumference (MUAC in cms)	20.87 ± 2.68	24.82*
	Arm Muscle Circumference (AMC in cm)	21.86 ± 2.89	
	Waist (inches)	23.68 ± 2.51	
	Hip (inches)	30.36 ± 2.83	
(b)	**Body fat measurements**		
	Triceps skin fold thickness (mm)	7.48 ± 1.14	11.70*
(c)	**Waist / Hip ratio**	0.78 ± 0.07	

* *Vijayaraghavan et al. (1971)*

Somatic circumferences such as MUAC (r = 0.2943) and hip (r = 0.1934) indicated a significant positive relationship with haemoglobin at 1 per cent level while waist circumference (r = 0.1731) showed this relationship at 5 per cent level of significance.

The mean triceps skinfold thickness was observed to be 7.48 mm, which was 36.20 per cent less than the recommended value.

Table 36 depicts the distribution of the respondents with respect to waist to hip ratio. It was found that many respondents (55.88 per cent) had waist to hip ratio ranging from 0.71 to 0.80, 31.36 per cent had waist to hip ratio from 0.81 to 0.90 and 2.64 per cent of the respondents had this

Table 36. Distribution of respondents based on Waist to Hip ratio

Waist to Hip ratio	Distribution of respondents	
	Number	Per cent
< 0.70	17	7.48
0.70	6	2.64
0.71-0.80	127	55.88
0.81-0.90	69	31.36
> 0.90	6	2.64
Total	225	100

ratio as > 0.90. Among the respondents, 2.64 per cent, were found to be with waist hip ratio of 0.70 and 7.48 per cent of them had a waist/ hip ratio of < 0.70.

4.4.5. Nutritional Status Index (NSI)

Nutritional Status Index of the respondents was developed on the basis of their haemoglobin level, height, weight, quality of life index, arm muscle circumference, mid upper arm circumference, waist, hip, triceps skinfold thickness, body mass index, waist/hip ratio and calorie consumption index and the results are furnished in Appendix. XIII.

Distribution of the respondents based on the NSI are presented in Table 37.

Table 37. Nutritional Status Index of the respondents

Nutritional Status	Details of respondents	
	Number	Per cent
Low (< mean - SE)	32	14.22
Medium (Between mean ± SE)	153	68.00
High (> mean+SE)	40	17.78
Total	225	100

Nutritional status of the respondents ranged from 225.14 to 325.08, with a mean of 260.12 ± 15.38 (± SE). Based on this, the respondents were classified as low, medium and high. The respondents whose nutritional status was below mean - SE, between mean ± SE and above mean +SE were respectively classified as low, medium or high. Lowest nutritional status was observed in 14.22 per cent of the respondents. Many respondents, (68.00 per cent) were in medium level category and 17.78 per cent were identified under higher level category.

Relationship between nutritional status index and various socio economic, nutritional and health variables were analysed statistically. The socio economic variables were positively correlated with NSI but the relationship was found insignificant.

Among the nutritional variables, intake of some food stuffs and nutrients showed significant relationship with NSI.

It was observed that the cereals and sugar and jaggery intake had a significant positive correlation with NSI (r = 0.2165 and r = 0.1565 respectively). Among the nutrients, a significant positive relationship with NSI was found with the intake of protein (r = 0.2625), minerals (r = 0.2116), carbohydrates (r = 0.1773), energy (r = 0.2604), calcium (r = 0.1720), phosphorus (r = 0.2374), iron (r = 0.2268) and thiamine (r = 0.2178) at 1 per cent level of significance. It was also found that the calorie consumption index and NSI were positively correlated at 1 per cent level of significance (r = 0.2683).

Among the health variables, age at menarche was positively correlated with NSI (r = 0.1830) at 1 per cent level of significance, while the association between duration of menstrual cycle and NSI was negative one (r = -0.1326) significant at 5 per cent level.

A positive association existed between haemoglobin level (r = 0.1494) and NSI at 5 per cent level of significance. The other health variables which showed significant positive correlation with NSI were waist circumference (r = 0.5665), BMI (r = 0.1346) and waist/hip ratio (r = 0.9264).

Mild vitamin A deficiency symptoms showed a negative correlation (r = -0.2052) with NSI at 1 per cent level of significance.

From the large sample study, it was found that majority of the socio economic variables studied had insignificant effect on prevalence of anemia. However, quality of life index had a direct impact on its prevalence. The adequacy in food and nutrient intake has no direct impact on mild degree of anemia. Hence a micro sample (n = 35) study was conducted to assess the effect of iron and vitamin supplementation on iron profile of anemic adolesent girls.

4.5. Metabolic experiment on the effect of iron and vitamin supplementation on iron profile

A metabolic experiment of 60 days duration was conducted on adolescent girls (n = 35) having moderate degree of anemia (Hb 7-10g/dl), to investigate the effect of iron and vitamins such as vitamins A, B_2 ,C and folic acid supplementation on their haematological profile. The subjects were selected from the large sample surveyed.

4.5.1. Preparation for the experiment

Two institutions, situated in the locale, were selected for the experiment. Haemoglobin levels of the girls residing in these institutions were tested and 20 adolescent girls with haemoglobin levels of 7 - 10 g/dl were selected from a group of 44 girls in institution I and 15 out of 38 girls with similar Hb level were selected for the study from institution II.

4.5.1.1. Actual food and nutrient intakes of the subjects

The actual food and nutrient intakes of the individual subjects were assessed prior to the experiment by 3 day food weighment method and the mean intake was compared with the quantity specified in a balanced diet. Nutrient content of the diet was computed by using food composition tables (ICMR, 1989).

Table 38, details the actual food intake of the subjects residing in the two institutions. It was found that there were variations in the food intake of the girls residing in the two institutions, since,in institution II, vegetarian diet was served while in institution I the diet contained, foods other than plant foods. Consumption of diet components, except roots and tubers and nuts and oil seeds in the case of institution I and nuts and oil seeds in the institution II, were below the RDA levels.

The percentage of RDA met for cereals (86.95 per cent) other vegetables (27.32 per cent), roots and tubers (137.67 per cent), nuts and oil seeds (219.47 per cent), fats and oils (18.25 per cent), fish (55.57 per cent), sugar and jaggery (81.93 per cent), fruits (77.20 per cent) and egg (55.57 per cent) were higher in institution I when compared to institution II. However the intake of protein rich foods like pulses (80.66 per cent of RDA) and milk (98.27 per cent of RDA) and iron rich green leafy vegetables (14.67 per cent of RDA) were higher among the diets served in institution II, although the percentage of RDA met was very low.

Table 38. Actual food intake of the subjects selected for metabolic experiment from Institution I and II.

Foodstuffs	Actual food intake (g)		
	Institution I (n = 20)	Institution II (n=15)	RDA
Cereals	304.33 (86.95)	260.28 (74.37)	350.00
Pulses	23.33 (46.66)	40.33 (80.66)	50.00
Green leafy vegetables	16.67 (11.11)	22.00 (14.67)	150.00
Other vegetables	13.66 (27.32)	12.33 (24.66)	50.00
Roots and tubers	137.67 (137.67)	7.89 (7.89)	100.00
Milk	99.08 (66.05)	147.41 (98.27)	150.00
Nuts and oil seeds	65.84 (219.47)	37.13 (123.77)	30.00
Fats and oils	7.30 (18.25)	2.69 (6.73)	40.00
Fish	16.67 (55.57)	-	30.00
Sugar and jaggery	24.58 (81.93)	19.44 (64.80)	30.00
Fruits	23.16 (77.20)	20.78 (69.27)	30.00
Egg	16.67 (55.57)	-	30.00

Numbers in parenthesis indicate percentage of RDA met

Table 39. Actual nutrient intake of the subjects selected for the metabolic experiment

Nutrients	Actual nutrient intake		RDA
	Institution I (n=20)	Institution II (n=15)	
Protein (g)	46.89	36.54	62.00
	(75.63)	(58.94)	
Fat (g)	43.47	27.93	22.00
	(197.59)	(126.95)	
Carbohydrate(g)	317.42	259.47	402.50
	(78.86)	(64.46)	
Energy (kcal)	1722.57	1356.87	2056.00
	(83.78)	(66.00)	
Calcium (mg)	391.79	306.17	550.00
	(71.23)	(55.67)	
Phosphorus (mg)	1105.25	1178.54	550.00
	(200.95)	(214.28)	
Iron (mg)	11.51	8.01	30.00
	(38.37)	(26.70)	
Carotene (µg)	327.87	295.22	2400.00
	(13.66)	(12.30)	
Thiamine (mg)	1.26	1.12	1.00
	(126.00)	(112.00)	
Riboflavin (mg)	2.25	1.93	1.20
	(187.50)	(160.83)	
Niacin(mg)	14.34	11.05	14.00
	(102.43)	(78.93)	
Folic acid (µg)	106.73	86.22	100.00
	(106.73)	(86.22)	
Vitamin C (mg)	50.02	31.54	40.00
	(125.05)	(78.85)	

Numbers in parenthesis indicate percentage of RDA met.

Table 39 revealed that the diets of subjects from institution I was superior to those of institution II in terms of nutrient content. Diets supplied in institution I were observed to contain fats, phosphorus, thiamine, riboflavin, niacin, folic acid and vitamin C above RDA level. Proteins, carbohydrates, energy, calcium, iron and carotene were found to be higher in the diets of institution I when compared to RDA met for the respective nutrients available in the diets of institution II. However, the percentage of RDA met for these nutrients was below the RDA levels. 38.67 and 26.70 per cent of RDA for iron was met by the subjects from institution I and II respectively.

Dietary constituents like oxalic acid, phytic acid and total dietary fiber are known to inhibit absorption of iron from gastrointestinal tract. Hence the quantity of these inhibitors of iron absorption was computed with the help of food composition tables (ICMR, 1989) and are presented in Table 40.

Table 40. Iron inhibitors present in the diets consumed by the subjects

Inhibitor	Institution I	Institution II
Oxalic acid (mg)	55.49	27.47
Phytin P (mg)	600.58	469.33
Total dietary fiber (mg)	9.56	6.42

From the table, it was observed that the diets of institution I contained higher amounts of iron inhibitors such as oxalic acid (55.49 mg), phytin P (600.58 mg) and total dietary fiber (9.56 mg) than that of institution II, the diet of which contained 27.47 mg oxalic acid, 469.33 mg phytin P and 6.42 mg total dietary fiber.

4.5.1.2. Basal diet for the experiment

In order to maintain homogeneity, the cyclic menus of the institutions, were made uniform in quantity, so as to meet the RDA of nutrients for adolescent girls, without affecting the normal menu and functioning of the institutions. The non vegetarian menu of institution I was made vegetarian by replacing non-vegetarian items with low cost vegetarian dishes as served in institution II. The basal menu worked out for a week and its nutrient composition are given in Appendix XIV and XV.

As depicted in Table 41, it was found that the basal menu contained adequate amounts of all nutrients, over and above the RDA specified for adolescent girls.

Table 41. Nutrient composition of the basal menu

Nutrient	Quantity
Protein(g)	63.52
Fat(g)	71.96
Carbohydrate (g)	446.99
Energy(kcal)	2531.99
Iron (mg)	37.55
Carotene (μg)	5193.04
Riboflavin (mg)	2.21
Folic acid (μg)	167.81
Vitamin C (mg)	278.44

The following battery of treatments along with basal diet (BD) were conducted in order to assess the effect of iron and vitamin supplementation on iron profile of anemic adolescent girls.

Treatment	**Particulars**
T_0 (Control)	Basal diet (BD) alone
T_1	BD + 60 mg Fe + 500 μg folifer
T_2	BD + 60 mg Fe + 500 μg folifer + 600 μg equivalent vitamin A
T_3	BD + 60 mg Fe + 500 μg folifer + 1.2 mg equivalent of vitamin B_2

T_4 BD + 60 mg Fe + 500 µg folifer + 40 mg equivalent vitamin C

T_5 BD + 60 mg Fe + 500 µg folifer + 600 µg equivalent vitamin A + 1.2 mg equivalent vitamin B_2 + 40 mg equivalent vitamin C

T_6 BD + supplementary foods which contains 60 mg Fe + 500 µg folifer + 600 µg equivalent Vitamin A + 1.2 mg equivalent Vitamin B_2+ 40 mg equivalent vitamin C.

Iron and vitamin tablets prescribed under the National Nutritional Anemia prophylaxis Programme, formed the supplements in the metabolic experiment from Treatment T_1 to T_5. These iron and vitamin supplements were given along with dinner, as it was the convenient time for administration by institutional personnel.

4.5.1.3. Development of supplementary foods

A combination of foods which would give similar quantity of nutrients viz., 60 mg iron, 500 µg folic acid, 600 µg equivalent Vitamin A, 1.2 mg equivalent Vitamin B_2, and 40 mg equivalent Vitamin C was developed and included in the daily dietaries of the subjects included under Treatment 6 (T_6).

In order to develop these conbinations, foods rich in iron and vitamins, under the study, 14 recipes were formulated and evaluated for the

nutrient content and cost. The formulated recipes were given in Appendix. XVI.

Table 42 details the nutrient content, cost and acceptability scores of the formulated recipes.

From the 14 recipes, four easy to prepare and low cost recipes viz., rice flakes, amaranth soy pugath, soya gingelly balls, and ladies finger fry which together could supplement 60 mg iron. 500 µg folate, 600 µg equivalent vitamin A, 1.2 mg equivalent vitamin B_2 and 40 mg equivalent vitamin C were selected as the supplementary foods for Treatment 6. These four recipes were further tested at the field for their acceptability among the subjects and found that all of them like the recipes very much to include in their daily menu with a mean score of 7 for each recipe in a 9 point scale.

The selected recipes and their ingredients are given in Table 43. From the table, it was found that the four recipes were distributed among the major meals viz., breakfast (Soya gingelly balls and rice flakes), Lunch (Amaranth Soya pugath and Ladies finger fry), evening tea (Soya gingelly balls and Rice flakes) and dinner (Amaranth Soya pugath).

Table 42. Nutrient content, cost and acceptability scores of the formulated recipes

Sl. No.	Recipe	Nutrient content					Cost (Rs)	Mean acceptability score
		Iron (mg)	β carotene (μg)	Vitamin B_2 (mg)	Folic acid (μg)	Vitamin C (mg)		
1.	Soya puttu	12.410	2017.50	0.9990	53.00	95.35	1.30	2
2.	Soya pakkavada	11.130	1943.25	0.9470	64.90	95.60	2.00	4
3.	Bonda	7.620	1545.00	0.2840	33.70	90.40	1.85	5
4.	Soya cookies	12.410	2017.50	0.9990	53.00	95.35	2.20	3
5.	Wheat-soya-dates idli	8.810	96.20	0.1180	27.16	0.60	1.20	4
6.	Soya-vegetable cutlet	21.650	3596.80	0.9010	90.25	148.20	2.30	6
7.	Gingelly balls	6.150	30.00	0.1800	68.25	0.10	1.25	6
8.	Amaranth Bengalgram dhal pugath	19.500	5552.25	0.3550	187.13	99.35	0.95	6
9.	Rice flakes	6.660	-	0.0325	2.50	0.30	0.35	7
10.	Black gram dhal vadai	3.800	38.00	0.2000	132.00	-	1.00	6
11.	Amaranth - soya pugath	23.540	5733.00	0.6950	201.50	99.20	0.65	7
12.	Soya-Gingelly balls	11.420	121.50	0.2100	59.75	0.10	0.85	7
13.	Sweet Soya balls	5.490	85.20	0.1530	34.13	0.25	2.89	6
14.	Ladies finger fry	0.295	26.00	0.0520	53.75	8.70	0.90	7

Table 43. Ingredients of the developed recipes

Name of recipe	Ingredients per serving	Quantity per serving (g)	Name of the meal to which the recipe forms a part	Number of servings given in a day
Amaranth soy pugath	Amaranth Soya beans Coconut	100.00 50.00 20.00	Lunch + Dinner	2
Soya gingelly balls	Gingelly seeds Soyabean flour Rice flakes Jaggery Coconut	12.50 12.50 12.50 25.00 10.00	Break fast + Evening tea	2
Rice flakes	Rice flakes Coconut Jaggery	12.50 10.00 25.00	Break fast + Evening tea	2
Ladies finger fry	Ladies finger Onion Oil	50.00 20.00 5.00	Lunch	1

4.5.1.4. Bioavailability of iron from basal dinners and iron and vitamin supplements

The availability of iron from the basal dinners along with which iron and vitamins are supplemented were assessed by *in vitro* technique.

As depicted in Table 44, the institutions were found following a light and low cost menu at dinner time. On weekly basis, the cyclic menu

Table 44. Food composition of the basal dinners

Dinner	Diet	Food composition (g)							
		Cereals	Pulses	Roots & tubers	Green leafy vegetables	Other vegetables	Fruits	Nuts & oil seeds	Fats and oils
D1	Rice	150	-	-	-	-	-	-	-
	Avial	-	-	20	-	80	-	40	-
	Rasam	-	-	-	-	-	40	-	8
D2	Rice	150	-	-	-	-	-	-	-
	Green gram pugath	-	20	-	-	-	-	10	2
	Rasam	-	-	-	-	-	40	-	8
D3	Rice	150	-	-	-	-	-	-	-
	Cabbage pugath	-	-	-	50	-	-	20	5
	Rasam	-	-	-	-	-	40	-	8
D4	Rice	150	-	-	-	-	-	-	-
	Potato curry	-	-	70	-	-	-	-	2
D5	Rice	150	-	-	-	-	-	-	-
	Bringal mezhukku puratti	-	-	25	50	-	-	-	-
	Rasam	-	-	-	-	-	40	-	8

contained South Indian preparations with all the foods such as cereals, pulses, roots and tubers, green leafy vegetables, other vegetables, fruits, nuts and oil seeds and fats and oils at moderate amounts.

As detailed in Table 45, the protein content of the dinners (D_1 to D_5) ranged from 10.96 (D_5) to 15.21 (D_2) grams. The average fat content was found to be 17.47 g and that of carbohydrates was 129.14 g. Energy availability from these dinners was in the range of 666.38 to 819.60 kcal.

The ratio of calcium to phosphorus in the dinners was 1:1.29. Iron content of the dinners ranged from 2.00 mg (D_4) to 4.08 mg (D_1) with a mean of 2.70 mg. The mean carotene content of the dinners was 182.60 µg. The meals also contained B complex vitamins such as thiamine (0.56 mg), riboflavin (0.24 mg), niacin (5.72 mg) and folic acid (44.00 µg) and vitamin C (29.43 mg).

Concentration of inhibitors of iron absorption such as oxalic acid, phytin P and total dietary fiber in the meals was in the ranges of 3.70 (D_2) to 109.30 (D_1), 126.00 (D_5) to 242.10 (D_1) and 0 (D_1,D_2.D_3 and D_5) to 5.08 (D_4) milligrams respectively.

60 mg of iron, 500 µg of folic acid, 600 µg of vitamin A, 1.2 mg of vitamin B2 and 40 mg vitamin C were given as supplements along with dinners to different treatment groups.

Table 45. Chemical compostion of basal dinners

Chemicals	Chemical composition					Mean
	D_1	D_2	D_3	D_4	D_5	
Protein (g)	12.02	15.21	11.76	11.00	10.96	12.19
Fat (g)	25.50	15.20	22.05	10.75	13.86	17.47
Minerals (mg)	2.17	2.05	1.75	1.63	1.50	1.82
Fibre (mg)	3.02	1.88	1.92	1.02	1.50	1.87
Carbohydrate(g)	133.48	131.86	124.12	132.74	123.50	129.14
Energy (kcal)	819.60	728.20	666.38	675.50	668.50	711.64
Calcium (mg)	240.30	231.30	227.00	219.88	226.23	228.94
Phosphorus (mg)	356.70	311.70	292.50	252.50	258.50	294.38
Iron (mg)	4.08	2.81	2.50	2.00	2.10	2.70
Carotene (µg)	223.60	159.20	200.40	152.40	177.40	182.60
Thiamine (mg)	1.06	0.46	0.40	0.43	0.42	0.56
Riboflavin (mg)	0.20	0.55	0.16	0.11	0.16	0.24
Nianin (mg)	5.97	5.71	5.47	5.79	5.66	5.72
Folic acid (µg)	67.54	29.75	42.50	33.20	47.00	44.00
Vitamin C (mg)	22.40	10.90	72.80	21.50	19.55	29.43
Oxalic acid (mg)	109.30	3.70	4.60	13.30	12.35	28.65
Phytin P (mg)	242.10	182.80	183.00	131.50	126.00	173.08
Total dietary fibre(mg)	-	-	-	5.08	-	5.08

Table 46. details the bioavailability of iron from the meals supplemented with iron and vitamins.

It was observed that the bioavailability of iron from the diets without supplements (T_0) was found to be ranging form 3.68 (D_1) per cent to 11.65 per cent (D_5). Inclusion of 60 mg iron and 500 µg folic acid (T_1) to the basal diet was found to enhance the bioavailability of iron from 3.05 (D_5) to 9.25 (D_1) times. Addition of vitamin A along with iron and folic acid (T_2) to meals was observed to cause an increase in the bioavailability of iron from 3.23 (D_5) times to 10.03 (D_1) times. When riboflavin was added to the meal (T_3) in addition to iron and folic acid, the bioavailability of iron was found to increase from 3.20 (D_5) to 9.99 (D_1) times. While addition of vitamin C along with iron and folic acid (T_4) derived to result in an increase of 3.50 (D_5) to 10.88 (D_1) times when compared to basal meals. The highest rise in bioavailability was noticed in the meals in which iron, folic acid, vitamins A, B_2 and C (T_5) were added together, since the rise in bioavailability of iron for this treatment ranged from 3.87 (D_5) to 10.89 (D_1) times from the bioavailability of basal dinners alone.

Analysis of variance (ANOVA) of the data indicated that there was significant difference between bioavailability of different diets (F = 988.58) and also between different treatments (F = 181471.10) both at 1 per cent level of significance. However differential results were indicated by different diets and treatments when considered together (F = 321.57) at 1 per cent level of significance.

Table 46. Estimated bioavailabilty of iron from basal dinners given to different treatment groups

Diets	Total iron (Computed value) (mg)	Bioavailability of iron (per cent of total iron available) (Analytical value)					
		T_0	T_1	T_2	T_3	T_4	T_5
D_1	4.08	3.68	34.03 (9.25•)	36.92 (10.03•)	36.75 (9.99•)	40.03 (10.88•)	43.77 (10.89•)
D_2	2.81	5.34	34.20 (6.40•)	37.01 (6.93•)	37.07 (6.94•)	40.11 (7.51•)	43.82 (8.21•)
D_3	2.50	6.00	34.67 (5.78•)	37.33 (6.22•)	37.09 (6.18•)	40.42 (6.74•)	44.25 (7.38•)
D_4	2.00	10.25	35.39 (3.50•)	37.50 (3.66•)	37.25 (3.63•)	40.66 (3.97•)	44.50 (4.34•)
D_5	2.10	11.65	35.48 (3.05•)	37.58 (3.23•)	37.33 (3.20•)	40.72 (3.50•)	45.05 (3.87•)
Mean	2.70	7.38	34.75 (4.71•)	37.27 (5.05•)	37.10 (5.03•)	40.39 (5.47•)	44.28 (6.00•)
Bioavailability of Fe from tablets alone	60.00	-	74.25	81.20 (109.36••)	82.23 (110.75••)	84.00 (113.13••)	93.75 (126.26••)

	$F_{(5,4)}$	CD
Between treatments :	181471.10**	0.0896
Between diets :	988.58**	0.0818
Between treatments and diets :	321.57**	0.2004

** Significant at 1 per cent l evel

• Numbers in parenthesis indicate, increase in number of times from T_0

•• Numbers in parenthesis indicate percentage of increase from T_1

It was also observed that for D_2 the increase in bioavailability evoked by T_2 and T_3 were on par.

For the treatments, T_2 and T_3, the bioavailability observed in D_4 and D_5 were on par. Also the rise in bioavailability due to T_3 on D_2 and D_3 was not significantly different from each other.

There was no significant variation in bioavailability between D_1 and D_2 and D_4 and D_5 when they were treated with T_5.

The supplements were tested alone without the basal meal to ascertain the bioavailability of iron without the influence of other cooked foods. Bioavailability of iron was highest (93.75 per cent) when iron and folic acid were tested along with vitamin A, B_2 and C (T_5) followed by T_4 (84.00 per cent), T_3 (82.23 per cent), T_2 (81.20 per cent) and T_1 (74.25 per cent).

4.5.1.5. Bioavailability of iron from supplementary foods

Bioavailability of iron from the supplementary foods was assessed by *in vitro* technique and details are presented in Table 47.

It was found that greater per cent of iron was found available from ladies finger fry (13.56 per cent) followed by rice flakes (12.69 per cent), soya gingelly balls (10.99 per cent) and amaranth soya bean pugath (6.89 per cent).

Table 47. Bioavailability of iron from supplementary foods

Supplementary foods	Quantity served (mg)	Iron content (mg)	Analytical value of bioavailability of iron (% of total Fe available)
Amaranth Soya-bean pugath	170.00	47.08	6.89
Soya - Gingelly balls	72.50	11.42	10.99
Rice flakes	47.50	6.66	12.69
Ladies finger fry	75.00	2.95	13.56

4.5.2. Personal characteristics of the subjects

The personal characteristics of the subjects, relating to age, prevalence of anemia and degree of parasitic infestations were observed prior to the start of the metabolic experiment. Age of the respondents ranged from 12 to 18 years with a mean of 13 years and 2 months. It was found that the haemoglobin level of the subjects ranged from 8.4 to 10 g/dl, with a mean of 9.4 g/dl, and the subjects were suffering from moderate degree of anemia.

Table 48 details the distribution of subjects based on the rate of worm infestation. From the table, the subjects were observed to be infected either with round worm (94.29 per cent) or whip worm (34.29 per cent). Faecal matter of 77.14 per cent of the subjects was found to have ova of round worm at a moderate rate of infestation, while 5.71 per cent showed ova of round worm with a severe rate of infestation.

Table 48. Distribution of subjects based on rate of worm infestation

Details of parasite	Details of infestation				Total
	Nil	Mild	Moderate	Severe	
(a) Round worm					
Ova	2 (5.71)	4 (11.44)	27 (77.14)	2 (5.71)	35 (100)
Cysts	23 (65.71)	2 (5.71)	10 (28.58)	-	35 (100)
(b) Whip worm	23 (65.71)	1 (2.86)	9 (25.72)	2 (5.71)	35 (100)

Numbers in parenthesis indicate percentage

Majority of the subjects (65.71 per cent) had no cysts of round worms, while 28.58 per cent had it at a moderate level in their faecal matter.

Ova of whip worm was present in the faecal matter of 34.29 per cent of the subjects. According to their population density, the subjects were grouped, as they suffered from mild (2.86 per cent), moderate (25.72 per cent) and severe (5.71 per cent) rates of infestation.

All the faecal samples were found to have puss cells and undigested materials.

Prior to the start of the experiment, all the subjects were dewormed with albendazol.

35 moderately anemic respondents, who were dewormed prior to the experiment were divided into seven groups of five each, at random to form different treatment groups as mentioned earlier. Care was taken to reduce intra group variations in haemoglobin levels and to preserve homogeneity within the groups. Data regarding iron profile and physical endurance were collected at pre and post experimental stages.

4.5.3. Effect of iron and vitamin supplementation on haematological profile of the subjects

The changes in haematological profile of the subjects, as indicated by variations in haemoglobin, packed cell volume, red blood cell count, mean cell haemoglobin, mean cell volume and mean cell haemoglobin concentrations are given in Table 49.

As indicated in the table, the percentage change of haemoglobin concentration was highest (44.59 per cent) in T_5, the group supplemented with iron, folic acid, vitamin A, B_2 and and C followed by T_4 (41.03 per cent), the group supplemented with iron, folic acid and vitamin C and T_3 (38.68 per cent), the group supplemented with iron, folic acid and vitamin B_2. The percentage of increase in haemoglobin levels due to iron folate and vitamin A (T_2) and iron and folic acid supplementation (T_1) are 28.38 and 22.88 per cent respectively.

Table 49. Effect of iron and vitamin supplementation on the haematological profile of the subjects

Treatment Number	Haematological variables											
	Haemoglobin (g%)		PC V (%)		RBC (Million/mm^3)		MCH (pg)		MCV (fl)		MCHC (%)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T_0 (control)	9.20	10.50 (14.13)	27.60	34.00 (23.19)	2.98	3.68 (33.56)	31.32	28.83 (-7.95)	92.45	93.16 (0.77)	34.22	30.96 (-9.53)
T_1	9.44	11.60 (22.88)	26.94	38.00 (41.05)	2.80	4.08 (45.71)	34.02	28.42 (-16.46)	95.759	3.06 (-0.73)	35.41	30.58 (-13.64)
T_2	9.44	13.18 (28.38)	26.60	42.00 (57.89)	3.02	4.92 (62.91)	31.26	26.78 (-14.33)	88.19	85.36 (-3.21)	36.03	31.42 (-12.79)
T_3	9.72	13.48 (38.68)	24.60	41.20 (67.48)	2.88	4.86 (68.75)	33.86	27.26 (-18.02)	85.91	84.88 (-1.20)	39.96	32.73 (-18.09)
T_4	9.36	13.20 (41.03)	25.80	43.40 (68.22)	2.92	4.94 (69.18)	32.80	26.76 (-18.41)	88.16	87.84 (-0.36)	37.47	30.47 (-18.68)
T_5	9.24	13.36 (44.59)	22.40	42.40 (89.29)	2.82	5.05 (79.08)	32.81	26.48 (-19.29)	78.91	84.07 (6.54)	42.15	31.55 (-25.15)
T_6	9.36	11.18 (19.44)	26.20	36.60 (39.69)	3.04	4.50 (48.03)	31.00	24.98 (-19.42)	86.16	81.33 (-5.61)	36.34	30.57 (-15.88)
Normal values	11-15		36-37		4.0-5.5		27-30		85-90		32-33	
$F_{(5,4)}$	16.760**		9.480**		15.250**		2.194		2.504		1.034	
SE	0.010	0.218	0.665	0.665	0.046	0.092	0.617	0.356	1.888	1.204	0.993	0.267
CD	0.852		3.315		0.387		2.421		7.587		2.013	

** *Significant at 1 per cent level.*

The percentage of change of haemoglobin in T_6, the group given with supplementary foods was very low (19.44 per cent) when compared with that of other treatment groups. The control group (T_0) has also found to have 14.13 per cent rise in haemoglobin levels.

Analysis of variance (ANOVA) of the pre and post experimental haemoglobin levels showed significant difference (F = 16.76) between different treatments at 1 per cent level. It was also found that the difference in haemoglobin levels within groups were found to be insignificant. Haemoglobin levels recorded under T_2, T_3, T_4 and T_5 and T_0 and T_6, and T_1 and T_6 were on par while those under T_2, T_3, T_4 and T_5 were significantly different from T_0, T_1 and T_6.

It was found that the experimental group supplemented with iron, folic acid, vitamin A, B_2 and C (T_5) showed maximum rise (89.29 per cent) in Packed Cell Volume (PCV) levels followed by the group supplemented, with vitamin C and iron folate (T_4) (68.22 per cent) and with vitamin B_2 and iron folate (T_3) (67.48 per cent).

The percentage of increase in PCV observed in T_2 and T_1 were 57.89 and 41.05 per cent respectively. The percentage of rise in PCV in T_6 group was very low (39.69 per cent) when compared with that of other groups. The change in PCV indicated by the control group was 23.19 per cent.

A statistically significant difference exists between the pre and post experimental PCV values of different groups (F = 9.4841) at 1 per cent level. Variation in PCV values within the experimental groups was insignificant and differences between T_0 and T_6, T_1 and T_6, and T_2, T_3, T_4 and T_5 were on par.

Correlation studies indicated a positively significant association (r = 0.8851) between PCV and haemoglobin levels at 1 per cent level.

Prior to the start of the experiment, the subjects showed, RBC counts lesser than the normal values. After the experiment all the experimental groups except the control group indicated normal values. Control group showed RBC count of below normal range after the experiment.

Percentage of increase in RBC count was highest in T_5 (79.08 per cent) followed by T_4 (69.18 per cent), T_3 (68.75 per cent) and T_2 (62.91 per cent). But T_1 and T_6 showed a percentage increase of only 45.71 and 48.03 per cent respectively. In control group the RBC count was found increased by 33.56 per cent from the initial values.

Analysis of variance showed significant intertreatmental differences in pre and post experimental RBC counts (F = 15.25). The differences between the treatments T_2, T_3, T_4 and T_5 were on par, while T_0, T_1 and T_6 were found significantly different from each other and other experimental groups.

RBC count was found positively correlated with haemoglobin level (r = 0.8131) and PCV (r = 0.8174) at 1 per cent level.

Red cell indices viz., Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC) showed decreasing tendency at the end of the experiment. For MCH, the rate of decrease was greater in T_6 (-19.42) Among the experimental groups, the lowest rate of decrease in MCH was noted in T_2 (-14.33 per cent) followed by T_1 (-16.46 per cent), T_3 (-18.02 per cent), T_4 (-18.41 per cent) and T_5 (-19.29 per cent). The control group showed only -7.95 per cent decrease from the initial values.

Highest decrease in MCHC was noted in T_5 (-25.15 per cent) followed by T_4 (-18.68 per cent), T_3 (-18.09 per cent), T_6 (-15.88 per cent), T_1 (-13.64 per cent) and T_2 (-12.79 per cent). The rate of decrease in MCHC was very low in the control group (-9.53 per cent) when compared to groups supplemented with iron and vitamins.

Statistical analysis of the pre and post experimental values of MCH and MCHC showed no significant difference between the treatments indicating that there was no significant effect of iron and vitamin supplementation on MCH and MCHC. The values of MCH were positively correlated with MCHC ($r = 0.3723$) at 5 per cent level and negatively correlated with RBC count ($r = -0.5347$) at 1 per cent level while MCHC was positively correlated with haemoglobin level ($r = 0.3400$) at 5 per cent level.

The red cell index, Mean Corpuscular Volume (MCV) showed variations during the experimental period. Experimental groups such as T_5 and T_2

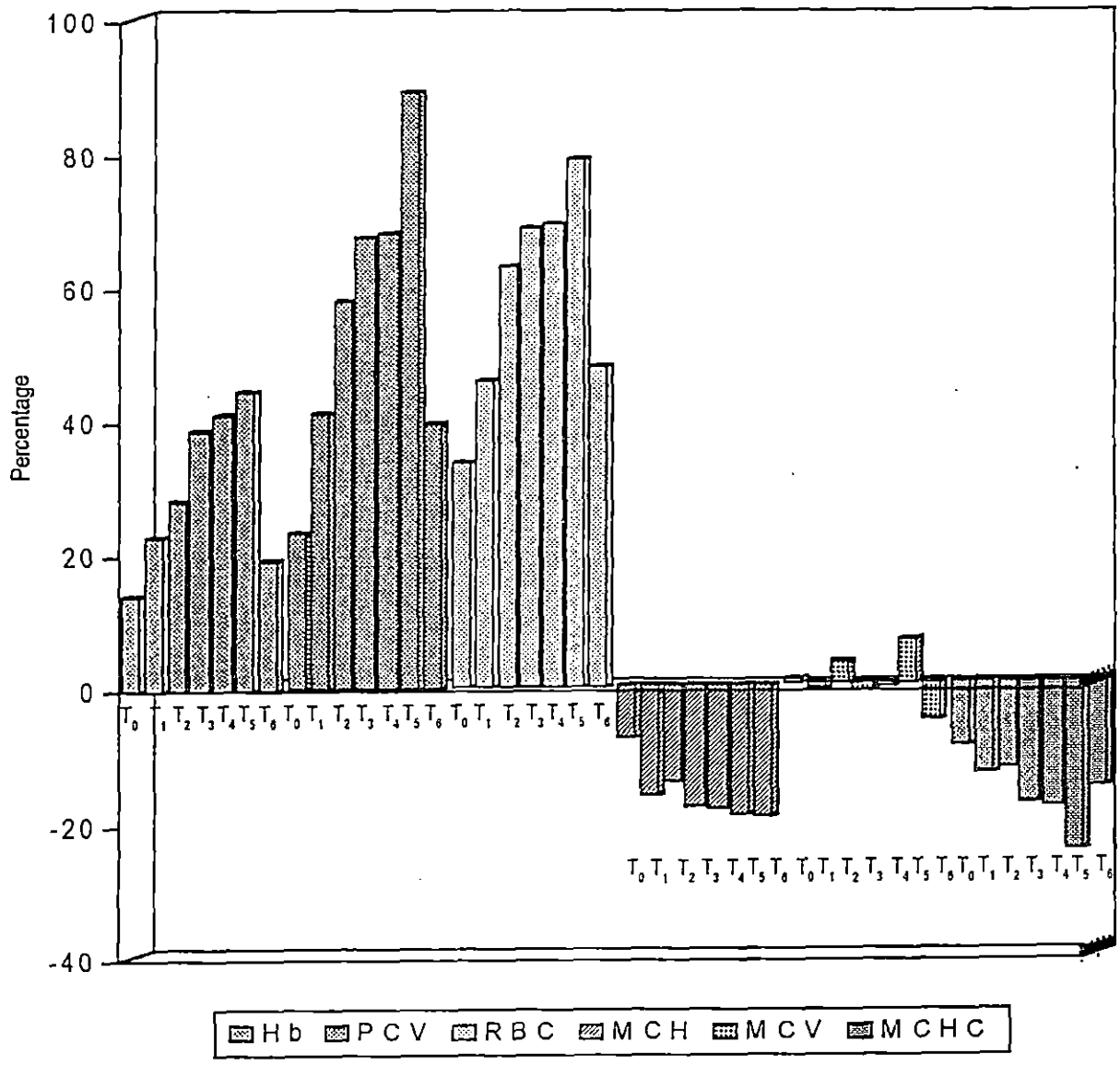
showed an increase of 6.54 per cent and 3.21 per cent respectively in MCV while T_6, T_3, T_1 and T_4 indicated 7.46, 1.20, 0.73 and 0.36 per cent decrease respectively in MCV from the initial values. Control group showed an increase of 0.77 per cent from the initial values of MCV.

Analysis of variance showed no significant difference between the pre and post experimental values of MCV of different treatments and within each treatment group. The values of MCV was found positively correlated with RBC count (r = 0.5171) and MCH (r = 0.7548) at 1 per cent level of significance.

Figure 3 is the diagrammatic representation of percentage of increase in haematological profile due to iron and vitamin supplementation. T_5 was found to have higher rate of change in all the haematological variables viz., Hb level, PCV, RBC count, MCH, MCV and MCHC followed by T_4 in the case of haemoglobin level, RBC count, PCV, MCH and MCHC. T_2 showed the peak rise in MCV.

Table 50 depicts the rate of change in haemoglobin levels during the experimental period. Thirty days after the start of the experiment, the highest rate of increase in haemoglobin level was indicated by T_4 (28.42 per cent) followed by T_5 (27.71 per cent). After thirty days, there was a decreasing trend in the rate of change of haemoglobin levels from the midterm haemoglobin values which was lowest in T_5 (13.23 per cent) followed by T_2 (13.22 per cent). However the highest percentage of increase in haemoglobin

Fig 3. Percentage of increase in haematological profile due to iron and vitamin supplementation



level during the entire experimental period, was produced by T_5 followed by T_4 as represented in Figure 4 and Table 50.

Table 50. Effect of iron and vitamin supplementation on haemoglobin profile

Treatment Numbers	Haemoglobin (Mean ± SD) (g/dl)		
	Initial	30 days after the start of the experiment	Final
T_0 (Control)	9.2± 0.73	9.68± 0.54 (5.22)	10.50± 0.86 (8.47)
T_1	9.44± 0.43	10.64+1.01 (12.71)	11.60± 0.62 (9.02)
T_2	9.44± 0.70	11.64± 0.43 (18.90)	13.18± 0.77 (13.23)
T_3	9.72± 0.11	11.96± 0.30 (18.72)	13.48± 0.41 (12.71)
T_4	9.36± 0.71	12.02± 0.29 (28.42)	13.20± 0.67 (9.82)
T_5	9.24± 0.71	11.80± 0.49 (27.71)	13.36± 0.86 (13.22)
T_6	9.36± 0.67	10.36± 0.43 (10.68)	11.18± 0.29 (9.65)

Numbers in parenthesis indicate percentage of change.

4.5.4. Effect of iron and vitamin supplementation on biochemical profile

Table 51 details the effect of iron and vitamin supplementation on biochemical profile of the subjects. It was found that the change in serum

Fig 4. Haemoglobin curve of the subjects

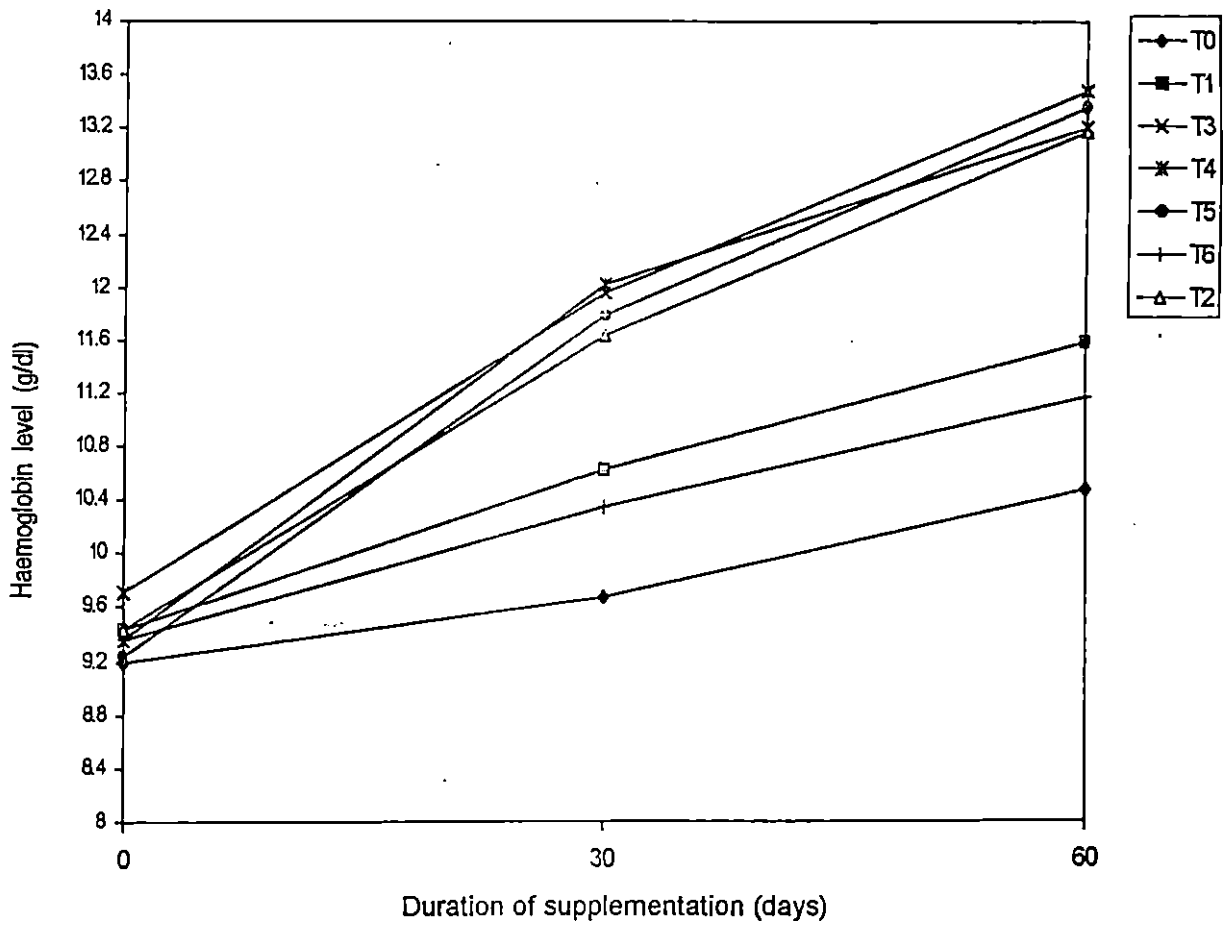


Table 51. Effect of iron and vitamin supplementation on iron profile of the subjects

Treatment Numbers	Iron profile indicators							
	Serum Iron (µg/dl)		TIBC(µg/dl)		Transferrin Saturation (%)		Ferritin (µg/dl)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T_0 Control	40.20	56.00 (39.30)	295.20	315.40 (6.84)	13.66	18.89 (38.29)	35.62	36.20 (1.63)
T_1	40.20	81.80 (103.48)	267.80	272.04 (1.58)	14.82	29.64 (100.00)	22.90	106.33 (364.32)
T_2	40.00	108.40 (171.00)	274.80	273.80 (-4.24)	14.24	43.90 (208.29)	29.20	101.29 (246.88)
T_3	31.40	121.20 (285.99)	293.00	271.20 (-7.44)	10.70	45.94 (329.35)	37.40	101.89 (172.43)
T_4	51.20	123.00 (140.23)	295.60	267.80 (-9.40)	17.27	46.27 (167.92)	33.60	108.62 (223.27)
T_5	47.00	124.80 (165.53)	297.40	260.80 (-12.31)	15.54	47.93 (208.43)	27.30	110.10 (303.30)
T_6	35.00	71.20 (103.43)	272.60	278.00 (1.98)	12.74	25.58 (100.78)	24.40	95.81 (292.66)
Normal values		41-132		250-380		30-40		10-130
$F_{(5,4)}$		21.7569**		4.2316		21.2544**		30.3713**
SE	2.6575	4.8210	5.4717	4.2208	0.7797	2.0489	2.2380	4.3374
CD		17.5343		25.2421		7.5993		13.7347

Numbers in Parenthesis indicate percentage of change from the initial values.

** *Significant at 1 per cent level*

iron of experimental groups due to supplementation ranged from 103.43 to 285.99 per cent and control group showed 39.30 per cent increase in serum iron. The highest percentage of increase was noted in T_3 with iron, folic acid and vitamin B_2 as supplements followed by T_2 (171 per cent rise), T_5 (165.53 per cent rise) and T_4 (140.23 per cent increase). The experimental groups supplemented with iron and folic acid (T_1) and with supplementary foods (T_6) showed almost similar results in percentage of rise in serum iron as 103.48 and 103.43 per cent respectively.

A statistically significant difference was found to exist between the pre and the post experimental serum iron values of different treatment groups ($F = 21.7569$). However, the difference between T_2 and T_3 ; T_1 and T_6 ; and T_0 and T_6 were on par. A highly significant correlation was found to exist between serum iron and haemoglobin level ($r = 0.8796$), PCV ($r = 0.8210$) and RBC count ($r = 0.8205$) at 1 per cent level.

T_1 and T_6 had a positive impact on TIBC which caused 1.58 and 1.98 percentage of rise in TIBC, while T_2,T_3,T_4 and T_5 showed a negative impact on TIBC which ranged from 4.24 (T_2) to 12.31 (T_5) percentage of decrease from initial values. The control group showed highest rise in TIBC (6.84 per cent) from the initial values. However there was no statistically significant difference between pre and post experimental values of TIBC of different experimental groups ($F = 4.2316$).

TIBC showed a highly significant (1 per cent level) negative correlation

with haemoglobin level (r = -0.5859), PCV (r = -0.5909), RBC count (r = -0.6529) and serum iron (r = -0.6673).

The percentage of change in the percentage of transferrin saturation was highest in T_3 (329.35 per cent) followed by T_2 (208.29 per cent), T_5 (208.43 per cent) and T_4 (162.92 per cent). A cent per cent rise in transferrin saturation (TS) was noted in T_1 while T_6 indicated 100.78 per cent rise in TS as the effect of iron and vitamin supplementation. The percentage of rise in TS in control group was as low as 38.29 per cent.

Statistical analysis of the data showed a significant difference between pre and post experimental values of TS of different treatment groups (F = 21.2544) at 1 per cent level. However, the difference was similar in T_2, T_3, T_4 and T_5 and T_0 and T_6.

Transferrin saturation showed positive correlation with Hb level (r = 0.8922), PCV (r = 0.8187), RBC count (r = 0.8408), serum iron levels (r = 0.9676) which were significant at 1 per cent level. Transferrin saturation showed a significant negative correlation with TIBC (r = -0.7273) at 1 per cent level.

Effect of iron and vitamin supplementation on ferritin level was indicated by changes in ferritin values. The highest percentage of rise was indicated by T_1 (364.32) followed by T_5 (303.30), T_6 (292.66), T_2 (223.37) and T_4 (172.43). The control group, without any supplementation (T_0) showed 1.63 per cent rise in ferritin level from the initial value.

Analysis of variance indicated a significant difference between the pre and post experimental ferritin values of different experimental groups (F = 30.3713) at 1 per cent level. The difference in ferritin values of T_1, T_2, T_3, T_4, T_5 and T_6 were on par.

Ferritin showed a highly significant positive correlation ($p = 0.01$) with haemoglobin level (r = 0.6363), PCV (r = 0.6217), RBC count (r = 0.6571), Serum Fe (r = 0.7004) and percentage of TS (r = 0.7010). Serum Ferritin and TIBC were found to be negatively correlated (r = -0.7369) at 1 per cent level of significance.

Effect of iron and vitamin supplementation on biochemical profile as percentage of increase from initial values is diagramatically represented by Figure 5.

As indicated in the figure, T_3, T_5, T_3 and T_1 showed maximum percentage of change from the initial values of serum iron, TIBC, percentage of transferrin saturation and ferritin respectively.

4.5.5. Effect of iron and vitamin supplementation on anthropometric measurements

Anthropometric measurements such as height, weight, Triceps Skin fold Thickness (TST), Mid Upper Arm circumference (MUAC), Arm Muscle Circumference (AMC), waist and hip of the subjects were measured before and after supplementation trials, and the results are presented in Table 52.

Fig 5. Percentage of increase in iron profile due to iron and vitamin supplementation

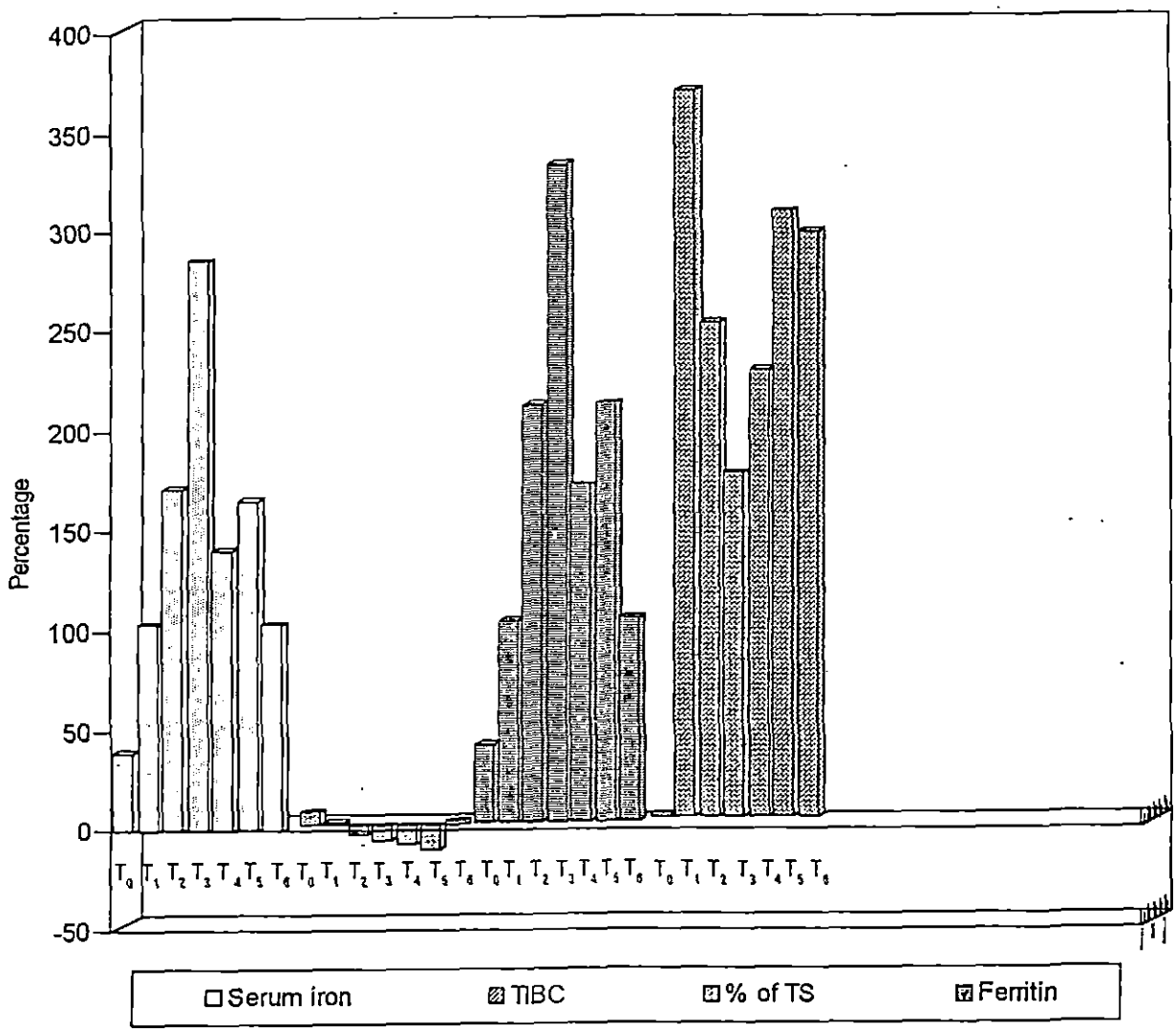


Table 52. Changes in anthropometry of the subjects due to iron and vitamin supplementation

Treatment Number	Anthropometric measurements													
	Height(cm)		Weight(kg)		TSF (mm)		MUAC(in)		AMC (in)		Waist(in)		Hip(in)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T_0	133.60	134.04 (0.33)	26.80	27.10 (1.12)	8.00	8.00 (0.00)	6.84	6.92 (1.17)	7.20	7.26 (0.83)	18.90	18.90 (0.00)	22.60	22.72 (0.53)
T_1	137.60	138.80 (0.87)	27.40	28.16 (2.77)	9.00	9.22 (2.44)	7.48	7.54 (0.80)	7.60	7.88 (3.68)	19.36	19.36 (0.00)	23.72	23.82 (0.42)
T_2	130.40	131.20 (0.61)	24.40	25.34 (3.85)	6.40	7.02 (9.69)	6.70	6.94 (3.58)	7.24	7.70 (6.35)	18.96	19.36 (2.11)	23.28	25.38 (9.02)
T_3	144.20	145.10 (0.62)	30.80	31.62 (2.66)	7.20	8.10 (12.50)	6.92	7.02 (1.45)	7.38	7.52 (1.90)	18.34	18.56 (1.20)	23.52	23.78 (1.11)
T_4	136.00	136.20 (0.15)	28.60	29.20 (2.10)	6.40	7.20 (12.50)	6.80	6.80 (0.00)	6.88	7.24 (5.23)	19.00	19.28 (1.47)	23.56	23.60 (0.17)
T_5	141.80	142.32 (0.37)	36.20	37.02 (2.27)	7.20	8.02 (11.39)	7.22	7.56 (4.71)	7.80	8.04 (3.08)	21.08	22.34 (5.98)	25.08	25.98 (3.59)
T_6	141.00	142.40 (0.99)	34.00	36.70 (7.94)	10.60	13.40 (26.42)	8.08	9.30 (15.10)	8.26	10.00 (21.07)	21.40	22.12 (3.36)	25.64	30.00 (17.00)
$F_{(5,4)}$		1.6413*		8.0573**		16.0323**		29.1634**		12.6114**		14.6250**		9.9498**
SE	1.8450	1.8263	1.4604	1.5018	0.4633	0.5040	0.1570	0.1907	0.1566	0.2034	0.4520	0.4722	0.4667	0.5703
CD		1.0601		0.7840		0.6965		0.2233		0.4740		0.3428		1.5200

Numbers in parenthesis indicate percentage of change from initial values

* *Significant at 5 per cent level.*

** *Significant at 1 per cent level.*

As indicated in the table, percentage of increase in height due to iron and vitamin supplementation among different groups was observed to range from 0.33 (T_0) to 0.99 (T_6) per cent. There was no significant difference between initial and final values of height of different treatment groups, when compared between the groups.

Maximum percentage of increase in weight was indicated by T_6 (7.94 per cent) followed by T_2 (3.85 per cent), T_0 (2.77 per cent), T_3 (2.66 per cent), T_5 (2.27 per cent) and T_4 (2.10 per cent). The control group showed 1.12 per cent increase from the initial values of weight. There was significant difference between the initial and final values of weight of different experimental groups ($F = 8.0574$) at 5 per cent level. The difference in weight of treatment groups from T_1 to T_5 and T_0 were on par. T_6 stood alone with the highest weight gain. Weight of the subjects showed a significant positive correlation with height ($r = 0.8829$) at 1 per cent level.

Data regarding the changes in *Triceps Skinfold Thickness* (TST) showed no change in the case of control group. The lowest rise in TST was indicated by T_1 (2.44 per cent) followed by T_2 (9.69 per cent) and T_5 (11.39 per cent). T_6 showed the highest TST gain (26.42 per cent) followed by T_3 and T_4 (12.50 per cent each). There was significant difference between the pre and post treatment values ($F = 16.0323$) at 1 per cent level in a comparison within the groups. However, the difference between T_0, T_1 and T_2 and T_1, T_2, T_3, T_4 and T_5 were insignificant. T_6 showed significant difference

from all the other treatment groups.

TST was found positively correlated with height (r = 0.4651) and weight (r = 0.5527) at 1 per cent level.

The percentage of change in MUAC ranged from no change (T_4) to 15.10 (T_6) per cent. T_5 and T_2 showed a percentage of rise in MUAC of 4.71 and 3.58 per cent respectively, while that of T_1 and T_3 were 0.80 and 1.45 per cent respectively. Control group (T_0) indicated a rise of 1.17 per cent.

Analysis of variance showed a significant difference between pre and post experimental values of MUAC of different treatment groups (F = 29.1634) at 1 per cent level. Further, it indicated that the difference in MUAC of T_0,T_1,T_2 and T_3; T_0,T_1,T_3 and T_4 and T_2 and T_5 were on par while MUAC of T6 was found significantly different from the other groups.

MUAC was found to be correlated positively with height (r = 0.5902), weight (r = 0.6888) and TST (r = 0.8427) at 1 per cent level.

The highest percentage of change in Arm Muscle Circumference (AMC) was noted in T_6 (21.07 per cent) followed by T_2 (6.35 per cent), T_4 (5.23 per cent), T_1 (3.68 per cent), T_5 (3.08 per cent) and T_3 (1.90 per cent). Control group (T_0) indicated 0.83 per cent rise in AMC at the end of the experiment. A significant difference was found to exist between the pre and post experimental values of AMC of the different experimental groups (F = 12.6114) at 1 per cent level. However, the difference in AMC of T_0, T_1, T_2, T_3, T_4 and T_5 was on par, while T_6 was found significantly different from all the other groups.

AMC was found to be correlated positively with height (r = 0.5561), weight (r = 0.6618), TST (r = 0.7980) and MUAC (r = 0.9675) at 1 per cent level.

The highest percentage of change in waist circumference was noted in T_5 (5.98 per cent) followed by T_6 (3.36 per cent) and T_2 (2.11 per cent). The control group (T_0) and T_1 showed no change in waist measurements during the experimental period. Analysis of variance showed significant difference between pre and post experimental waist measurement (F = 14.6250) at 1 per cent level in between the treatment groups. However, the difference in waist circumferences of T_0 and T_1 and T_2, T_3 and T_4 were on par, while there was significant difference in T_5 and T_6 from the other experimental groups. Waist circumference was observed to have highly significant positive correlation (p = 0.01) with height (r = 0.6806), weight (r = 0.8398), TST (r = 0.5760), MUAC (r = 0.7098) and AMC (r = 0.7047).

The percentage of change in hip measurements ranged from 0.42 (T_1) to 17.00 (T_6) per cent. T_2 showed 9.02 per cent increase in hip measurement from the initial value followed by T_5 (3.59 per cent) and T_3 (1.11 per cent). Other experimental groups such as T_1 (0.42 per cent), T_4 (0.17 per cent) and T_0 (0.53 per cent) showed less than 1 per cent rise in hip measurement at the end of the experiment.

Statistical analysis of the data on hip measurements pointed out a

significant difference between initial and final values of different experimental groups (F = 9.9498) at 1 per cent level. It was found that the difference in hip measurements of T_0 and T_1; T_2, T_3, T_4 and T_5; T_2 and T_5; and T_3, T_4 and T_5 was on par. T_6 indicated a significant difference from the other treatment groups and control group.

Hip measurements were observed to have a highly significant (p = 0.01) positive correlation with height (r = 0.5676), weight (r = 0.6505), TST (r = 0.7793), MUAC (r = 0.8270), AMC (r = 0.8006) and waist (r = 0.7775).

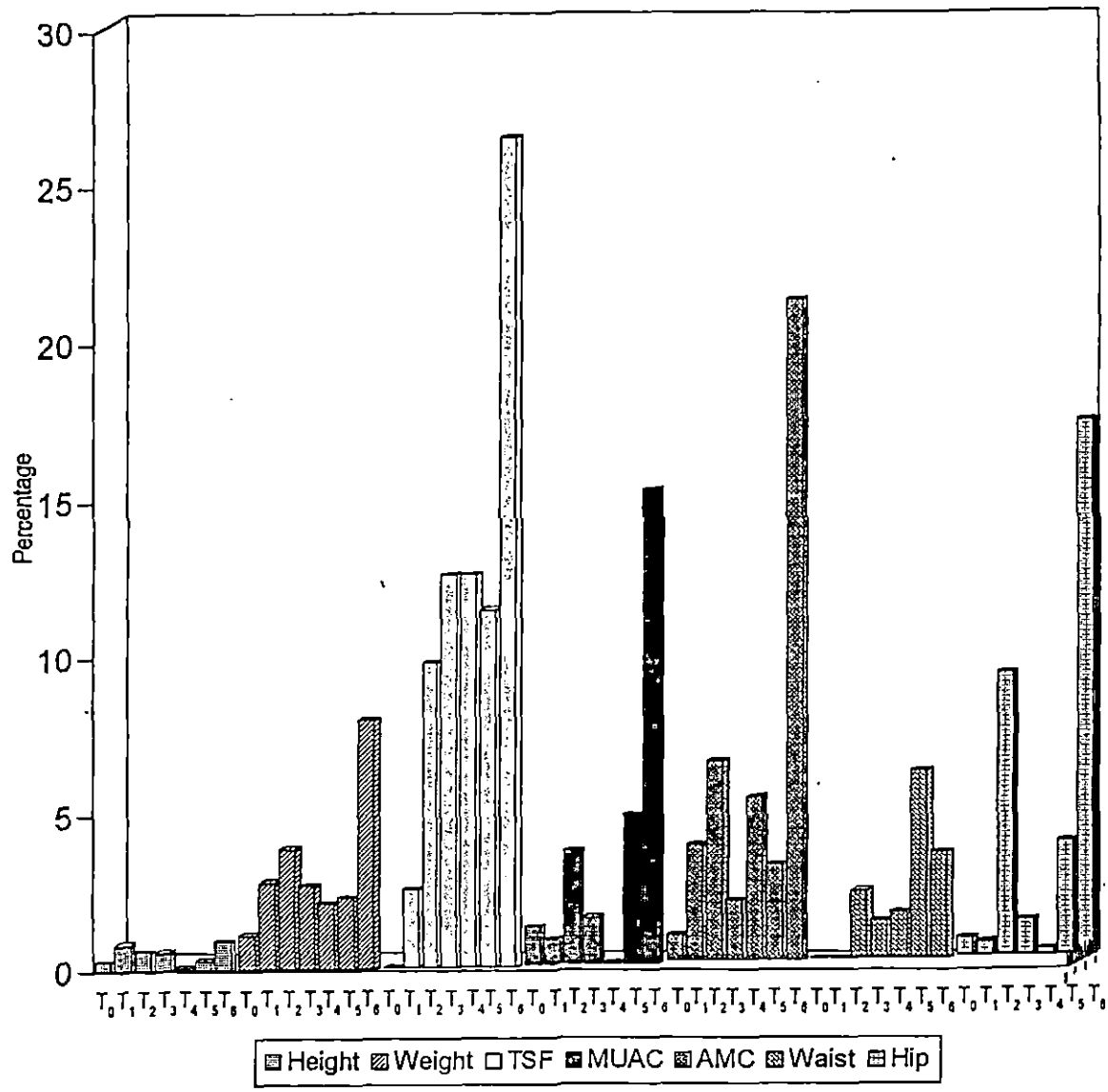
Figure 6 explains the percentage increase in anthropometric measurements due to iron and vitamin supplementation.

As indicated in Figure 6, it was found that T_6, the experimental group with supplementary foods indicated a peak rise in all the anthropometric measurements except waist measurement.

Anthropometric indices such as waist/hip ratio and Body Mass Index (BMI) were worked out. Table 53 explains the effect of iron and vitamin supplementation on these indices.

It was found that highest percentage of change of BMI was given by T_6 (6.24 per cent) followed by T_2 (2.43 per cent) and T_3 (2.20 per cent). 1.78 and 1.71 per cent respectively were the percentage of increase in BMI

Fig 6. Percentage of increase in anthropometric measurements due to iron and vitamin supplementation



resulted in T_4 and T_5. T_1 showed 0.93 per cent rise from initial BMI while the same for control group was only 0.52 per cent. Statistical analysis of the data indicated that there was no significant difference between pre and post experimental values of BMI of different experimental groups.

Table 53. Effect of iron and vitamin supplementation on anthropometric indices of the subjects

Treatment Numbers	Anthropometric indices			
	Body mass index (kg/m²)		Waist / Hip ratio	
	Initial	Final	Initial	Final
T_0(Control)	14.896	14.974 (0.52)	0.8460	0.8340 (-1.42)
T_1	14.392	14.526 (0.93)	0.8180	0.8140 (-0.49)
T_2	14.234	14.580 (2.43)	0.8140	0.7620 (-6.39)
T_3	14.720	15.044 (2.20)	0.7794	0.7800 (0.08)
T_4	14.974	15.240 (1.78)	0.8040	0.8180 (1.74)
T_5	17.550	17.850 (1.71)	0.8380	0.8620 (2.86)
T_6	16.560	17.594 (6.24)	0.8360	0.7340 (-12.20)
$F_{(5,4)}$		2.3292		12.6422**
SE	0.4045	0.3960	0.0089	0.0184
CD		1.2482		3.6480

Numbers in parenthesis indicate percentage of change from initial values

** *Significant at 1 per cent level.*

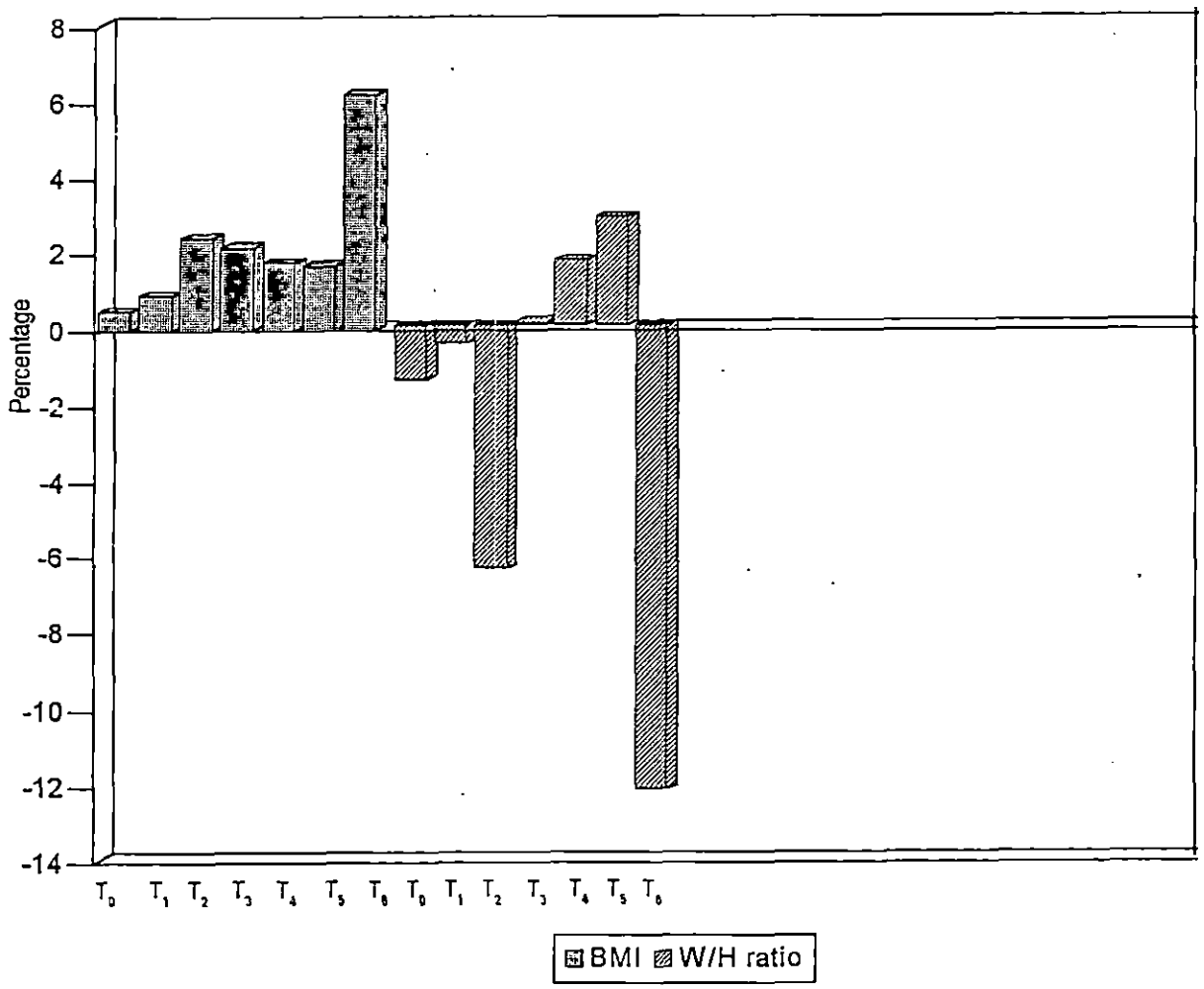
It was found that highly significant positive correlation existed between BMI and height (r = 0.5895), weight (r = 0.8523), TST (r = 0.5136), MUAC (r = 0.6302), AMC (r = 0.6125), waist (r = 0.7435) and hip (r = 0.6089) at 1 per cent level.

Waist to hip ratio (W/H ratio) of T_0, T_1, T_2 and T_6 showed a decreasing tendency, indicative of rise in hip measurements. The percentage of decrease in W/H ratio was highest in T_6 (-12.20 per cent) followed by T_2 (-6.39 per cent), T_0 (1.42 per cent) and T_1 (0.49 per cent). The experimental groups with positive changes in W/H ratio were T_5 (2.86 per cent), T_4 (1.74 per cent) and T_3 (0.08 per cent).

Analysis of variance of the data showed significant difference between pre and post experimental values of W/H ratio of different experimental groups (F = 12.6422) at 1 per cent level. However, the difference in W/H ratio of T_0, T_1, T_3 and T_4 and T_1, T_3, T_4 and T_5 were on par while T_2 and T_6 showed significant difference from each other and from other experimental groups. W/H ratio was found positively correlated with waist measurements (r = 0.3676) significant at 5 per cent level.

Figure 7 is the diagrammatic representation of percentage of change in anthropometric indices due to iron and vitamin supplementation. From the figure it was found that T_6 had the peak rise in BMI while that for W/H ratio similar difference was found in T_5. T_6 indicated highest decrease in W/H ratio from the initial values.

Fig 7.Percentage of increase in anthropometric measurements due to iron and vitamin supplementation



4.5.6. Effect of iron and vitamin supplementation on physical endurance/ work capacity of the subjects

Physical endurance or work capacity of the subjects were measured by assessing aerobic and anaerobic fitness or cardiovascular and muscular endurance of the subjects.

Table 54 is concerned with the effect of iron and vitamin supplementation on aerobic and anaerobic fitness.

The percentage of change in aerobic fitness ranged from 6.00 (T_0) to 29.95 (T_5) per cent. Percentage of change showed by T_6 and T_4 were 25.59 and 23.04 respectively while that of T_2, T_1 and T_3 were 12.80, 11.98 and 8.33 per cent respectively.

Statistical analysis of the data showed a significant difference from pre and post experimental values of cardiovascular (Aerobic fitness) endurance of different experimental groups at 5 per cent level. The difference in aerobic fitness of T_1, T_2 and T_3; T_1, T_2 and T_4 and T_4, T_5 and T_6 was on par and was significantly different from the control group (T_0).

Aerobic fitness or cardiovascular endurance was positively correlated with RBC count (r = 0.3644), BMI (r = 0.3603), TST (r = 0.3995), waist measurement (r = 0.3843) at 5 per cent level of significance and ferritin (r = 0.5165), MUAC (r = 0.4410), AMC (r = 0.4449) and hip (r = 0.4584)

Table 54. Effect of iron and vitamin supplementation on physical endurance

Treatment Number	Cardiovascular endurance (ml of O_2/kg body weight/min) (Aerobic Fitness)		Muscle endurance (Watts) (Anaerobic fitness)	
	Initial	Final	Initial	Final
T_0 (Control)	40.00	42.40 (6.00)	67.63	70.79 (4.67)
T_1	43.40	48.60 (11.98)	60.86	114.43 (88.02)
T_2	42.20	47.60 (12.80)	49.83	108.20 (117.14)
T_5	39.40	51.20 (29.95)	81.46	155.67 (91.10)
T_6	42.20	53.00 (25.59)	71.30	145.06 (103.45)
$F_{(5,4)}$		9.0014*		34.5529**
SE	0.4663	0.6813	3.4600	4.6974
CD		3.4662		12.7508

Numbers in parenthesis indicate percentage of change from initial values.

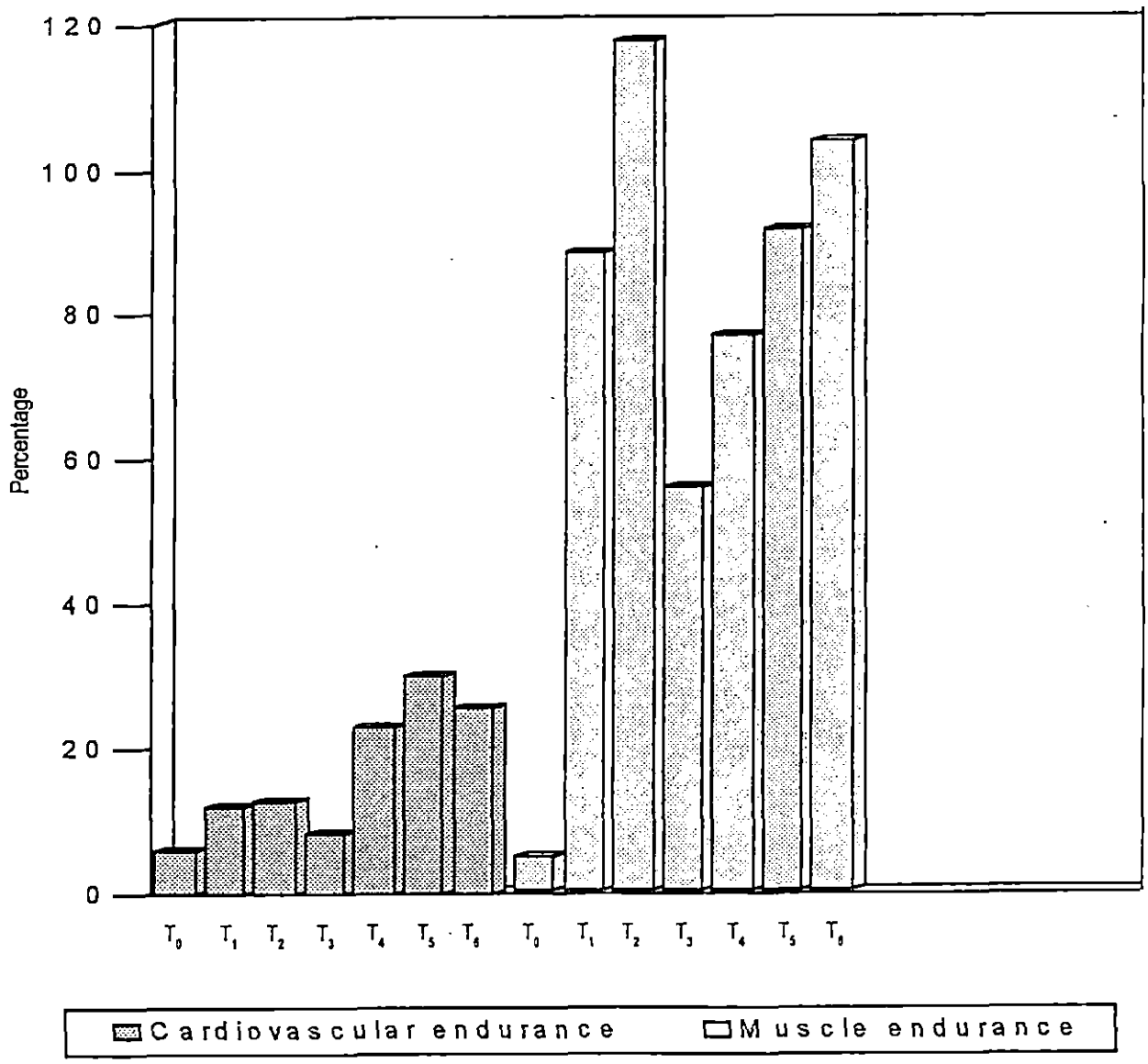
* *Significant at 5 per cent level.*

** *Significant at 1 per cent level.*

at 1 per cent level of significance. Aerobic fitness and MCH (r = 0.3607, p = 0.05) and MCV (r = 0.4300, p = 0.05) were found negatively correlated.

Highest percentage of change in anaerobic fitness or muscular endurance

Fig 8. Percentage of change in cardiovascular and muscle endurance due to iron and vitamin supplementation



was indicated by T_2 (117.14 per cent) followed by T_6 (103.45 per cent), T_5 (91.10 per cent), T_0 (88.02 per cent), T_4 (76.40 per cent) and T_3 (55.59 per cent). The control group showed 4.67 per cent rise in anaerobic power (Anp) at the end of the experiment.

It was found that there was significant difference between pre and post experimental values of Anp of different treatment groups (F = 34.5529) at 1 per cent level. The difference in Anp of T_1, T_2, T_3 and T_4 and T_5 and T_6 were on par.

Anaerobic fitness or muscular endurance was found positively correlated with Hb level (r = 0.4028), PCV (r = 0.4168), height (r = 0.3994) at 5 per cent level and RBC count (r = 0.6175), MCH (r = 0.4847), Serum iron (r = 0.4560), ferritin (r = 0.6607), percentage of TS (r = 0.4587), weight (r = 0.5646), BMI (r = 0.5662), MUAC (r = 0.5090), AMC (r = 0.5077), waist (r = 0.5742), and hip (r = 0.5613) at 1 per cent level of significance.

Anaerobic fitness was found negatively correlated with MCV (r = -0.5196) and TIBC (r = -0.6097) significant at 1 per cent level.

Aerobic and anaerobic fitness were intercorrelated (r = 0.6500) and were found to be significant at 1 per cent level.

Percentage of change in cardiovascular and muscle endurance due to iron and vitamin supplementation is diagrammatically represented in Figure 8. From the figure, it was found that T_5 and T_2 showed the peak rise in cardiovascular endurance and muscle endurance respectively.

DISCUSSION

DISCUSSION

Adolescence is a crucial period of rapid growth and development with increased demand for nutrients as well as increased susceptibility to micro nutrient deficiency especially iron deficiency. Iron deficiency anemia is the most common form of dietary deficiency among adolescents. There is a dearth of information about this situation among adolescent girls.

5.1 Prevalence and magnitude of iron deficiency among adolescent girls

Reports of WHO (1993) had indicated that in India, more than 25 per cent of the adolescent girls are affected by anemia. In the present study around 49 per cent of adolescent girls surveyed were found to be anemic. But Kellog's Nutrition Advisory service (1997) found that around 7 per cent of the girls in New Delhi and over 16 per cent girls in nearby villages of New Delhi had haemoglobin levels less than 10 per cent. While surveys conducted by Shivaji (1999) in Chennai found a higher rate of prevalence of anemia at 88 per cent. According to Sarala (1996) iron deficiency anemia is prevalent in 50 to 80 per cent of Indian population. Reddy et al., (1993) noted 50 per cent of Indian women have iron deficiency anemia.

5.2 Socio economic variables responsible for iron deficiency anemia

Economic and social conditions are reported to affect the nutritional status of an individual (Gibson, 1990). Documentation and analysis of socio

economic differences between households is considered to be complementary to an understanding of the causal processes of iron deficiency operating within the households.

Nutritional deficiency diseases, occur endemically in the greater part of the developing world are the end product of under development and mass poverty (Balakrishnan, 1990). According to Kellog's Nutrition Advisory Service (1997) prevalence rate of anemia among adolescent girls is very high in rural areas (81 per cent) than in urban areas (62 per cent). Balakrishnan (1990) found that the iron deficiency anemia in rural India is much more widespread. In the present study also majority (84.89 per cent) of the anemic adolescent girls surveyed were from rural areas.

Nuclear type families were found to be more popular in the areas surveyed. Earlier studies conducted by Karuna (1993) among fishermen families (64 per cent), by Jyothi (1993) among stone breaking women (79 per cent) also indicated the common prevalence of nuclear families in these areas. Besides the type of family, in this context, present study pointed out the significance of religion and caste of the respondents also.

The average size of the families surveyed were found to be 5. Chi-square analysis of the data in the present study also indicated influence of religion and caste of the respondents. Out come of similar studies in the area by Krishna (1988) Karuna (1993) and Jyothi (1993) have also stated average

family size as 5.6, as 5 and as 5.8 respectively. In the surveys conducted by Rameshwar (1993) in Andra Pradesh and Madhya Pradesh also reported average family size as 5 and 6 respectively.

Average family income was in the range of Rs 1501 to 2000. This finding is found to be similar to the findings of a survey conducted by Government of Kerala (1990) in which 85.00 per cent of the households were in the income group of Rs 1000 to 2000 per annum.

Regular employment become the major source of income in 41.28 per cent of the families. 58.72 per cent of the families depended on other sources such as agriculture, fishing and fish vending, coolie work and petti business for an income. Family income was significantly influenced by the location of residence, religion and caste of the respondents,. The source of income of the familyhead was greatly influenced by religion and caste and not by the location selected for the house.

Majority of the families were from Hindu communities (67.11 per cent) followed by christians (29 per cent) and other backward classes (76.44 per cent). This distribution is found to be in conformity with the apportionment of the population in Trivandrum district (Manorama Year book, 1997).

Many families (56.89 per cent) had 1 to 2 children. The average number of children in the families was found to be 3 with a sex ratio of

1000 male children for 2000 female children and the family size was found to be directly influenced by occupational status of the family head. However in comparison with other states Nevin (1994) has opined that, Kerala with relatively poor per capita income has the lowest fertility rates.

Vinodini *et al.* (1993) found that at the country level, sex ratio is low in all states, except in Kerala. Raman (1990) has also observed that females have always outnumbered males in Kerala and have attained females favourable sex ratios in Kerala society. Sex ratio in Trivandrum district as per Manorama Year book (1997) was 1000 males for 1036 females. In the present study also the male female ratio in the families surveyed was found to be 1000 males for 1500 females.

Girippa (1998) observed that female headed households had poor survival chances greater dependency on wage income, high rate of involuntary unemployment and illiteracy. As per the observation of Onyango *et al.* (1994) children of female heads had an opportunity to consume a greater variety of foods. In the present study, very few families had come under this category.

Literacy and educational attainments are the indicators of qualitative improvements in human resources and female literacy is said to hold the key to the generation of full genetic potentials pertaining to health and nutrition and for family planning. Female literacy is also indicative of better nutritional status. However information regarding the ways to improve the quality of life

and to realise basic human rights including rights for better nutrition are not furnished through any education programme (Saramma, 1997). But the socio economic and literacy status of the family members are influential on variations in health and nutritional status, intake of foods and dietary habits of children as observed by Viswewara Rao (1987). However in the present study majority of the respondents and their parents had better educational status.

The average monthly income of the families surveyed was in the range of Rs 1501 to 2000 and were also found to be comparable with the findings of earlier studies (Karuna, 1993 and Government of Kerala, 1990).

Assessment of per capita monthly income of the families showed that majority of the families had Rs $\geq$ 500 as per capita monthly income. As per Manorama Year book (1997), the per capita monthly income of the families in India was Rs 686.40. Per capita monthly income of the families were also found to depend on the maintenance of domestic animals (47.53 per cent) and birds (55.56 per cent).

Socio economic variables such as location of the house, religion, caste, type of the family, family size, family income, sources of income, educational status and economic status of individuals, which are the constant antecedants of nutritional disorders, are found to have nothing much to contribute in this context, for the prevalence of anemia since many respondents in a congenial situation are also found to be the victims of moderate anemia.

5.3 Nutritional variables responsible for iron deficiency anemia

A number of nutritional variables are known to cause iron deficiency anemia. Among them food habits, food expenditure pattern of the families, frequency of use of different food items, People's Quality of Life Index (PQLI), dietary habits, food and nutrient intake of the respondents, caloric consumption index and knowledge of respondents regarding anemia were selected to assess their possible role on the prevalence and aeitiology of nutritional anemia due to iron deficiency.

Majority of the families are observed to be habitual nonvegetarian and confirms the results of earlier studies (Suja, 1989., Felsy, 1989., Sujatha, 1990 and Karuna, 1993) done in Trivandrum district. Kerala diets can also be considered as a representative of Indian diet since it is also based on cereals which is consumed by majority of Indian population (Narasingha Rao, 1994).

Many families (79.12 per cent) surveyed were found to spent more than 70 per cent of their family income on food. According to NSSO (1991), a major portion of the income of an average Indian is spent an food. A rural Indian spends relatively more on food (64 paise) as compared to his urban counterpart (57 paise) as it is the position in many Indian families residing in different states in the country (Wadekar *et al.*, 1998 and Karuna, 1993).

Percentage of expenditure on food has been observed to be influenced by family income and per capita income, indirectly indicating the influence of family size. Percentage of expenditure on food is also found to decrease with increase in per capita income. In other words, a household's welfare is unambiguously indicated by its income per adult equivalent. As in this study, Wong *et al.* (1985) has also found a direct relation between family income and expenditure on food. However a number of sound econometric studies indicate that changes in household incomes and food consumption have comparatively smaller effects on malnutrition, at least at the margin and in the short run (Horold, 1993). Thomas *et al.* (1990) and Harold (1993) have also found that an increase in wages increases the intake of some nutrients and one of the reasons for iron deficiency anemia is decreased intake of foods rich in iron (Abdulrahman, 1996).

In this context, anvil variables such as family size, number of highly educated members in the family, number of employed persons in the family and family income showed significant positive correlation with monthly expenditure on food. Similar findings have been reported by Karuna (1993).

Among the various socio economic variables studied, few variables such as caste, educational status of the respondents, occupational status of the head of the family, family income, per capita income, expenditure on food as percentage of monthly income and calorie and protein requirements of adolescent girls, were taken into consideration to develop an index by which quality of life of the families of anemic adolescent girls were assessed.

Caste was selected as an important indicator of economic progress of the family since it was considered to be an important input hampering economic progress (Government of India, 1981). Dhanasekharan (1991) has also reported that, in India caste system is one of the major reasons for perpetuating poverty in rural areas.

Ignorance is abysmal in the socio economically under privileged among whom the maximum number of deaths and illness occur (Saramma, 1997) and ignorance is one of the most important factors underlying poverty (Rajammal, 1993). The lower social status of women is reflected in the low educational status of women (Saramma, 1997). Thus education is one of the dynamic factors on the development of an individual and an essential component as the cultural resolution for stimulating equality among people of both sexes (Charyulu and Narayana, 1987). Further education is recognised as an important social input which helps an underdeveloped community to seek ways and means of bringing about changes to develop itself and solving its social and economic problems (Government of India, 1981). The prevalence of nutritional deficiency diseases was higher among people with lesser educational status than in highly educated groups (Rajammal, 1994). Hence educational status of the respondents was considered as an indicator of their quality of life.

Occupational status and hence family income are also indicated as factors related to quality of life (Karuna, 1993). The heterogeneity in the occupational status and family income of the surveyed population justifies the inclusion of these factors as variables for determining the quality of life.

Moreover families with a relatively higher proportion of unemployed persons as well as other dependents (old persons and children) have lower per capita income. Hence per capita income of the family is found to have direct relation to the quality of life.

Magnitude of poverty as observed by the Central Bureau of Health Intelligence (1991), Lipton (1989) and Rao (1987) is often assessed based on the per capita monthly expenditure on food. In this study also, it was accounted that, the poorer the household, the higher would be the percentage of income spent on food.

Another yardstick for measuring poverty as propounded by Planning Commission (Mathur, 1982) is the calorie intake. Poverty lines are defined on the basis of mean calorie intake and if it is less than 2400 kcal/cu in rural areas and 2100 kcal/cu in urban areas, then the families are considered to be below poverty line (CBHI, 1991). The diet surveys carried out in India showed that a sizeable proportion of the population belonging to low income groups and with low quality of life was unable to fulfill the requirements of nutrients like calories and proteins (Krishna, 1988). Because of these reasons, in the present study, calorie and protein requirements were considered as the basis for developing the quality of life index using approved RDA suggested by ICMR (1990).

In Kerala, 17 per cent of the population is under poverty line as disclosed by CBHI (1991). Physical quality of life index developed using

different indicators mentioned that all the families were poverty stricken due to poor socio economic and cultural living conditions. Major findings of Karuna (1993) revealed that 100.00 per cent of fishermen families in the same district were under poverty line. Salient findings of this study was also found to be an alliteration of the earlier surveys conducted in the same area.

As indicated in food use frequency scores, food articles viz,, cereals (rice), nuts and oil seeds (coconut), fats and oils, sugar and jaggery and beverages like coffee or tea were the most perpetually used foods in the dietaries of all the respondents. Mony (1993) observed that cereals, vegetables, roots and tubers, milk, fish, fats and oils, sugar and jaggery and spices were the high frequently used food items by the adolescents and these food items had a food use frequency score of above 60. Use of milk and milk products in the dietaries was also observed to be depended on tea or coffee drinking habits of the respondents. Similar results were also obtained for Karuna (1993) and Jyothi (1993) in their studies among fishermen families and stone breaking women.

Pulses, roots and tubers and other vegetables, formed the moderately used foods. This observation is contradictory to earlier studies conducted in the same district (Annon, 1987., Krishna, 1988., Sujatha, 1990., Karuna, 1993., and Jessy, 1996). A projected fact in this context is that frequency of use of pulses and other vegetables were found to increase from, "occasionally or least frequently", used foods to "moderately used" ones. This change in the

frequency of use of food items which are the major sources of proteins and vitamins may be due to the impact of increased literacy and nutrition education movements going on in Kerala. But similar target in the frequency of use of food items, viz., green leafy vegetables, fruits, egg, meat and fish has not been attained probably because of their cost or due to the diminished importance given to these foods. Commercially prepared foods formed the least frequently used food items.

An underlying cause and fundamental constraint in solving micro nutrient problem is that the non consumption of the above non staple foods particularly animal products, which are the foods richest in bioavailable nutrients, probably because of their cost (Howarth, 1996) and by increasing the availability of these foods, the prevalence of micro nutrient deficiencies can be reduced (Vijayaraghavan, 1994).

Dietary variety depends on economic and cultural factors, (INACG, 1989). Among the families surveyed frequency of use of cereals and cereal products were found unaffected with variation in family income, educational level of members and PQLI worked out for each family. This finding was supported by the results of Radolfo (1990) in which he found that intake of cereals, especially rice was constant across age, gender and religion with the highest intake seen in lower income groups who had the highest prevalence of anemia.

Similar association was observed in the frequency of use of bengal gram, cow pea and black gram. However, the number of employed persons in the family showed significant positive correlation with the frequency of use of bengal gram and black gram, which were generally used for the preparations, occasionally used by the low income families.

Legumes were underutilized probably because of their cost and presence of antinutritional factors and flatulence factors.

The frequency of use of chekkurmanis, the iron rich green leafy vegetable, showed significant negative correlation with family income and PQLI. Rural communities were observed to consume a variety of seasonal and perennial green leafy vegetables but not on a regular basis (Vinodini, 1996).

India is reported to be the second in the production of fruits and vegetables. However, the per capita availability of vegetables, is low and its distribution is unequal for favouring high income groups (Vijayaraghavan, 1994). In this study also, frequency of consumption of vegetables was correlated with the number of employed persons in the family and family income.

Frequency of use of fruits is found to be influenced by educational status of the respondent ($r = -0.1736$). As per earlier observations, educational level of rural women, has little impact on food consumption or nutritional status (Evenson (1986)). A significant positive association was found between family income and frequency of use of animal foods. Among the different

variables studied income, occupational level and family size were the major variables affecting the food intake of the families.

Majority of the respondents were in the habit of consuming a minimum of three meals a day. Mony (1993) observed in her study that adolescents took 4 meals a day.

Adolescents usually have a good appetite and their liking for sweets and peer influence may develop a habit of nibbling between meals. Likes and dislikes of adolescents regarding various foods may make their diet deficient in major nutrients especially in proteins. However, in the present study, foods consumed in this order were observed to supplement their food. Bundy *et al* (1982) revealed that snacks provided several dietary components particularly energy, vitamin B_6, iron and magnesium to adolescents.

Similarly during festive occasions nutrient rich foods were observed to be included in their diets.

Karuna (1993) observed that majority of the families supplemented breast milk with cow's milk. Similar findings were also observed in this study also. In the present study 7.11 per cent of the families added sugar based sweet foods, green leafy vegetables, egg and fish preparations into the infants diet.

During infancy after six months of age complimentary foods such as milk and milk products as source of protein and calcium, other animal products

as source of iron and zinc and fruits and vegetables as sources of vitamins especially vitamin A and C are to be given to infants. In this context,many families (6.22 per cent) were not found to be habituated to such practices. When introduction of complementary food is delayed beyond six months, breast milk is found, insufficient to meet child's nutritional requirements. Urban (1997) has also observed that in many parts of South Asia, complimentary foods are introduced too late. Only one third to half of the number of infants are given mushy or solid foods by the nineth month.

Pre school age period is an important time for health and future development of the child. In this study, sugar based food items, green leafy vegetables,egg, cow's milk and fish preparations were the special foods given to pre schoolers by 78.67 per cent of the families surveyed. But Suja (1989) had observed, inadequacy with respect to quantity and quality of foods given to pre schoolers. Bhat and Dahiya (1985) also had indicated that majority of Indian children received only ordinary home diets, deficient in many nutrients like vitamin A,C and iron.

Adolescent female is a stakeholder, that has not been a target of nutrition intervention (ACC/SCN, 1997). Poor nutrition and poor supplementation at home and community levels and increased demands for nutrients may make adolescent girls vulnerable to micro nutrient deficiencies. It was regretting to observe in this study, that majority of adolescent girls (88.89 per cent) were not given special foods to nourish their daily diet.

Interactions of nutrition and infection with regard to individual infections and defined nutrients are now better known. Most infections or diseases call for a change in the dietary intake both in the consistency and nutrient content of diet to be consumed. Nutrition is relevant to disease management because dietary interventions during and immediately after infectious diseases can affect the cause and effects of the disease and reduce the extent to which nutritional status suffers or nutritional disorders develop.

Vitamin A deficiency is observed to occur during and in the immediate post infection phases of measles and respiratory tract infections and vitamin A supplementation has been shown to be effective in reducing case fatality, preventing further infection and promoting recovery as observed by WHO (1988). In the present study, in majority of the families, common infections included fever and diarrhoea and the dietary modifications include a change from solid to liquid food. According to Nevin (1994) fever increases basal metabolic rate approximately 13 per cent for each 1°C. Hence during a period of high fever, metabolism may increase nearly one third. In Meghalaya, among Khasi rural population bland diets are found to be suitable during fever, chickenpox and malaria (Parvathi and Babitha, 1989). Similarly, withdrawal of food from individuals suffering from fever, diarrhoea or other symptoms of infection is also found to be an universal practice. During acute diarrhoea, a high level of absorption of micronutrients is maintained but in persistent diarrhoea, there may be more severe malabsorption with endogenous nutrient

loss (Andrew and Fiona, 1989). Since diarrhoea and arterial and respiratory infections are very common in South Asia and contribute significantly to the high prevalence of PEM, due attention need to be given to the therapeutic aspects of diet. Moreover, Urban (1997) has noticed about prevalence of PEM in Kerala as 32 per cent. According to Martorell and Ho (1984) food support given to malnourished children may not make them less susceptible to infection, but the severity of any given infection is clearly reduced, thereby reducing child mortality. Many respondents in this study were unaware of the modifications, to be made in diarrhoea, jaundice, chicken pox and respiratory or chest infections. In this context, observation of Thomas *et al.* (1990) that maternal education should be complimentary in producing health. Studies conducted by Gillespie (1997) and Deepti (1997), also found a high correlation between adult education and child nutrition.

Cooking methods administered do have an effect on the nutrient content of preparations. Major cooking methods practised by the families were boiling and draining of excess water (cereals and roots and tubers), boiling (pulses, other vegetables, flesh foods and milk) and frying (green leafy vegetables and egg). Cooking methods with reduced nutrient loss such as simmering, steaming, pressure cooking, soaking or sprouting before boiling, roasting, stewing, baking, condensing and boiling and fermenting were practised by very small percentage of the families. This observation is also indicative of lack of education regarding scientific culinary practices among these households.

The 24 hour recall survey being valid, relatively simple with high response rate (Soares *et al.* 1994) was conducted and it was revealed that the intake of various foods was not balanced or adequate. In this context, common error problems which may occur due to the intrusive nature of the method which may embarrass poor households into reporting more than the actual amount consumed on that day are to be taken into consideration (Osmani, 1997).

An adequate diet or balanced diet which provides all the essential nutrients in sufficient quantities and properties is essential to meet the needs of the body.

Cereals formed the major staple of the diet. It was found that 95.80 per cent of the RDA for cereals was met. Similar trends has been reported in NNMB (1994) reports of studies conducted in Trivandrum among slum dwellers and in NNMB reports (1996) in rural Kerala among adolescents, where 74 to 95 per cent of the RDA for cereals has been found to be met. Renu (1993) also got the same results among adolescents of Agricultural labour families in Trivandrum.

Consumption of roots and tubers, nuts and oil seeds, fish, sugar and jaggery were also observed to be equal to or above the RDA levels. NNMB (1994) surveys among the urban slums of Trivandrum also indicated that the consumption of roots and tubers, nuts and oil seeds, fish and sugar and jaggery were comparable to or higher than RDA. But NNMB (1996) data on

rural adolescence in Kerala indicated that the consumption of sugar and jaggery and roots and tubers were respectively 60 per cent and 54.67 per cent of RDA. However, the NNMB data further points out that 145.57 per cent and 100 per cent of RDA were met respectively by the consumption of nuts and oil seeds and fish. Mony (1993) and Jayantha (1993) found that consumption of fish was very high (2 to 3 times of RDA) among adolescent females in Trivandrum.

Contradictory to the present findings on the consumption of fruits, NNMB (1994) survey findings on the consumption of fruits was very less (14g/Cu/day) in slum areas of Trivandrum. The level of consumption of fruits in the present study was 100.07 per cent of RDA. This may be due to the increased availability of fruits to the respondents, residing in rural agricultural areas. Earlier studies (Renu, 1993) and Jayantha (1993) indicated that fruit consumption of adolescent females in adjacent areas of Trivandrum were either adequate or above RDA levels. This argument to an extent will be supported by the NNMB (1996) data on consumption of fruits by the rural adolescents of Kerala, where 75.57 per cent of RDA for fruits was met and this was 1.6 times higher than the RDA for fruits met by Urban slum dwellers in Trivandrum as reported in NNMB (1994) surveys.

Unlike other food articles, in their diets, inclusion of fats and oils was much lower than RDA specification. Only 23.50 per cent of the RDA of fats and oils was met. This finding was also on the line with the findings

of Renu (1993), Jayantha (1993) and NNMB (1994) data elicited from urban slums of Trivandrum city, in which it was observed that fat and oil consumption was < 30 per cent of RDA (9g/Cu/day). NNMB data (1996) on rural Keralite adolescents also indicted similar results in which 22.50 per cent of RDA for fats and oils was met.

NNMB (1994 and 1996) survey datas indicated that consumption of major sources of iron such as green leafy vegetables, was 40 per cent and 5.3 per cent of RDA respectively. Adolescents in rural Kerala were found to consume meat and other flesh foods, meeting 54.43 per cent of RDA (NNMB, 1996) In the present study, consumption of green leafy vegetables and meat was far below the RDA level and the deficit observed was greater than 80 per cent of RDA. This finding was supported by 1993 data on adolescent females from agricultural labour families in Trivandrum (Renu, 1993 and Mony, 1993).

Consumption of other vegetables was found better than that of green leafy vegetables since 71.86 per cent of RDA was met for these foods. Similar results were observed in surveys conducted by NNMB in 1994 and in 1996, where 65 per cent and 113.34 per cent of RDA respectively was met for other vegetables. In Kerala more than 45 varieties of green leafy vegetables have been identified as edible ones and sufficient importance is not given at present to include these nutritious foods in the daily dietaries probably because of ignorance. These inferences point out that green leafy vegetables are expected

to be replaced by the increased inclusion of other vegetables in the dietaries, indicative of a change in consumption pattern during the years. Pietinen *et al.* (1996) have felt that with increasing urbanization, many habitual dietary patterns and life styles have changed and this has brought nutritional problems ranging from an adaptation to unfamiliar and costly diet to serious nutritional problems. However in neighbouring states during the last 10 to 15 years there was no significant change in the consumption pattern of households despite an impressive food production in the country (Chittemma, 1993).

Only 32.88 per cent and 20.13 per cent of RDA was met respectively from protein rich foods like pulses and egg. NNMB (1994) observed that the average intake of pulses in Trivandrum was 10g, 25 per cent of RDA while as per NNMB (1996) data on rural adolescents of Kerala, 46 per cent of RDA was reported to be met from pulses.

73.35 per cent of RDA specified for milk and milk products was observed to be met as an ingredient in tea and coffee. According to coffee drinking habit, quantity of milk consumed differs. NNMB (1994) data for Trivandrum indicated that 65.33 per cent of RDA specified for milk was met for the slum dwellers of Trivandrum, while NNMB (1996) data showed that only 41.11 per cent of RDA for milk was met for rural adolescents of Kerala. Earlier studies (Renu 1993) and Mony (1993) indicated that below 40 per cent of RDA for milk was met by adolescent females.

Socio cultural attitude is found to influence considerably household nutritional care of girls in their natal homes (Meera and Julian, 1990). In this study, family size is found to have a significant negative relationship with consumption of cereals (r = -0.1834) and green leafy vegetables (r = -0.1972). Similar results, though statistically insignificant was observed in the quantity of consumption of milk, nuts and oil seeds, fats and oils, sugar and jaggery and eggs. A negative relationship between family size and food intake was observed by Karuna (1993). But Thimmayamma (1983) has reported that as family size increased, the food distribution among family members become improper due to low purchasing power and faulty food habits.

In the present study, all food items, except meat, fish and green leafy vegetables were found to have a positive but insignificant association with family income, while, "meat" is found to have a highly significant positive relationship (r = 0.1816 at 1 per cent level) with family income, indicating indirectly the cost of meat as reason for the exclusion. Reason for inclusion of fish from this category may be its comparitively low cost. Again exclusion of green leafy vegetables only shows that people will turn to this only when no other foods are available. NNMB (1994) observation supports this finding as the quantity of the diet appeared to improve with increase in income and also with the regular source of income of the families with particular respect to the consumption of protective foods like pulses, milk, fish , vegetables etc. Gillespie (1997) has commented that food use frequencies are directly related to the purchasing power.

Similar association was observed with the variation in number of employed persons in the family, which has a significant positive correlation with the intake of roots and tubers (r = 0.1447 at 5 per cent level) but insignificant positive relationship with consumption of milk, fish, sugar and jaggery, fruits and meat.

Education of an adult male or female member in the household at least above the primary level is reported to improve child nutrition significantly. In this study also, educational status of the respondents showed positive relationship with the intake of fats and oils, sugar and jaggery and egg. However it showed negative and significant correlation with consumption of fish. A significant positive correlation was found between educational status of the mother of the respondent and consumption of vegetables, milk, fruits and meat by the respondent. But the same variable was found to be negatively correlated with consumption of fish.

PQLI worked out with selected socio economic variables found to have positive correlation with the consumption of milk, fats and oils, sugar and jaggery and meat. The index was found to have a positive relationship with other foodstuffs eventhough statically insignificant. These findings indicate that with the improvement in the quality of life of the people, there was simultaneous increase in the quality and quantity of the food they consumed.

Data on the nutrient intake by the adolescent girls revealed that their diets were inadequate in proteins, carbohydrates, calcium, iron, carotene and

riboflavin. 77.44 per cent and 94.51 per cent of RDA for proteins and carbohydrates respectively were found to be met. Mony (1993) and Jayantha (1993) found that above 90 per cent of RDA for proteins was met by adolescent females in Trivandrum. NNMB (1994) data also indicated that protein intake of slum dwellers in Trivandrum is above RDI specification because of high intake of fish while NNMB (1996) data on rural adolescents in Kerala indicate a deficient protein intake by these groups meeting only 72.58 per cent of RDA.

In the present study, the fat intake of the respondents was far above the specifications of RDA. Similar findings were observed in NNMB (1996) surveys also, where 186.80 per cent of RDA for fats was found to be met.

Eventhough there was deficiency in protein and carbohydrates in the diets of the respondents, their energy intake was found to be in compliance with RDA, possibly due to the high fat intake which increases calorie density. In 1993, Mony, Renu and Jayantha reported that energy intake of adolescent females was in the range of 85 to 90 per cent of RDA. NNMB (1994) surveys indicated that the average intake of energy among slum dwellers varied from a minimum of 1685 kcal (72 per cent of RDI) in Hyderabad to a maximum of 2249 kcal (96 per cent of RDI) in Trivandrum, while the energy intakes of rural adolescents of Kerala was observed to be 82.36 per cent of RDA (NNMB, 1996).

Protein calorie adequacy of a diet is observed through protein energy per cent (ICMR, 1992). In the present study, PE per cent of the diets was observed to be 9.31 per cent. ICMR (1992) has opined that the PE per cent between 8 and 12 would indicate protein adequacy provided its energy needs are met. The present study indicated a high fat intake (194.59 per cent of RDA), which may fulfill the energy needs of the adolescent girls. Fat is important in the diets of young children to ensure adequate intake of energy without making the diet bulky.

This finding is contradictory to NNMB (1994) data on slum dwellers, in which they found that the diets were deficient in energy than in protein. However, they commented that the diets were inferior to those of rural households, particularly with respect to energy intakes and 44 per cent of households from Trivandrum slum areas were consuming calorie deficient diets.

The present study indicated that the consumption of phosphorous, thiamine, niacin, folic acid and vitamin C were above RDA levels. Mony (1993) reported that intake of thiamine, niacin and vitamin C were higher than the RDA for adolescent females who were from Trivandrum. NNMB (1994) data showed that intake of vitamin C in Trivandrum slum dwellers was observed to meet 97.50 per cent of RDA, while for thiamine and niacin about 58.33 per cent and 86.88 per cent respectively were found to be met. Similar results were observed, in NNMB (1996) survey also where, rural household diets were found to be adequate in Vitamin C but deficient in thiamine (55 per cent of RDA) and niacin (66.07 per cent of RDA).

Calcium intake was observed to meet 86.45 per cent of RDA while phosphorous intake was very high (202.33 per cent of RDA). An elemental Ca:P ratio of 1:1 is to be maintained in most age groups, except infancy for effective utilization of these elements (ICMR, 1992). Renu (1993), Mony (1993) and Jayantha (1993) found that calcium intake of adolescent females from Trivandrum was in the range of 60 to 85 per cent of RDA. In earlier studies calcium intake in Trivandrum was reported to be almost twice that of RDI, perhaps due to very high consumption of fish (NNMB, 1994). As pointed out by Vijay (1997) intake of proteins, thiamine and calcium were always found to be better in India than in other South Asian countries.

In the present study, the iron intake was observed as 35.43 per cent of the RDA. Earlier studies (Renu (1993), Mony (1993), and Jayantha (1993)) indicated a high percentage of consumption of iron (80 to 90 per cent of RDA) among adolescent females in Trivandrum. But, NNMB (1994) data showed that iron consumption of slum dwellers in Trivandrum (99.58 per cent) was comparable to RDA. The present findings were similar to those obtained for NNMB (1996), in which they observed that the iron consumption in rural Kerala was 35.08 per cent of RDA. Thus the data clearly points out the rural-urban difference in nutrient intake and a time and cause effect on iron consumption.

The respondents were observed to consume 57.39 per cent of RDA for carotene. This result was similar to that of NNMB survey conducted on

1994 and 1996. In the present study, riboflavin intake of adolescent girls was observed as 76.67 per cent of RDA. Renu (1993) had reported the same trend. According to NNMB (1984) and NNMB (1996) riboflavin intake was 50 per cent of RDI both among slum dwellers of Trivandrum and rural adolescents in Kerala. Vitamin C and ribloflavin intakes were reported to be deficient in India and in other South Asian Countries (Vijay, 1997).

Consumption pattern of iron rich foods was observed to be significantly influenced by the size of the family with a steady decrease in intake as family size increased. But family income had a direct influence on the intake of iron rich foods since there was a positive association between intake and income. Similar findings were reported by Harold (1993) who is of the opinion that an increase in wages increases the nutrient intakes and subsequently reduces probability of illness.

Income level were found to have no direct influence on quantity or quality of cereals and cereal products consumed. Similar quantity of cereals were consumed by the lower and higher income groups, Howarth (1996) commented that per capita consumption of staple foods vary little according to income level and for the poor the staple foods are the primary sources of whatever micro nutrient are consumed particularly cereals.

For certain foods, income was found to have a positive and then a negative effect on the quantity consumed. Consumption pattern of pulses, roots

and tubers, fruits, fish and other sea foods can be identified under this group. Consumption was found to have a steady increase with a family income in the range of Rs 2001 to 3000, but a further rise in income was observed to decrease the consumption levels. This may either be due to over nutrition conciousness of the adolescent girls of upper income levels or due to the shift in dietary habits from staple raw foods to more refined and commercially prepared foods and the habit of taking nutrients in the form of capsules/ tablets. Thus income has a significant effect on food consumption but the magnitude on the effect was observed to be small. In UN surveys it has been noted that there was a linkage among increased income, higher food expenditure, and better food consumption with more expensive foods at household level (UN, 1989).

In the present study, allowances for nuts and oil seeds, fruits, fish and meat were found adequately met by all the income groups. Quantity of green leafy vegetables and other vegetables consumed was found to be directly related to the income level with adequacy in green leafy vegetables and excessiveness in other vegetables. Gillespie (1997) is also of opinion that even if incremental income is used to acquire more or differnt foodstuffs, they may not be foods that provide nutrients required for a balanced diet.

The nutritional status of individual households is determined more by their ability to acquire food than by the level of food output or its availability in the market and hence food security is clearly a pre-requisite for adequate

dietary intake of all household members which in turn is one of the requirements for preventing malnutrition. According to UN (1989), the nature and the scale of food security problem differs a great deal among and within rural and urban areas. Calorie Consumption Index (CCI) can be used as a measure of the food security experienced by the individual both at household and community levels. In this, calories consumed by the population of a developed country like USA is taken as "1" and the calories consumed by the population, whose CCI is to be calculated is taken as a fraction of it to obtain CCI.

In the present study, it was found that majority of the respondents (91.11 per cent) had good to excellent grades of CCI which was indicative of good to excellent household food security, while the remaining had fair (4 per cent) poor (3.56 per cent) and very poor (1.33 per cent) grades of CCI and hence had poor household food security. UN (1989) observed that food security continued to threaten large population of households in low income countries. However, in the present study, the mean CCI obtained for the respondents was 0.96 ± 0.208 (mean ± SD) which is an indication of excellent household and community food security. According to Potty (1995) India had a CCI of 0.60 indicating poor national food security.

According to UN (1989), a household is food secure, when it has access to the food needed for a healthy life for all its members. The excellent food security indicated in the results may be due to the excellent Public

Distribution System of Government of Kerala, where all the foodstuffs are marketed at fair prices throughout Kerala, through co-operative societies like Matsya fed (for fish) and Milma and Ksheera (for milk), fair price shops of civil supplies corporation like Supply-co and Maveli stores (for provision) and Haritha (for vegetables) and Meat products of India (for meat products). Further, food materials and fuel are also supplied through ration retail shops.

Vijay (1997) has supported this view by stating that the most importent safety net for the poor is an entitlement to cheaper food through PDS. He has further commented that PDS creates a dual market and enables the poor to obtain food grains and other necessities below the prices prevailing in the "Open market".

Under this context, the outcomes of socio political changes, such as rise in literacy rates with increased awareness of consumer protection acts, decentralisation of power through People's plan campaign currently going on in the state should also be taken into account.

5.4 Health variables responsible for the incidence of anemia

Anemia is a condition in which there is diminished oxygen carrying capacity of the blood as a result of reduction in total circulating haemoglobin and/or a reduction in red cell mass. Prolonged deficiency is said to result in reduced work capacity, diminished learning ability and increased susceptibility to infections (ACC/SCN, 1991).

In the present study, the respondents surveyed were either mild (68.00 per cent) with haemoglobin level between 10 and 11g/dl or moderately anemic (32.00 per cent) with haemoglobin level 7 to 10g/dl. Severe degree of anemia was not observed among them. Earlier studies (NNMB, 1994) indicated that, there was an increase in the proportion of normal children with simultaneous decline in the extent of severe grade malnutrition. This might be due to the impact of the various target oriented nutrition and poverty alleviation interventions and other development programmes which have been in operation since the past several years all over the country.

Quality of life index worked out in the study showed significant positive correlation with haemoglobin level, indicating that the variables like caste, educational status of the respondents, occupational status of the head of the family, family income, percapita income, expenditure on food as percentage of monthly income and calorie and protein requirements of adolescent girls, might have played a positive role in this context. UN (1989) also emphasized that the quality of life experienced by the people, and not the economic development, which would solve nutrition problems. In the present study, it was also found that the occupational status of the family head and heamoglobin levels were positively correlated, indicating that secured life warranted better food and better health. NNMB (1994) has also observed that the nutrient intakes increased with increase in per capita income per month.

Fresh coconut is reported to be an essential ingredient in Kerala diets. Similarly in seasons, jack fruits finds an important role in the daily dietaries.

This survey was conducted in such a season and quantity and frequency of use of jack fruit and coconut had a positive significant association with haemoglobin level. Consumption pattern of dates, a rich source of iron was also found to be positively correlated with haemoglobin level.

Food items sold through provision stores are expected to be within the reach of the families of lower income strata. Similarly under exploited green leafy vegetables and fruits were also abundantly included by these families. Frequency of use of these foods showed significant positive correlations with haemoglobin levels. These foods included wheat semolina, chekkurmanis, amaranthus, bringal, amla, bilimbi and sapota.

Excess boiling method adopted by many families were found to have a negative effect on the retention of water soluble nutrients viz., vitamins and minerals (iron) in cooked foods. Swaran (1991) has also commented that during rapid boiling maximum loss of nutrients takes place.

Acceleration of growth particularly during the years of sexual maturation imposes increased requirements of iron particularly for the production of haemoglobin during adolescence. Menustrual losses further raises the iron requirements. Further, the present health status may be the outcome of long term or short term impact of nutritional status as affected by the personal characteristics such as age, spacing between siblings and birth order of the

respondent, menustrual features, morbidity status of the respondents and her mother when she was in the womb.

A negative relationship excited between the age of the respondents and haemoglobin level indicating that prolonged imbalance in iron intake and iron utilizastion in the body had resulted in the gradual depletion of stored iron. Vasanthi *et al* (1994) also observed that with increasing age urban girls who had attained menarch showed an increase in the prevalence of anemia.

Many respondents (44.89 per cent) are found to be the eldest in their families and spacing between siblings were observed to be 2 years in the 60.00 per cent of the families. ICN (1992) has stressed the significance of birth order and spacing as determinants of child malnutrition. Good nutrition tends towards earlier puberty and malnutrition delays the age of menarche. Kaul *et al.* (1982) had observed earlier onset of menarche in girls from higher socio economic groups. Menarcheal age of 56.89 per cent of the respondents were also found to be higher than the figures (12.40 to 12.80 years) reported in Indian studies (Rana *et al.*, 1986 and Rao *et al* 1985) among girls from economically better families. Shobha (1996) has found that average menarcheal age of rural girls was 14.02 years as against 12.20 years for the urban affluent. Further, Kathleene (1994) observed that the average median age of manarche could be 13 to 15 years in populations with chronic but not severe undernutrition. Around 77.00 per cent of the respondents in

this study are also found to be placed in this category. Menstrual flow for 5 to 6 days, dysmenorrhoea and menorrhagia are the complications as reported by 64.44 per cent of the respondents. Age at menarche was found significantly influenced regularity of menstruation, nature and duration of menstrual flow and complications experienced during menstruations. All these observations indicate the insufficient health status of the respondents.

The "nutrition - infection nexus" is well known as a powerful determinant of the ultimate nutrition outcome (ACC/SCN, 1997). Viral and bacterial infections and diarrhoea were the discomforts with which the respondents were familiar. Faina and Oberg (1995) observed that dental caries was most commonly caused by bacterial infection. Slight to marked amounts of dental caries were observed among 57.73 per cent of the respondents.

Iron deficiency anemia is always found to be associated with weakness, fatigue and exhaustion (Viteri, 1997). General appearance of the respondents from a clinical point of view found to have a highly significant positive correlation with haemoglobin level.

Deficient adipose tissue quantity was observed in 12.44 per cent of the respondents, which may be due to the inadequate energy intake.

Slight vitamin A deficiency affecting the conjuctiva, cornea, eyelids, skin and hair were observed in 86.67 per cent of the respondents. Underwood and Arther (1996) commented that vitamin A deficiency contributes to inefficient

utilization of iron for haemoglobin production. This observation may look meaningful in respondents when the intensity of clinical symptoms and haemoglobin level are carefully guarded.

Riboflavin deficiency, symptoms such as angular stomatitis, stomatitis of buccal mucosa and haziness and diminished transparency of cornea are found in all the respondents. In a cereal based diet, riboflavin is found to be the most limiting nutrient (Mahtab and Lakshmi, 1994). Cereal is found to be predominant in the diets of these respondents.

Vitamin C deficiency such as bleeding gums and/gingivitis and pyorrhoea are found among very few respondents and this state is well advocated by the dietary intake of vitamin C.

Iron deficiency signs, such as pale coloured tongue, anorexia and diarrhoea at times were observed in many respondents.

Malnutriention results from the interaction between poor diet and disease and leads to most of the anthropometric deficits (WHO, 1997)

According to ACC/SCN (1997) weight for age and height for age are commonly used as indicators of malnutrition. Height and weight for the respondents were below the standards specified for height for age and weight for age. On an average, they were found to have 82.94 per cent of standard weight for age which was indicative of mild malnutrition as per Gomez

classification. However weight of the respondents showed significant positive relationships with haemoglobin levels.

Marginal malnutrition (90 to 95 per cent of standard height) was indicated among 93.76 per cent of the respondents as over Waterlow's classification. Height for age also showed significant positive relationship with haemoglobin level. Moderate malnutrition in terms of weight for age and marginal malnutrition in terms of height for age were observed among adolescent girls of Trivandrum - Urban slums (NNMB, 1994).

Body Mass Index (BMI) expressed as ratio of weight to height square (Wt/Ht^2) was used as a parameter for detecting Chronic Energy Deficiency (CED) and for purposes of classifying the respondents of deficient energy intake. Findings indicated that the prevalence of mild (33.78 per cent), moderate (11.11 per cent) and severe (6.22 per cent) grades of CED among the respondents, probably the basic reason for under weight.

Somatic circumferences and body fat measurements of the respondents were found below the standards for adolescent girls. However the somatic circumferences showed significant positive relationship with haemoglobin level.

Theodore (1998) reviewed that waist to hip circumference ratio is better predictor of obesity than BMI. The mean waist to hip circumference ratio of the respondents was 0.78 indicative of slightly obese condition.

Nutritional status is an outcome of food and non-food factors of privately consumed basic needs and socially provided basic needs (Gillespie, 1997). In this study, it was observed that majority (68.00 per cent) of the respondents had medium NSI. Among the socio economic variables tested, a negative correlation was found to exist between the educational status of the father and NSI.

Among the nutritional variables, intake of energy rich foods and nutrients and calorie consumption index showed positive correlations with NSI.

Age at menarche, haemoglobin level, waist circumference, BMI and waist to hip ratio were showed positive correlations with NSI, while NSI and mild vitamin A deficiency symptoms were negatively correlated.

5.5 Metabolic experiment on the effect of iron and vitamin supplementation on iron profile.

Effect of iron and vitamin supplementation on iron nutriture of moderately anemic (Hb 7-10g/dl) adolescent females was assessed by a metabolic experiment of 60 days duration.

Information on the diets generally consumed by the respondents will throw light on variables which might have determined the development of such nutritional symptoms. When compared to the quantity specified in a balanced diet, the diets in the two institutions were found inadequate both in quantity and quality. Nutrient composition of these diets also revealed the

predominance of energy rich foods and insufficiency of protein rich foods.

The intake in iron was 38.37 and 26.70 per cent of RDA levels respectively for institution I and II, while only 13.66 and 12.30 per cent of RDA for carotene were met in the diets of institution I and II respectively. Riboflavin intake was above RDA levels in both institutions. Vitamin C intake was above RDA levels for institution I and 78.85 per cent of RDA in institution II. Only a nutritionally adequate diet with proper proportion will ensure the internal utilisation of nutritients. Similarly the inhibitors present in the diets such as oxalic acid, phytin P and total dietary fiber also had an impact on the per cent of iron absorbed for metabolism. The content of the inhibiting agents of iron absorption were higher in the diets of institution I than that of institution II.

Homogeneity of the diets served in the two institutions were ensured by monitoring the quantity served and adjusting the same so as to meet the RDA of nutrients specified for adolescent girls. 60 mg iron in the form of ferrous sulphate and 500 µg folic acid were the supplements prescribed for one group. Since earlier studies have indicated the beneficial role of vitamin A, B_2 and C (Vinodini *et al.*, 1992), an attempt was made in this experiment to monitor the impact of supplementing 600 µg equivalent vitamin A, 1.2 mg equivalent vitamin B_2, 40 mg equivalent vitamin C or all the three vitamins along with iron and folic acid.

The effect of iron and vitamin supplementation in the form of foods rich in iron and the above vitamins were also tested. From the 14 recipes formulated and standardised only 4 recipes (viz., rice flakes, amaranth, soya pugath, soya gingelly balls and ladies fiber fry) which are rich in specified quantity of the iron and vitamins under study with lower cost and higher acceptability (score of 7) was selected for the metabolic experiment.

Amaranth, the rich and low cost source of iron and β–carotene was included in the supplementary foods since the availability of β-carotene is higher in amaranthus than that of dark green leafy vegetables, (ACC/SCN, 1995). Soya beans had the highest iron content when compared to other pulses, while rice flakes, jaggery and gingelly seeds were known not only for their iron content but also for the richness in B complex vitamins and vitamin A as per nutrient composition tables (ICMR, 1991). Ladies finger included in this experiment served as a source of vitamin C and folic acid besides amaranth and coconut. In the present study, the developed recipes together supplemented 60 mg iron, 500 µg folic acid, 600 µg equivalent vitamin A, 1.2 mg vitamin B_2 and 40 mg vitamin C.

It has become increasingly apparent in recent years that variation in the bioavailability of food iron has far greater significance for iron nutrition than the iron content of the diet (INACG, 1984). Young *et al.*(1982) and O'Dell (1985) defined bioavailability of a mineral as that fraction of the dietary mineral which is available for utilization for specific biological functions or processes in the body.

Earlier reports have also indicated that even when the diet is rich in iron, the proportion of iron absorbed from the diet will vary (INACG, 1984). *In vivo* method to assess bioavailability of iron using radio isotopic measurements in humans is expensive and difficult to perform. Hence in the present study, *in vitro* method of Rao and Prabhavathi (1978) was adopted. According to Subadra (1993) the *in vitro* method correlates well with *in vivo* absorption values over a wide range.

The proportion of iron absorbed from a component/foodstuff in a meal is profoundly influenced by the composition of the meal (INACG, 1984). In the current study, data regarding the food composition of basal dinners indicated that they included South Indian vegetarian preparations. The cyclic menu on a weekly basis contained all the foods such as cereals, pulses, roots and tubers, green leafy vegetables, other vegetables, fruits, nuts and oil seeds, fats and oils at moderate amounts. Composite meals consumed by different regions differ considerably in their dietary constituents and attempts to improve iron status of different population groups will be facilitated by a knowledge of the potential availability of iron in different types of meals.

Data on the chemical composition of the basal dinners indicated that they contained protein (12.19 g), fat (17.47 g), mineral (1.82 g), fiber (1.87 g), carbohydrates (129.14 g),energy (711.64 kcal), calcium (228.94 mg),

found to be monotonous with one or two food items. Nutrient content of the diets were not similar with each other, but they had lower oxalic acid, phytin P, dietary fiber and calcium content. Anand (1991) reported a bioavailability of 4.8 per cent for a meal consisted of wheat chapathies, potato vegetable khichdi and Kadhi.

Diet D_3 with a bioavailability of 6 per cent consisted of rice, rasam and cabbage pugath. This diet had the highest vitamin C content when compared to other diets. Anand and Seshadri (1991) found that ascorbic acid and citric acid enhanced bioavailability *in vitro*. Subadra (1993) found that, rice based diets had a higher bioavailability than wheat based diets. The vegetables such as cauliflower, cabbage and potatoes brought about a marked increase in bioavailability.

Diet D_2 composed of rice, rasam and green gram pugath showed a bioavailability of 5.34 per cent next to D_3. This was the only diet with pulses and had the lowest oxalic acid and vitamin C content. But pulses contain polysaccharides and tannins that provides roughage and interferes with iron absorption. Also, polyphenols present in the legumes account for their poor bioavailability of iron.

These findings indicate the role of enhancers and inhibitors on non - heme iron absorption in a mixed diet, which is a complex procedure since the amount ultimately absorbed is a function of complex interactions.

An important thing on this regard is the presence of many different ligands. The effects of a single ligand is determined by a number of variables such as the concentration of the ligand, its affinity for both ferrous and ferric iron, the effectiveness of complexing in the changing physico chemical conditions within the intestinal lumen, the nature and concentration of other ligands and the efficiency with which the complex can be absorbed by the mucosal cells (INACG, 1984). Charlton and Bothwell (1983) had observed that the quantity of bioavailable non-heme iron is determined by many factors, including the amount of non-heme iron in the meal, manufacturing process, cooking, the process of digestion and its relative proportions of diverse iron ligands competing for the ionic iron. However, the composition of the meal has far greater significance for iron nutrition than the amount of iron provided.

In the present study the mean bioavailability obtained for the meals was 7.38 per cent indicating the subjects were on medium bioavailable diets. A low bioavailable diet (iron absorption about 5 per cent) is reported to be dominant in many developing countries particularly among lower socio economic groups (FAO/WHO. 1988).

Iron and vitamin supplementation evoked gradual rise in bioavailability of iron from T_1 to T_3. The trend to increase the bioavailability after supplementation was same for different diets. However the effects were significantly different between treatments, between diets and between diets and treatments.

Iron and folic acid supplementation was found to increase the bioavailability. The rise in bioavailability may be due to the increased iron content in the diet by the addition of iron tablets. However, on an average only 34.75 per cent of iron was absorbed, probably because of the inhibitors present in them. According to Agarwal *et al.*(1996), the absolute amount of the absorbed iron depends upon the total amount of iron in the diet. If the dietary content is less, the percentage of absorption is higher, but the absolute absorption is found to be low and vice versa. The advantage of folic acid supplementation may be its action in the prevention of megaloblastic anemia, glossitis and gastrointestinal disturbances which may be masked by iron deficiency symptoms.

In the present study, addition of 600 µg equivalent vitamin A along with iron (60 mg) and folic acid increased the bioavailability of about 5.05 times. Like vitamin C, Vitamin A is also known for its antioxidative properties but it is fat soluble and may be misible in water. Hence it can slow down the oxidative formation of iron absorption inhibiting ligands. High bioavailability of iron present in animal food may not only be due to the presence of heme iron but also of high vitamin A content. However, Mejia *et al.* (1979) had found that vitamin A had no role in regulating the absorption of iron from gastrointestinal tract directly.

Compared to vitamin A riboflavin was observed to have lesser effect in enhancing the iron bioavailability since the mean rise in iron bioavailablility

was 5.03 times. Relatively large amounts of free riboflavin is present in bound form with specific proteins or as constituents of flavin co-enzymes (Bender, 1992). These flavoproteins are found to play active role along with oxidation-reduction enzymes and they contain metals especially iron as co-factor (Keshav, 1990). Moreover these enzymes catalyse some of the oxidation - reduction reactions at pre-absorptive stage of iron to produce complexes which can enhance iron absorption. Bender (1992) observed that iron absorption is impaired in riboflavin defficient animals.

Ascorbic acid is well known for its reducing properties and is reported to bind iron in equimolar concentrations to form a readily absorbed complex. It is also found that its absorption promoting effect on iron is dose dependent (INACG, 1984). In the present study, the second highest mean bioavailability of 5.47 times evoked by diets with vitamin C may be due to the reducing effect of vitamin C on pre-absorbed iron.

Among different treatments tested, the highest iron bioavailability was observed in T_5 group where vitamins A, B_2, C and folic acid and iron were supplemented in the basal diet. The mean rise in bioavailability obtained was 6 times. As per common pool concept, whatever may be the origin of non heme iron in a meal, they enter a common pool using the process of digestion, and the effects of a number of enhancers or inhibitors of iron absorption are equally susceptible (INACG, 1984). Presence of vitamins in the common pool, may result in a higher iron bioavailability.

When the tablets were tested alone, more than 70 per cent of bioavailability was observed in the respective treatments. The highest bioavailability of iron (93.75 per cent) was evoked in T_5, the treatment with the mineral and all the vitamins. Bioavailability of T_5 was followed by T_4 (84.00 per cent), T_3 (82.23 per cent), T_2 (81.20 per cent) and T_1 (74.25 per cent). The biological activity of iron in tablet forms can be influenced considerably by the amount of pressure used to form tablets, the nature of the exipient and the type and thickness of coating. The nonavailability of hundred per cent bioavailability of iron and vitamin supplements may be due to the above factors.

Since the highest bioavailability was observed, when supplements were tested alone, administration of iron folate and vitamin tablets one hour before or 3 hours after the meals was recommended to obtain more than 90 per cent of bioavailability and to ensure maximum utilization of supplementation. However, Lani (1995) observed that consuming iron supplements in an empty stomach may lead to nausea leading to decreased appetite and food intake.

The supplementary foods developed were also tested for their bioavailability. The highest iron bioavailability of 13.56 per cent was observed in ladies finger fry followed by rice flakes (12.69 per cent), soya gingelly balls (10.99 per cent) and amaranth soya pugath (6.89 per cent).

Maximum iron bioavailability from ladies finger fry may be due to the low oxalic acid and calcium content of the supplement as well as the

absence of phytic acid. Similarly, rice flakes are also found to be devoid of oxalic acid. On the other hand soya gingelly balls are found to be rich in oxalic acid (425mg), phytin P (104 mg) and calcium (468.50mg); but the presence of essential fatty acids might have enhanced the availability of vitamin A and indirectly enhanced the iron bioavailability. This supplement is also a rich source of proteins but the effects of EFA and vegetable proteins in a mixed meal on iron bioavailability will be regulated by various other metabolic factors. The immediate need to confirm the relative effects of phenolic compounds, calcium, vegetable proteins and muscle tissue on iron bioavailability are stressed in studies of Richard *et al.* (1998).

The inhibition of iron absorption from soya may be due to the presence of phytic acid and protein related moiety (Lynch *et al.* 1994). Any negative effects of soya on overall iron balance are however counter balanced to some degree, by its high iron content. Also the interpretation and identifying physiologic iron binding molecules is reported to be difficult because of the large amount of non-specific binding by iron (John *et al.* 1996)

Amaranth soya pugath had the lowest iron bioavailability (6.89 per cent). This low bioavailability of this leafy vegetable and legume based food may be due to its high oxalic acid (1544 mg), calcium (886 mg) and phytin P (118 mg) content, eventhough this food is rich in iron (47.08mg), carotene (11466 µg), folic acid (403 µg), riboflavin (1.03 mg) and vitamin C (198.40 mg) content. As per the report of INACG (1984) iron from spinach is observed

to be poorly absorbed when fed alone (±1 to 2 per cent) despite its ascorbic acid content. Chlorogenic acid present in a variety of fruits and vegetables is also found to inhibit non heme iron absorption but to a lesser extent (Bussard *et al.* 1997).

The subjects selected for the metabolic experiment were in the age group of 12 to 18 years with a haemoglobin level of 8.4 to 10 g/dl and were suffering from moderate degree of anemia. Surveys by Chhatray and Renjit (1990) have established the overall prevalence of parasitic infestation in urban (50 per cent) as well as in rural areas (68 per cent) of India. Intestinal parasitic infestation was found common among the subjects and most infestation was observed to be due to round worm (*Ascaris lumbricoides*) and whip worm (*Trichinuris trichinuria*). This may be one of the major reasons for the occurrence of moderate iron deficiency anemia among these subjects. The subjects were dewormed with albendazol before the start of the metabolic experiment.

Iron deficiency in an individual is usually diagnosed by lower haemoglobin concentrations. However, haemoglobin concentration may vary considerably in normal healthy persons and hence lesser degrees of iron deficiency will go undetected if it is the only measurement used. The red cell indices also help to decide whether the subjects are anemic or not. According to Annie (1995) the major iron status indicators among haematological variables are haemoglobin concentration. RBC count, Mean Cell Volume (MCV) and

Mean Cell Heamoglobin Concentration, (MCHC). Diana and Wood (1995) were of opinion that in the face of lack of single diagnostic measurement for iron deficiency anemia, a battery of measurements are to be attempted.

Increasingly positive trend observed in the heamatological profile of the iron and vitamin supplemented groups, after supplementation experiment may be due to the effect of vitamins, which had major roles in iron metabolism, supplemented along with it. Martin *et al* (1989) observed that both iron and vitamin deficiencies cause low haemoglobin levels. Increase in heamoglobin levels due to vitamin A supplementation was consistent with the role of Vitamin A in haemopoiesis (Rajammal *et al.* 1980). Majia and Arroyave (1983) found an association between iron metabolism and hypovitaminosis A. Martin *et al* (1989) found a significant correlation between serum retinol and haemoglobin among non-pregnant and non-lactating women.

Bender (1992) reported that riboflovin deficiency is associated with hypochromic anemia as a result of secondary iron deficiency. Lynch and Cook (1980) showed that vitamin C had an important role in iron absorption.

Similar to the treatment groups with iron and vitamin tablets, the group with supplementary foods also showed a rise in haematological variables. This indicates that iron supplementation either in the form of tablets or foods was beneficial on subjects. Control group also showed slight and positive changes which may be due to the fact that the subjects in T_0 were on a

RDA balanced diet. According to Fairbanks (1991) response to iron supplementation was considered the ultimate test for iron deficiency.

Prior to the experiment, the haemoglobin concentration of the subjects indicated that they were suffering from moderate degree of anemia. According to Thomas (1980), one of the haematological findings in an anemic patient was reduced haemoglobin concentration. In the present study, after the experimental period the subjects from T_5,T_4,T_3,T_2,T_6 and T_1 showed normal haemoglobin concentrations, while the control group indicated a shift from moderate to mild degree of anemia. It was also observed that the changes in haemoglobin concentrations evoked by T_0 and T_6 and T_1 and T_6 were on par. This indicates that effects of iron supplementation either in the form of tablets (T_1) without other vitamins or in the form of supplementary foods were similar. Alpana (1998) found that after 45 days of supplementary feeding, groups supplemented with calories, protein and iron and groups supplemented with calories, protein, iron and vitamin C evoked significant increase in haemoglobin level. She observed that vitamin C increased absorption of iron and this promotes the formation of haemoglobin in malnourished children at much faster rate and Vitamin A supplementation produced increased haemoglobin level in intervention trials.

According to INACG (1985) PCV provides a convenient and rapid measure of the degree of anemia and from a nutritional standpoint provides information comparable to the haemoglobin concentration.

Pre experimental values of PCV indicated that the subjects were below the normal ranges. Supplementation of iron and folic acid along with iron absorption enchancing vitamins raised the PCV due to rise in erythropoiesis. A positive correlation was found existing between PCV and haemoglobin level.

Like PCV, RBC count was observed to be below normal levels prior to the experiment. Vidyaratan (1993) reported that even in simple chronic anemia, there will be reduction in RBC count. After the experiment, normal values were obtained for all treatment groups except the control group. The effects of iron folate, vitamin A, B_2 and C and altogether when supplemented were statistically similar. The increase in RBC count may be due to the rise in erythropoiesis as vitamin A, B_2, C and iron folate are erythropoietic nutrtients and were supplemented in a more available form.

Bender (1992) was of opinion that the role of vitamin A in the control of cell proliferation and differentiation were much well defined. These functions are the results of nuclear effects of the vitamin, mediated by cytosolic binding proteins in target tissues. Folic acid and riboflavin are equally important for cell proliferation. Lynn (1998) reported that their deficiency caused slowing of cell division as evidenced by haematologic abnormalities that eventually resulted in anemia.

The role of vitamin C in iron and folic acid metabolism is well known. Macrocytic or hypochromic anemia indicative of folic acid and iron

deficiency were frequently associated with vitamin C deficiency. There is also evidence that erythrocytes have a shorter half life than normal in vitamin C deficiency (Bender, 1992). This will lead to abnormal erythropoiesis and anemia. Thus, in the present study, it was confirmed that iron and folic acid along with vitamin A, B_2 and C had an effect on erythropoiesis and maturation of RBC rather than supplementing the mineral and vitamins separately.

Red cell indices give the clear, morphologic characteristics of red cells, which is important in the diagnosis of the kind of nutrient deficiency and anemia prevalent among the individuals.

It was found that all the subjects showed above normal values of MCH before the experiment. This indicates that the subjects might have been suffering from microcytic, hypochromic anemia. Thomas (1980) observed that microcytosis and hypochromia are investigative features of iron deficiency anemia. Post experimental values indicated that except T_1 and T_3 all the other iron and vitamin supplemented groups had MCH of below normal range.

Before and after the experiment in T_0 and T_1, the MCV was above the normal range (85-90fl). This high value indicates that the subjects had macrocytic anemia due to folic acid deficiency as reported by Thomas (1980). The post experimental MCV values of all the other groups except T_5 and T_6 indicated normal ranges. T_5 indicated below normal range of MCV value, eventhough there was 6.54 per cent rise in MCV due to iron and vitamin supplementation. Reduced MCV is an indication of reduced microcytosis due to iron deficiency as stated by Thomas (1980).

Prior to the experiment, T_6 was in the normal range of MCV but after the experiment there was 5.61 per cent reduction in MCV. This indicates that the iron supplementation through the supplementary food was slowly available to the subjects. There was also suspected incidence of thalessemia. INACG (1984) reported that finding of anemia together with low MCV (< 85 fl) and a low MCH (< 25 pg) usually implies that haemoglobin synthesis has been inhibited by a curtailment in the supply of iron to the erythroid marrow, usually due to iron deficiency. Impaired haemoglobin synthesis resulting in similar morphologic changes occurs in thalessemia minor, and in areas where this disorder is common such as South East Asia (India), this possibility is also taken into consideration in supplementary trials. Hence the present result of T_6 was checked by using discriminative function for thalessemia trait. According to INACG (1984) discriminative function for thalessemia trait can be calculated by using the formula, "MCV - RBC - (5 x Hb) - 3.4". In the present study, for T_6, the suspected group for thalessemia, the result was + 17.53. Since the result was positive, the variations in MCV and MCH are not due to thalessemia but due to iron and folic acid deficiency.

MCHC is the most accurate measure of red cell indices (Raghuramalu *et al.*, 1983). It was found that all the treatment groups had above normal range of MCHC before the experiment. However, after the experiment, all the subjects indicated slightly below the normal values of MCHC. This change from above normal to below normal levels indicates that there was a shift

from microcytic to macrocytic anemia or it may be due to the increased erythropoiesis as a result of iron and vitamin supplementation.

Statistical analysis indicated that there was no significant difference between the pre and post experimental values of MCV, MCH and MCHC which was indicative that there was no significant effect on red cell indices by iron and vitamin supplementation.

When haemoglobin concentration of the subjects were checked, 30 days after the beginning of supplementation trial, highest rate of increase in Hb level was indicated by T_4 (28.42 per cent) and T_5 (27.71 per cent). After the 30th day, the rate of increase was found decreased. The decrease indicates that there was enhanced erythropoiesis during the Ist month of supplementation. Thomas (1995) reported that when erythropoiesis was actually stimulated, there was a prompt rise in absorption rate. According to him, if medicinal iron is given to subjects with iron deficiency anemia, 20-40 mg can be absorbed daily as long as anemia is presented. Thereafter, there is a sharp decline in the rate of absorption and iron stores are reconstituted at a slow rate.

Effect of iron and vitamin supplementation on iron nutriture can more precisely be analysed by the variations in biochemical variables related to iron metabolism such as serum iron, serum ferritin, Total Iron Binding Capacity (TIBC) and Transferrin Saturation (TS). According to James *et al.* (1985) haemoglobin and haematocrit determination, as single criterion for iron deficiency, defines only the degree of iron deficiency. They were of opinion

that, many of the limitations in defining the prevalence of iron deficiency using isolated measurements can be circumvalated by using combinations of two or more independent variables as mentioned above. Annie (1995) opined that major iron status indicating biochemical variables are serum iron, TIBC, TS and serum ferritin.

The *initial serum or plasma iron* of the subjects indicated that in all the treatment groups, except T_4 and T_5, had deficient plasma iron content. The initial serum iron content of the subjects ranged, from 31.4 to 51.2 µg/dl. According to INACG (1984), when serum iron is less than 40 µg/dl, it is probable that the needs of the erythroid marrow are not being adequately met. In the present study, after the supplementation trial, elevated serum iron content was indicated in all the groups. It was observed that the rate of increase in serum iron in iron and vitamin supplemented groups (T_2,T_3,T_4 and T_5) was related to initial serum iron content. The lower the initial serum iron, the higher was the rate of change. The effect of vitamins on iron absorption and metabolism was also clearly brought out by the fact that eventhough T_1 had a low initial serum iron level (40.30 µg/dl), which was almost similar to that of T_2 (40 µg/dl), with a low rate of increase in T_1 (103.48 per cent) when compared to that of T_2 (171 per cent). Baynes *et al.* (1987) has observed that the rate of iron absorption is inversely related to the size of body iron store as indicated by serum iron and ferritin values, the less the iron store, the higher will be the absorption rate.

The effects of supplementary foods (T_6) on iron profile are similar to that in T_1, the group supplemented with iron and folic acid. This may be due to the lower bioavailability of iron from foods than that of iron supplements. The rise in serum iron exhibited by the control group may be due to the fact that they were on an iron adequate diet.

TIBC represents the sum of endogenous iron bound to plasma and the additional iron which can be specifically bound (James *et al.* 1985). In the present study, the initial and final TIBC levels were in the normal ranges for TIBC (250-380 µg/dl). Iron and vitamin supplementation evoked a decreasing tendency in all the experimental groups except T_1 and T_6 in which there was an increasing tendency. This may be due to the body's absorption mechanism to absorb more iron on deficient iron stores. According to James *et al.*, (1985) iron utilization rates were higher at higher iron deficient states. But Thomas (1995) found that the size of iron stores in the body had lower influence on iron absorption. Lani (1995) observed that iron deficient persons absorbed 30 to 40 per cent of the iron given on the first day, but this rapidly decreased on the following days to an absorption of 3 to 6 per cent.

In the present study, control group showed 6.84 per cent rise in TIBC. The results of TIBC of different treatment groups indicated that vitamin A, B_2 and C had beneficial impact on TIBC. Martin *et al.* (1989) observed that after 2 years of vitamin A fortification, an overall significant improvement was noted in all the iron nutritional indices such as an increase in serum iron and decreased in TIBC.

In the study, TIBC showed a highly significant negative correlation with Hb level, PCV, RBC count and serum iron indicating the inverse relationship between TIBC and iron nutriture of the body.

Transferrin Saturation (TS) indicates the adequacy of iron supply to bone marrow (INACG, 1984). The TS is the ratio of serum iron to TIBC expressed in per cent. The normal values of TS ranged from 30 to 40 per cent (INACG, 1984).

In the present study, all the subjects were below the normal range of TS which ranged from 10.70 to 17.27 per cent. In subjects with TS levels below 15 per cent, the delivery of iron to erythroid marrow is severely compromised. When the supply of iron to the developing red cells in the marrow is suboptimal, not all the porphyrin being synthesized can be made into heme (INACG, 1984.) The rise in TS after iron and vitamin supplementation in iron and vitamin supplemented groups were higher than that in non-vitamin supplemented group (T_1) and group on supplementary foods (T_6). Mejia and Arroyave (1982) observed that after six months of vitamin A fortification, indices of iron status had improved because of the decreased TIBC and increased ferritin and TS. Martin *et al.* (1989) had also got the same results with vitamin A. They were of the opinion that vitamin A deficiency would cause a blockage of the reticulo - endothelial iron deposits, thus inhibiting their mobilization.

The most convenient yardstick of the body iron reserve is the plasma ferritin concentration, since it can detect the first stage of iron deficiency, namely a reduction in the size of the stores (INACG, 1984). In the present study, the initial and final ferritin values indicated that the subjects were in the normal range. Thomas (1995) opined that storage iron status reflected the previous iron nutrition of an individual which could most conveniently be assessed by measuring the levels of serum ferritin. There was significant increase in the values due to supplementation. The maximum rise was noted in T_1, which may be due to the lowest initial serum ferritin value of T_1 and hence increased absorption. Thomas (1995) indicated that serum ferritin and iron absorption are inversely related. This trend has been found in all the treatment groups supplemented with iron and vitamins. Baynes (1996) found that increases in serum ferritin reflected increased storage iron.

Eventhough the bioavailability of supplementary foods was low, it evoked 292.66 per cent rise in serum ferritin. This indicates that the constituents of the meal had a direct impact on the iron profile irrespective of its bioavailability. Johana (1981) opined that it was not possible to know the status of iron stores simply by knowing iron intakes, since absorption of dietary iron varied depending upon the stores and diet. Johnson *et al.* (1994) reported no correlation between estimates of dietary iron intake and iron status. Samuelson (1996) observed that after six weeks of oral iron therapy to adolescents with low serum ferritin concentration, showed an increase both in serum ferritin and blood haemoglobin.

In the present study, there was statistically significant difference between the pre and post experimental values of serum ferritin. However the differences in serum ferritin values of iron and vitamin supplemented groups as well as the group supplemented with supplementary foods were on par. Ferritin showed highly significant positive correlation with Hb level, PCV, RBC count, serum iron and percentage of transferrin saturation, but it was negatively correlated with TIBC. Similar results were also obtained for Peter and Wang (1981) and Martin *et al.* (1989).

Iron deficiency produces a number of deleterious effects in addition to anemia, one of which is the growth retardation. Since earlier studies showed converse results on the effect of iron supplementation on growth, the anthropometric measurements which are the important indicators of growth were also studied during the experiment. The important anthropometric measurements studied included height, weight, Triceps Skinfold Thickness (TSF), Mid Upper Arm Circumference (MVAC), Arm Muscle Circumference (AMC), waist and hip circumferences.

During the experimental period, there was slight but insignificant increase in height, in all the treatment groups. This is indicactive that iron and vitamin supplementation had insignificant effect on height. Pollit (1991) reviewed that 8 or 12 weeks of treatment was insufficient to result in an increase in growth.

In the present study, the maximum weight gain was indicated by T_6, the group supplemented with supplementary foods. Among the iron and vitamin supplemented groups T_2 showed the maximum weight gain followed by T_1, T_3, T_5 and T_4. Soewondo *et al.* (1989) reported that iron treatment had beneficial effect on weight gain, while there were studies which indicated no support for the assumption that the change in iron status among the iron deficient children resulted in an accelerated weight gain (Pollit, 1991) Comparative analysis provided little support for the notion that changes in iron status of iron deficient children produced by iron supplementation over 8 weeks resulted in incomparable changes in body weight and height.

The experimental group fed with supplementary foods (T_6) showed the highest gain in Triceps Skinfold Thickness (TSF). All the groups, supplemented with iron and vitamins showed an increasing tendency of TSF at the end of the experiment. TSF was found positively correlated with height and weight. Latham *et al.* (1990) observed that the differences in post experimental measures of weight for age, weight for height and triceps skinfold thickness were statistically significant favouring the iron treated group.

The maximum percentage of rise in MUAC and AMC were noted in T_6 the group supplemented with food supplements. While, the maximum rise in waist circumference was noted in T_5. The control group (T_0) showed no changes in waist circumference during the experimental period. T_6 and T_2 showed the highest rise in hip measurements.

It was observed that eventhough there was increasing tendency in BMI in all the experimental groups, the rate of change was not significantly different from each other. T_6 showed the highest changes in BMI and waist hip ratio.

In the present study, among the experimental groups T_6 showed the maximum percentage of increase in all the anthropometric measurements except waist circumference, for which T_5 produced the maximum percentage of change. This indicates that food supplements are better than the mineral and vitamin tablets for proper physical development. Usha and Beulah (1990) had also recorded similar results indicating that food source of supplement was superior to oral massive dose. Also, in the study, since the difference in the percentage of increase in majority of anthropometric measurements of different treatment groups supplemented with iron and vitamin supplements were statistically similar, the effects of these nutrients on growth can be assumed as similar and beneficial. However, since all the subjects were on a RDA balanced diet, the changes may partly be due to the effect of balanced diet. In this context, it is necessary to consider the possibility of important differences between the health and overall nutritional status of the populations concerned since they may be of direct relevance to physical growth.

Assessment of physical endurance and work capacity depend upon the aerobic as well as anaerobic pathways. The popular terms for aerobic and anaerobic pathways are cardiovascular endurance and muscle endurance

respectively. In the present study, both aerobic and anaerobic fitness were assessed by Sharkey's Anaerobic and Aerobic Forestry step tests (Sharkey, 1977).

Iron and vitamin supplementation resulted in an elevation in aerobic (cardiovascular endurance) and anaerobic (muscle endurance) fitness of the subjects. The highest rise in aerobic fitness was observed in T_5 which may be due to the highest changes in haematological and iron profile due to iron and vitamin supplementation since the improved iron nutrition had a direct effect on oxygen carrying capacity and hence aerobic fitness. The control group also showed slight increase in aerobic fitness which may be due to the RDA balanced basal diet which is different from the routine diets consumed by them.

According to Georgiades and Klissouras (1989) cardio respiratory fitness may be empirically defined as the capacity to perform moderately rigorous physical activity for prolonged time. From a physiological view point, it is the ability to transport oxygen from the atmosphere and utilize it in the tissues during short term maximal physical exertion. In the present study, the highest percentage of increase in aerobic fitness of T_5 may be due to the maximal rise in haemoglobin concentration as discussed earlier. Haemoglobin and oxygen transport mechanism of the body are linearly correlated and O_2 uptake is the key to cardio respiratory fitness. T_5 is the group supplemented with vitamin

A, B_2 and C along with iron and folic acid. Tradford *et al.* (1992) was of opinion that it was unlikely that deficiency of a single vitamin would occur due to diet alone. They opined that the biologic actions of most vitamins involved in energy metabolism, work in concert with other vitamins. Hence for improved aerobic fitness, mineral and multivitamin supplementation is more effective.

T_6 evoked the second highest percentage of rise in aerobic fitness (25.59 per cent). However it showed lowest percentage of rise in haemoglobin level but indicated maximal growth performance as evidenced from anthropometry and BMI and highest body fat deposition. Sholz *et al.* (1997) and Diaz *et al.* (1991) reported a significant positive correlation between weight, height, per cent of body fat, arm fat area and BMI and VO_2 max (the measure of cardio vascular endurance).

Next to T_6, the highest percentage of rise in aerobic fitness was noted in T_4, the group supplemented with iron, folic acid and vitamin C. 23.04 per cent rise in aerobic fitness of T_4, may be due to the rise in iron absorption due to Vitamin C's antioxidative properties. Hence vitamin C had an indirect effect on haemopoiesis and erythropoiesis.

Vitamin A's role in cell proliferation due to its effects on nucleus can easily explain the rise in aerobic fitness found in T_2. Vitamin A is essential for protein metabolism and hence the production of two important proteins

relating to aerobic fitness viz., haemoglobin and myoglobin. According to Martin *et al.* (1989) protein synthesis may explain the association between haemoglobin and retinol binding protein and vitamin A which seem to be essential for proliferation of RBC.

The increase in aerobic power of T_1 may be due to the better iron nutritional status, hence better oxygen carrying system in the body. According to Parkhouse and Mc kenizie (1983), the physiological rationale for the prediction of maximal oxygen consumption is based on the direct linear relationship between oxygen consumption and excrcise. .

The group supplemented with vitamin B_2 (T_3) showed 8.33 per cent rise in aerobic fitness which was the lowest when compared to other iron and vitamin supplemented groups. The increase in aerobic fitness may not only be due to riboflavin's effect on erythropoiesis and hence increased RBC production but also be due to the fact that riboflavin is necessary to form flavoproteins (FMN and FAD) which are the important hydrogen carriers in biological oxidation system. Hallberg and Scrimshaw (1981) opined that the increase in enzyme systems which involve in energy yielding processes improves VO_2 max. Subotinanec *et al.* (1990) found that vitamin B_2 and B_6 supplementation improved maximal oxygen uptake in adolescents with deficient blood levels of these vitamins.

It was found that the changes in anaerobic fitness of different groups was on line with the effects evoked by these groups, on all the anthropometric

measurements taken together or on growth performance of the subjects. Jana (1989) found a positive correlation between the amount of body fat and the level of total cholesterol and triglcerides in the blood. Hultman (1989) opined that during exercise, the energy demands are covered by oxidative ATP production, utilizing fat, carbohydrate and with only miner utilization of body proteins. He reviewed that fat, predominantly as Free Fatty Acids (FFA) brought to the muscle from adipose tissue store or released from intra muscular stores of triacyl glycerol, is the main energy source for muscles at rest and during exercise with low work intensities. Jana (1989) found that BMI correlated well with fat depots of adolescents.

The present results pointed out the importance of vitamins and iron supplementation on physical endurance also. The increased iron and vitamin nutritional status of the subjects as a result of supplementation have played an important role in improving the anaerobic power, since anemia affects work output in terms of oxygen carrying capacity to the muscles (Scholz *et al.*, 1997).

Statistical analysis of the data indicated that eventhough there was highly significant difference between the pre and post experimental values of anaerobic fitness of different treatment groups, the difference between T_1, T_2, T_3 and T_4; and T_5 and T_6 were on par. This indicates that when iron and folic acid alone or supplemented with either vitamin A or B_2 or C, evoked similar effects on anaerobic power. Van *et al.* (1984) reported a decrease in maximal oxygen causumption and anaerobic threshold when marginal deficiencies of vitamin B_1, B_2, B_6 and C were induced in normal healthy men. Regarding vitamin A supplementation and iron nurtition, Ahmed *et al.* (1996) argued

that there is an interaction between serum retionol and biochemical indices of iron nutriture of adolescent girls, which in turn had an impact on their physical endurance. According to Haymes (1987) iron supplementation appears to be beneficial in reducing blood lactate concentrations, following heavy exercise. Nasoladin *et al.* (1993) concluded that addition of vitamin complex with trace elements and macro elements to the ration improved iron balance in the body and functional status of athletes better than vitamins alone.

From the present study, it was found that iron and vitamin supplementation either in the form of tablets or in the form of supplementary foods had profound effect on haematological and biochemical indices related to iron nutritional status and on growth and physical endurance of anemic adolescent girls. Iron folate with multiple vitamin supplementation was found superior to iron folate with single vitamin supplementation in terms of haematological and biochemical profile of the subjects. However, the overall growth performance was better when iron and vitamins were supplemented through supplementary foods.

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

The study entitled, "Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls", was conducted to assess the magnitude of iron deficiency anemia among adolescent girls; to find out direct and indirect effects of causative factors and to evaluate the relative effect of supplementation on iron and vitamins on the iron status of anemic adolescent girls.

Rapid assessment technique was administered to determine haemoglobin (Hb) and 225 adolescent girls, suffering from iron deficiency (with Hb $\leq$ 12g/dl), were identified through medical camps conducted in 12 centres in the locale selected for the study. (Trivandrum, Neyyattinkara and Nedumangadu Taluks of Trivandrum district)

Socio economic variables responsible for the prevalence of iron deficiency anemia were identified by conducting a study among the anemic adolescent girls, already identified, using a suitably structured schedule.

Nutritional variables were determined through their mean food intake by 24 hour recall method and their anthropometric measurements were ascertained using universally accepted techniques.

Salient findings of this study were:

1. Among the three Taluks studied, Trivandrum showed the highest prevalence rate of 52 per cent with an overall prevalence rate of 49 per cent.

2. Of the different socio economic variables studied, variables such as family size and composition negatively influenced haemoglobin levels.
3. Quality of life Index, worked out for each respondents, had direct impact on their Hb level.
4. The respondent's knowledge on health and nutritional factors related to anemia, calorie consumption index and frequency of use of iron rich foods were found to influence the haemoglobin levels positively.
5. Adequacy in food and nutrient intake had no direct impact on the mild degree of anemia.
6. The predisposing factors for the prevalence of anemia observed were;
   (a) Slow growth rate indicated by delayed menarcheal age, regularity, nature, duration and complications during menstruation.
   (b) Low weight for age and height for age and BMI
   (c) Chronic Energy Deficiency
   (d) Low somatic circumferences and
   (e) Poor Nutritional status index

Effect of supplementary foods and iron and folic acid supplementation with and without vitamins (A, B_2 and C) were assessed by conducting a metabolic experiment of 60 days duration. For this moderately anemic adolescent girls (Hb 7-10g/dl) residing in boardings were selected.

The bioavailability of iron from the experimental diets were assessed by *in vitro* technique. Iron profile, anthropometry and physical endurance of the subjects (n = 35) were the major criteria considered in the metabolic experiment.

Major findings of the metabolic study were:

1. Iron and vitamin supplements had a direct effect on the bioavailability of food iron.
2. Supplementatory foods developed specifically for the study were found to be richer in bioavailable iron.
3. The highest positive changes in haematological (RBC count, PCV, Hb and Red Cell indices) and iron profiles (Serum Iron, Serum Ferritin, TIBC and Transferrin Saturation) were observed in the treatment, where, iron folate, vitamins A, B_2 and C were supplemented.
4. When compared to other treatments, subjects given supplementary foods, had the highest positive changes in anthropometric measurements and physical endurance.

Salient findings of the experiment indicate the importance of bioavailability of iron from diets, rather than their food or nutrient adequacy. Further studies are required to extend these findings to other foods and vitamin and mineral supplements and to the food components which influence iron absorption.

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APPENDICES

APPENDIX I

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE
DEPARTMENT OF HOME SCIENCE

SCHEDULE TO ELICIT INFORMATION ON THE SOCIAL STATUS OF THE FAMILES.

Serial No. :

1. Name of the respondent :
2. Address :
3. Age :
4. Type of family :
5. Location of the house :
6. Religion :
7. Caste :
8. Size of the family :
9. Number of children in the family :
10. Number of adolescent girls in the family :
11. Number of adolescent boys in the family :
12. Head of the family :
13. Number of adults in the family :
14. Number of adult females in the family :
15. Educational status of the father :
16. Educational status of the mother :

17. Educational status of the respondent :

18. Number of highly educated (College level) members in the family :

19. Occupation of the head of the family :

20. Birth order of the respondent :

21. Spacing between the siblings and respondent :

SCORE SHEET FOR THE SCHEDULE TO ELICIT INFORMATION ON THE SOCIAL STATUS OF THE FAMILIES.

1.				7.	ST	:	1
2.					SC	:	2
3.					OBC	:	3
4.	Joint	:	1		Forward	:	4
	Extended	:	2	8.	Actual details to be taken		
	Nuclear	:	3	9.	"		
5.	Coastal	:	0	10	"		
	Rural	:	1	11.	"		
	Suburban	:	2	12.	Mother	:	3
	Urban	:	3		Father	:	2
6.	Christian	:	1		Any other	:	1
	Hindu	:	2	13.	Five adults & above	:	1
	Muslim	:	3		Four adults	:	2

	Three "	:	3
	Two "	:	4
	Only one adult	:	5
14.	Five females & above	:	1
	Four adult females	:	2
	Three adult females	:	3
	Two adult females	:	4
	Only one adult female	:	5
15, 16, 17.			
	Illiterate	:	1
	Literate	:	2
	Lower primary	:	3
	Upper primary	:	4
	High School	:	5
	College level	:	6
18.	None	:	1
	Only one member	:	2
	Two members	:	3
	3 members & above	:	4
19.	Petti business	:	1
	Fishing & fish vending	:	2
	Coolie	:	3
	Agriculture	:	4
	Regular employment	:	5
	Regular employment and agriculture	:	6
20.	Actual details to be taken.		
21.	" "		

APPENDIX II

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE
DEPARTMENT OF HOME SCIENCE

SCHEDULE TO ASSESS THE KNOWLEDGE OF ADOLESCENT FEMALES REGARDING ANEMIA.

Serial No.

Name of the respondent :

INSTRUCTIONS :

i. State each statement "true" or "false"

ii. All the statements carry an equal mark of 2

iii. Try to answer all the statements

STATEMENTS :

1. Anemia is due to the deficiency of iron
2. Iron deficiency may cause paleness and easy fatiguability
3. Iron is necessary for the production of haemoglobin in the blood
4. Iron deficiency anemia is indicated by lowered level of haemoglobin in blood
5. Leafy vegetables are rich sources of iron
6. Anemia can be prevented by increasing the iron intake
7. Chekkurmanis is a low cost iron rich food
8. Amaranth is a low cost iron rich food

9. Eating rice flakes with jaggery helps to reduce the incidence of anemia
10. Increased blood loss can cause anemia
11. Anemia reduces work capacity
12. Fruits are rich sources of vitamin C
13. Milk is deficient in iron
14. Vitamin A deficiency leads to preventable blindness in children
15. Anemia is widely prevalent among pregnant women
16. Hookworms cause iron deficiency anemia
17. During pregnancy there is a continuous drain of iron
18. Liver is a rich source of iron
19. Papaya is a rich source of vitamin C and B carotene
20. Fe capsules are supplied through Public Health Centers in order to prevent anemia among pregnant women and adolescent girls
21. Severe anemia in pregnant women increases maternal morbidity and mortality
22. Severe anemia in pregnant women is fatal to the foetus
23. Anemia during pregnancy is mainly due to poor nutrition
24. Anemia during pregnancy can be caused due to repeated pregnancies
25. Folic acid along with Fe is required for the multiplication and maturation of red cells
26. Inadequate intake of iron rich foods cause anemia

27. Poor absorption of dietary iron causes anemia
28. Excessive bleeding can cause anemia
29. Anemia in pregnant women causes moderate iron stores in the new born babies
30. Excessive tiredness / fatigue indicate that you are suffering from anemia
31. To prevent iron deficiency anemia, iron rich foods are to be consumed regularly
32. Anemic children may have impaired language development and scholastic achievement
33. Protein present in milk increases the absorption of iron from vegetables

APPENDIX III

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE
DEPARTMENT OF HOME SCIENCE

SCHEDULE TO ELICIT INFORMATION ON THE ECONOMIC STATUS OF THE FAMILIES

Serial No.

1. Name of the respondent :
2. Number of earning members in the family :
3. Number of members who are not earning in the family :
4. Total monthly income of the family :
5. Major source of income in the family :
6. Per capita income of the family :
7. Area of land possessed by the family :
8. Type of domestic animals possessed by the family :
   - 8.1. Number of cows possessed :
   - 8.2. Number of buffalo :
   - 8.3. Number of sheeps :
9. Type of domestic birds possessed by the family :
   - 9.1. Number of chicken :
   - 9.2. Number of Turkey :
   - 9.3. Number of Duck :

10. Total monthly expenditure of the family :

11. Total monthly expenditure on food :

SCORE SHEET FOR THE SCHEDULE TO ELICIT INFORMATION ON THE ECONOMIC STATUS OF THE FAMILIES.

1.

2. Only one member : 1

Two members : 2

Three members : 3

Four members and above : 4

3. The respondent only : 4

Two members : 3

Three members : 2

Four members and above : 1

4. Below Rs 1000/- : 1

Rs 1001 - 1500/- : 2

Rs 1501 - 2000/- : 3

Rs 2001 - 2500/- : 4

Rs 2501 - 3000/- : 5

Rs 3001 and above : 6

5. Income from petti business : 1

Income from fishing and fish vending : 2

	Income from coolie	:	3
	Income from agriculture	:	4
	Income from regular employment of one person	:	5
	Income from regular employment of one person and agriculture	:	6
	Income from regular employment of two persons	:	7
	Income from regular employment of two persons and from agriculture	:	8
6.	Actual details to be taken	:	
7.	"		
8.	"		
9.	"		
10.	"		
11.	"		

APPENDIX IV

KERALA AGRICULTURAL UNIVERSITY
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DEPARTMENT OF HOME SCIENCE

SCHEDULE TO ELICIT INFORMATION ON THE NUTRITIONAL VARIABLES RESPONSIBLE FOR THE DEVELOPMENT OF ANEMIA

Serial No.

1. Food habit of the respondent :

2. Consumption pattern of iron rich foods

Foods stuffs	Quantity consumed per day (g)	Frequency of use	
		Per day	Per week

3. Methods employed for cooking

3.1. Cereals :

3.2. Pulses :

3.3. Green leagy vegetables :

3.4. Other vegetables :

3.5. Roots and tubers :

3.6. Flesh foods :

3.7. Egg :

3.8. Milk :

4. Foods used during special occasions

   4.1. Festivals :

   4.2. Visit of guests :

   4.3. According to the desire of the family members :

5. Special foods given during special conditions :

   5.1. Infancy :

   5.2. Preschool :

   5.3. Adolescence :

6. Dietary modifications made during disease condition

Sl. No.	Name of disease	Alternation made
1.	Fever	
2.	Cold	
3.	Diarrhoea	
4.	Jaundice	
5.	Chicken pox	
6.	Chest infections	

7. Frequency of taking meals in a day

8. 24 hour recall survey to ascertain the foods consumed by the respondents.

Type of food preparation	Food stuffs	Ingredients	Quantity (g)

9. Foods taken from outside

Type of food preparation	Frequency of intake						
	Never	Daily	Weekly once	Weekly twice	Weekly thrice	Once in a fortnight	Once in a month

10. Frequency of use of various foods in the dietaries

Foods	Frequency of use					
	Daily	Weekly once	Weekly twice	Weekly thrice	Once in a fortnight	Once in a month.
1. **Cereals**						
Rice						
Wheat						
Semolina						
Maida						
Others (to be specified)						
2. **Pulses**						
Green gram						
Bengal gram						
Red gram						
Cow pea						
Others (to be specified)						
3. **Green leafy vegetables**						
Amaranthus						
Drumstick leaves						
Chekkurmanis						
Others (to be specified)						
4. **Root and tubers**						
Potato						

Tapioca

Coleus

Yam*

Colocasia

Carrot

Beet root

5. **Other vegetables (to be specified)**

6. **Fruits**

7. ***Milk and milk products***

8. **Meat**

9. **Fish**

10. **Egg**

11. **Nuts and oil seeds**

12. **Fats and oils**

13. **Sugar and Juggery**

14. **Bakery items / commercially prepared foods**

15. **Beverages**

---

11. Habit of taking foods in between meals

Nature of foods	Frequency of use per day.				
	Nil	Once	Twice	Thrice	Five times and more
1. Chinese foods or Fast foods					

2. Confectionaries
3. Fried foods
4. Nuts and oil seeds
5. Fruits
6. Lunch items
7. Sugar / Jaggery
8. Carbonated beverages
9. Colourful eataries
10. Sip ups
11. Bubble gum
12. Chewing gum

---

12. Nutritional assessment schedule

12.1. General

12.1.1. Appearance :

12.2. Eyes (A) Conjunctiva :

12.2.1. Xerosis :

12.2.2. Pigmentation :

12.2.3. Discharge :

12.2. (B) Cornea :

12.2.4. Xerosis :

12.2.5. Vasculaization :

12.2. (C) Lids :

12.2.6. Exceniation :

12.2.7. Folliculosis :

12.2.8. Augelar conjunctivitis :

12.2. (D) Functional :

12.2.9. Night blindness :

N.B.: Exclude other eye diseases not associated with eye defects

12.3. Mouth (A) Lips :

12.3.1. Condition :

(B) Tongue

12.3.2. Colour :

12.3.3. Surface :

12.3. (C) Buccal Mucosa :

12.3.4. Condition :

12.3. (D) Gums :

12.3.5. Condition :

12.4. Teeth :

12.4.1. Fiaurosis :

12.4.2. Caries :

12.5. Hair :

12.5.1. Condition :

12.6. Skin (A) General :

12.6.1. Appearance :

12.6.2. Elasticity :

12.6. (B) Regional :

12.6.3. Trunk :

12.6.4. Face :

12.6.5. Perineum :

12.6.6. Extremities :

12.7. A dipose tissue (to be judged by the examination of arm over the biceps.)

12.7.1. Quantity :

12.8. Odema :

12.8.1. Distribution :

12.9. Bones :

12.9.1. Condition :

12.10. Alimentary system :

12.10.1. Appetite :

12.10.2. Stools :

12.10.3. Liver :

12.10.4. Spleen :

12.11. Nervous system :

12.11.1. Calf tenderness :

12.11.2. Parathesia :

SCORE SHEET FOR THE SCHEDULE TO ELICIT INFORMATION ON THE NUTRITIONAL VARIABLES RESPONSIBLE FOR THE DEVELOPMENT OF ANEMIA.

1. Vegetarian - 1

   Ovo-vegetarian - 2

   Lactovegetarian - 3

   Ovo - Lactovegetarian - 4

   Non - Vegetarian - 5

2. A LISTED IRON RICH FOODS

   a. Cereals.

   Rice bran - 1

   Rice flakes - 2

   Rice - puffed - 3

   Rice (raw, hand pounded) - 4

   Rice (parboiled, hand pounded) - 5

   Rice (parboiled, milled) - 6

   Wheat (whole) - 7

   Wheat flour (whole) - 8

   Wheat flour (refined) - 9

   Wheat semolina - 10

   Wheat vermicelli - 11

   Wheat bread (brown) - 12

   Wheat bread (white) - 13

   Ragi - 14

(b) Pluses and legumes

Bengal gram (whole)	-	15
Bengal gram (dhal)	-	16
Bengal gram (roasted)	-	17
Black gram dhal	-	18
Cow pea	-	19
Feild beans (dry)	-	20
Green gram (whole)	-	21
Green gram dhal	-	22
Red gram dhal	-	23
Soya bean	-	24

(c) Leafy vegetables.

Agathi	-	25
Amaranth Sp.s.	-	26
Betel leaves	-	27
Cauliflower greens	-	28
Chekkurmanis	-	29
Curry leaves	-	30

(d) Roots and tubes.

Beet Root	-	31
Carrot	-	32
Onion (small)	-	33
Tapioca chips (dried)	-	34

(e)	**Other vegetables**		
	Beans	-	35
	Bittergourd	-	36
	Broad beans	-	37
	Cauliflower	-	38
	Cow pea pods	-	39
	Jack tender	-	40
	Jack fruit seeds	-	41
	Plantain (green)	-	42
	Snakegourd	-	43
	Tomato (green)	-	44
(f).	**Nuts and oil seeds.**		
	Cashew nuts	-	45
	Coconut, dry	-	46
	Coconut, fresh	-	47
	Coconut, milk	-	48
	Gingelly seeds	-	49
	Ground nut	-	50
	Ground nut, roasted	-	51
	Almond	-	52
(g).	**Fruits**		
	Amla	-	53
	Bilimbi	-	54

	Dates, dried	-	55
	Mango, ripe	-	56
	Water melon	-	57
	Passion fruit	-	58
	Pineapple	-	59
	Raisins	-	60
	Sapota	-	61
	Seethaphal	-	62
(h).	**Fishes and other sea foods**		
	Mackerel	-	63
	Mullet	-	64
	Sardine	-	65
	Ribbon fish, fresh	-	66
	Ribbon fish, dried	-	67
	Shark	-	68
(i).	**Meat and poultry**		
	Beef meat	-	69
	Egg (hen)	-	70
	Liver (sheep)	-	71
	Mutton muscle	-	72
	Pork muscle	-	73
(j).	**Sugar**		
	Sago	-	74

2B. *Frequency of use per day*

Once	-	1
Twice	-	2
Thrice and more	-	3

2C. Frequency of use per week

Daily	-	7
Weekly thrice	-	6
Weekly twice	-	5
Weekly once	-	4
Once in a fortnight	-	3
Once in a month	-	2
Never	-	1

3. Actual details to be taken -

4. Actual details to be taken -

5. "

6. "

7. Once in a day - 1

Daily twice - 2

Daily thrice - 3

Four times a day - 4

Five times a day - 5

Six times and more - 6

8. Actual details to be taken.

9. "

10.	"		
11.	"		
12.1.1.	Good	-	4
	Fair	-	3
	Poor	-	2
	Very poor	-	1
12.2.1.	Absent, glistening and moist	-	4
	Slightly dry on exposure for $^1/_2$ minute, lack of lustre	-	3
	Conjunctiva dry and wringled	-	2
	Conjunctive very dry and bitot's spots present	-	1
12.2.2.	Normal colour	-	4
	Slight discolouration	-	3
	Moderate browning in patches	-	2
	Severe earthy discolouration	-	1
12.2.3.	Absent	-	4
	Watery, excessive lachrymation	-	3
	Mucopurulent	-	2
	Purulent	-	1
12.2.4.	Absent	-	4
	Slight dryness and diminished sensibility	-	3
	Haziness and diminished transparency	-	2
	Ulceration	-	1

12.2.5.	Absent	-	3
	Circumcerneal infection of blood vessels	-	2
	Vascularization of cornea	-	1
12.2.6.	Absent	-	3
	Slight exertion	-	2
	Blepharitis	-	1
12.2.7.	Absent	-	4
	A few grannules	-	3
	Lids covered with extensive grannules	-	2
	Hypertrophy	-	1
12.2.9.	Absent	-	2
	Present	-	1
12.2.8.	Absent	-	2
	Present	-	1
12.3.1.	Normal	-	3
	Angular stamatitis, mild	-	2
	Angular stamatitis, marked	-	1
12.3.2.	Normal	-	4
	Pale, but not coated	-	3
	Red	-	2
	Red & raw	-	1
12.3.3.	Normal	-	4
	Fissured	-	3

	Ulcered	-	2
	Glazed and atrophic	-	1
12.3.4.	Normal	-	2
	Stomatitis	-	1
12.3.5.	Normal	-	4
	Bleeding and / or gingivitis	-	3
	Pyrrhorea	-	2
	Retracted	-	1
12.4.1.	Absent	-	4
	Chalky teeth	-	3
	Pitting of teeth	-	2
	Mottled and discoloured teeth	-	1
12.4.2.	Absent	-	3
	Slight	-	2
	Marked	-	1
12.5.1.	Normal	-	4
	Loss of lustre	-	3
	Discoloured and dry	-	2
	Sparse and brittle	-	1
12.6.1.	Normal	-	4
	Loss of lustre	-	3
	Dry and rough or crazy pavements	-	2
	Hyperketesis, phrynoderma	-	1

12.6.2.	Normal	-	3
	Diminished	-	2
	Wrinkled skin	-	1
12.6.3.	Normal	-	2
	Collar like pigmentation and dermatitis around the neck	-	1
12.6.4.	Normal	-	3
	Nasolabial seborrhoea	-	2
	Symmetrical, sub - orbital pigmentation	-	1
12.6.5.	Normal	-	2
	Scrotal or fudendal dermatitis	-	1
12.6.6.	Normal	-	2
	Symmetrical dermatitis with pigmentation of glove or stocking type	-	1
12.7.1.	Normal	-	2
	Deficient	-	1
12.8.1	Absent	-	4
	Odema in different parts	-	3
	Odema in face and dependent parts	-	2
	General anasarca	-	1
12.9.1.	Normal	-	2
	Stigmata of part rickets	-	1
12.10.1.	Normal	-	2
	Anorexia	-	1

12.10.2.	Normal evacuation	-	2
	Diarrhoea	-	1
12.10.3.	Not palpable	-	2
	Palpable	-	1
12.10.4.	Not palpable	-	2
	Pal pable	-	1
12.11.1.	Absent	-	2
	Present	-	1
12.11.2.	Absent	-	2
	Present	-	1

APPENDIX V

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE
DEPARTMENT OF HOME SCIENCE

1. Name Serial No.
2. Haemoglobin :
3. Height :
4. Weight :
5. Mid upper arm circumference :
6. Triceps skinfold thickness :
7. Arm muscle circumference :
8. Waist :
9. Hip :
10. Age at menarche :
11. Regularity of menustration :
12. Nature of menustrual flow :
13. Duration of menustrual flow :
14. Complications during menustruation :
15. History of incidence of any disease during the part 3 months :
16. Occurrence of infectious diseases during the last 2 years :
17. Frequency of occurrence of this infection during the last 2 years :

18. Occurrence of infectious diseases during the pregnancy period of respondent's mother :

SCORE SHEET FOR THE SCHEDULE TO ELICIT INFORMATION ON THE HEALTH VARIABLES RESPONSIBLE FOR THE DEVELOPMENT OF ANEMIA

1-9. Actual measurements to be measured :

10. Actual details are to be taken :

11. Irregular - 1

Regular - 2

12. Normal flow - 3

Medium - 2

Heavy - 1

13. One week or more - 1

6 days - 2

5 days - 3

4 days - 4

3 days - 5

14. Menorrhagia - 1

Dysmenorrhoea - 2

Normal - 3

15,16. No history of occurrence of diseases - 4

Diarrhoea - 3

Bacterial infections - 2

Viral infections - 1

17.	Nil	-	5
	Once in two years	-	4
	Once in a year	-	3
	Once in 6 months	-	2
	Once in 3 months	-	1
18.	Viral infections	-	1
	Bacterial infections	-	2
	No diseases at all	-	3

APPENDIX VI

DEVELOPMENT OF PEOPLE'S QUALITY OF LIFE INDEX TO ASCERTAIN POVERTY LEVELS OF ADOLESCENT FEMALES (n=225)

Sl. No	Variable								QL. Index
	Caste	Educational status	Occupational status	Family income	Per capita income	% of expenditure on food	Calorie requirement	Protein requirement	
001	2	5	2	2	0	2	6	0	19
002	3	4	1	0	1	1	5	0	15
003	2	5	2	2	1	2	6	0	20
004	3	4	1	0	1	1	5	0	15
005	3	4	1	0	1	1	5	0	15
006	1	5	2	3	2	1	5	6	25
007	2	5	2	3	2	0	2	6	22
008	2	5	92	2	2	0	4	0	17
009	2	4	1	1	1	1	5	0	15
010	2	4	1	5	2	2	6	6	28
011	2	5	2	2	1	1	5	0	18
012	2	5	1	3	2	0	3	0	16
013	2	5	1	2	1	1	5	0	17
014	2	0	1	1	1	0	2	0	7
015	2	4	1	3	2	0	4	0	16
016	2	5	1	3	2	0	4	3	20

017	1	5	2	5	2	1	5	4	25
018	2	5	1	2	2	1	5	0	18
019	2	5	1	3	1	1	6	2	22
020	2	5	1	5	4	1	5	0	23
021	2	5	2	3	4	1	5	2	21
022	3	5	1	2	1	2	6	0	20
023	3	4	1	2	1	0	3	0	14
024	2	4	2	3	2	0	4	6	23
025	2	5	3	3	2	2	7	0	24
026	2	5	4	3	2	1	6	2	25
027	2	5	1	1	1	1	6	0	17
028	2	5	3	2	2	2	6	0	22
029	2	3	1	3	2	2	6	0	21
030	2	5	4	5	2	1	5	0	24
031	3	5	2	4	3	2	6	0	25
032	2	1	1	3	2	2	7	0	18
033	2	4	1	2	1	1	5	0	16
034	2	4	1	0	1	0	2	0	10
035	2	4	1	1	1	1	5	2	17
036	2	4	1	1	1	1	5	2	17
037	2	5	1	1	1	2	6	0	18
038	2	4	1	1	1	1	5	0	15
039	2	5	4	2	1	2	6	0	22

040	2	5	1	5	3	3	7	0	31
041	2	4	1	2	1	1	6	0	17
042	2	5	2	0	1	1	4	0	15
043	2	5	1	3	2	2	7	0	22
044	2	4	1	3	2	1	6	1	20
045	2	4	3	3	2	2	6	0	22
046	3	5	3	4	2	1	5	4	27
047	2	5	3	5	2	1	5	2	25
048	2	5	3	5	3	1	5	4	28
049	2	5	1	3	2	1	5	0	19
050	2	5	1	3	2	1	5	0	19
051	2	5	1	2	1	1	6	0	18
052	2	5	2	3	2	2	7	0	23
053	2	5	1	2	1	2	6	0	19
054	2	5	3	3	2	2	6	0	23
055	2	5	1	2	1	2	6	0	19
056	2	5	1	2	2	2	6	0	20
057	2	5	3	3	2	0	3	2	20
058	2	4	1	1	1	1	5	2	17
059	2	5	4	5	3	2	6	0	27
060	2	4	1	3	1	1	5	2	19
061	2	5	4	5	2	1	6	2	27
062	2	5	4	5	2	2	6	6	32

063	2	5	1	5	1	2	6	2	24
064	2	5	2	3	2	1	5	0	20
065	2	4	1	1	1	2	7	4	22
066	2	5	2	3	1	1	5	2	21
067	2	5	1	1	1	1	6	0	17
068	2	5	4	3	2	1	6	2	25
069	2	4	1	1	1	1	5	0	15
070	2	4	2	3	2	0	4	6	23
071	2	5	1	5	4	1	5	0	23
071	2	5	2	0	1	1	5	2	18
073	2	5	4	2	1	2	6	0	22
074	3	4	1	2	1	0	3	0	14
075	2	5	1	3	2	2	6	0	21
076	2	4	1	2	1	1	5	0	16
077	2	5	4	4	3	2	7	2	29
078	2	4	1	1	1	1	5	2	17
079	3	5	1	2	1	2	6	0	20
080	2	5	3	2	2	2	6	0	22
081	2	5	3	3	2	2	7	0	24
082	2	5	4	5	2	1	5	0	24
083	2	4	1	2	1	1	5	0	16
084	1	4	3	2	2	1	5	2	20
085	2	5	1	1	1	2	6	0	18

086	2	4	1	0	1	0	2	0	10
087	3	4	1	0	1	1	5	0	15
088	2	4	3	3	2	2	6	0	22
089	3	5	2	4	3	2	6	0	25
090	2	5	2	0	1	1	4	0	15
091	2	0	1	1	1	0	2	0	7
092	2	4	1	2	1	1	6	0	17
093	1	5	2	3	2	1	5	0	19
094	2	4	1	3	2	1	6	1	20
095	2	1	1	2	2	2	7	0	18
096	2	5	3	5	2	1	5	2	25
097	3	4	1	0	1	1	5	0	15
098	2	5	2	0	1	1	4	0	15
099	2	5	1	1	1	2	6	0	18
100	2	5	1	3	2	2	7	2	24
101	2	4	1	0	1	2	7	0	17
102	3	5	1	0	1	1	5	0	16
103	2	4	2	2	2	1	6	0	19
104	3	5	4	4	2	2	7	0	27
105	2	4	1	3	2	1	6	0	19
106	2	5	1	0	1	1	5	0	15
107	2	5	1	0	1	1	5	0	15
108	2	4	1	0	0	1	5	0	13

109	2	5	1	0	1	0	3	0	12
110	2	4	2	2	2	3	7	0	22
111	2	5	4	3	2	1	4	0	21
112	3	4	1	1	1	3	7	0	20
113	3	4	1	1	1	1	5	0	16
114	2	5	1	0	1	1	5	0	15
115	2	5	2	0	1	1	5	0	16
116	2	4	1	1	1	1	6	0	16
117	2	4	1	1	1	2	7	0	18
118	2	4	1	0	1	1	5	0	14
119	3	5	1	0	1	1	6	0	17
120	2	4	2	2	2	2	7	0	21
121	3	5	4	4	2	1	6	0	25
122	2	4	1	3	2	2	6	0	20
123	2	5	2	2	2	1	5	0	19
124	2	4	1	0	1	1	6	0	16
125	2	5	2	2	1	1	5	0	18
126	3	4	1	0	1	1	5	0	15
127	3	4	1	0	1	1	5	0	15
128	3	5	3	4	2	1	5	4	27
129	2	5	3	5	2	1	5	2	25
130	2	5	3	5	3	1	5	4	28
131	2	5	1	3	2	1	5	0	19

132	2	5	1	3	2	1	5	0	19
133	2	5	1	0	1	1	5	0	15
134	2	5	1	0	1	1	5	0	15
135	2	4	1	0	0	0	3	0	10
136	2	5	1	0	1	3	7	0	19
137	2	4	2	2	2	2	6	0	20
138	2	5	1	5	2	1	5	2	23
139	2	5	2	3	2	2	7	0	23
140	2	4	1	1	1	1	5	4	19
141	2	5	2	3	1	1	6	2	22
142	2	5	1	1	1	1	6	0	17
143	2	5	4	3	2	2	6	2	26
144	2	4	2	2	2	1	4	0	17
145	2	5	4	3	2	3	7	0	26
146	3	4	1	1	1	1	5	0	16
147	3	4	1	1	1	1	5	0	16
148	2	5	1	0	1	1	5	0	15
149	2	5	2	0	1	1	6	0	17
150	2	4	1	1	1	1	4	0	14
151	2	5	2	0	1	1	5	0	16
152	2	4	1	2	1	1	4	0	15
153	2	5	2	0	1	1	5	0	16
154	2	4	1	1	1	1	5	0	15

155	2	5	1	5	4	1	5	0	23
156	2	5	1	3	2	2	6	0	26
157	2	5	1	3	2	2	6	0	21
158	2	5	3	2	2	2	6	0	22
159	2	5	1	5	1	2	6	2	24
160	3	5	1	2	1	1	6	0	19
161	2	4	1	2	1	1	5	0	16
162	2	4	1	2	1	1	5	0	16
163	2	4	1	1	1	0	3	2	14
164	3	4	1	2	1	2	7	0	20
165	2	5	1	3	2	2	6	2	23
166	2	5	1	2	2	1	5	0	18
167	2	5	2	3	1	1	5	2	21
168	2	4	1	2	1	1	5	0	16
169	2	4	1	1	1	2	4	2	17
170	2	5	1	3	2	2	7	3	25
171	2	5	1	3	2	2	7	3	25
172	2	4	1	1	1	0	2	2	13
174	2	0	1	1	1	2	6	0	13
175	2	5	2	3	1	1	6	2	22
176	2	5	1	2	1	1	5	0	17
177	2	4	1	2	1	2	7	0	19
178	2	5	3	3	2	1	5	0	21

179	2	5	2	1	2	0	3	0	15
180	3	4	1	2	1	1	5	0	17
181	1	5	2	3	2	0	2	0	15
182	2	4	1	0	1	0	2	0	10
183	2	4	1	0	1	1	2	0	17
184	2	5	3	3	2	2	6	0	23
185	2	4	3	3	2	1	5	0	20
186	2	4	1	1	1	1	5	2	17
187	2	4	1	1	1	2	6	0	17
188	3	5	1	2	1	2	6	0	20
189	2	5	1	1	1	1	5	0	16
190	2	5	1	2	2	1	5	0	18
191	3	5	3	4	2	2	6	4	29
192	1	4	3	3	2	1	5	0	19
193	1	5	2	3	2	1	5	0	19
194	2	4	1	2	1	2	7	0	19
195	2	5	3	3	2	2	6	0	23
196	2	5	1	2	2	2	6	0	20
197	2	5	3	2	2	2	6	0	22
198	2	5	1	1	1	1	5	0	16
199	2	5	2	3	1	1	6	2	22
200	2	5	4	3	2	2	7	2	27
201	2	1	1	3	2	1	5	0	15

202	2	4	1	1	1	1	6	2	12
203	2	4	3	3	2	1	5	0	20
204	2	5	1	1	1	1	5	0	16
205	2	5	3	5	3	1	5	4	28
206	2	4	1	3	1	1	5	2	19
207	2	5	1	5	4	2	7	0	26
208	2	5	3	3	2	2	6	0	23
209	2	5	4	2	1	2	6	0	22
210	2	5	3	2	2	1	6	0	21
211	2	4	1	3	2	2	7	0	21
212	2	4	2	2	2	1	5	0	18
213	2	5	2	0	1	1	6	0	17
214	2	4	2	2	2	2	6	0	19
215	2	5	2	2	1	1	5	0	18
216	2	5	3	4	3	1	5	4	27
217	2	4	1	0	0	2	7	0	16
218	2	4	1	1	1	1	4	4	18
219	2	5	4	3	2	1	5	0	22
220	2	4	1	1	1	2	6	0	17
221	2	5	4	3	2	1	5	0	22
222	2	5	1	2	2	0	4	0	16
223	2	4	1	3	2	1	5	0	18
224	2	4	1	1	1	1	5	2	17
225	2	5	1	1	1	0	4	0	14

APPENDIX VII

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE
DEPARTMENT OF HOME SCIENCE

SCHEDULE TO ASSESS THE ACTUAL FOOD INTAKE OF THE SUBJECTS (n=35) (BY FOOD WEIGHMENT METHOD)

Name of the meal	Menu	Weight of food consumed (g)	Weight of Raw ingredients used by the Institution (g)	Weight of Raw ingredients required for standardised recipie (g)	Weight of raw ingredients used by the individuals (g)
Break fast					
Lunch					
Tea					
Dinner					

APPENDIX VIII

RELATIONSHIP BETWEEN SELECTED SOCIO ECONOMIC VARIABLES AND FOOD USE FREQUENCY

Food items	Correlation coefficient (r)						
	Family Size	Family Income	No. of employed persons in the family	No. of highly educated members	Educational status of the repondent	Educational status of mother of respondent	PQLI
1. Careals							
a. Maida	0.0480	-0.1394*	-0.0921	-0.1110	-0.0478	-0.1544	0.1310
b. Rice flakes	-0.1035	-0.2763**	0.0357	-0.0763	-0.0086	0.9059	-0.1938**
c. Ragi	-0.0595	-0.2516**	0.0141	-0.2050**	-0.1400	-0.0260	-0.2840**
2. Pulses							
a. Bengal gram	-0.1023	-0.1068	0.1735**	0.0579	-0.0122	-0.1288	-0.0780
b. Cow pea	0.0915	-0.1943**	-0.0274	-0.1938**	-0.0434	-0.0556	-0.2406**
c. Black gram	0.0978	-0.1427*	0.1882	-0.1567	-0.1672	-0.2061**	-0.1698*
3. Green leafy Vegetables							
a. Chekkurmanis	-0.0860	-0.2238**	0.1209	-0.0689	0.1141	-0.0078	-0.1698*
4. Roots and tubers							
a. Potato	0.1577*	-0.0581	0.0829	-0.0534	-0.1032	-0.0774	0.0013
b. Coleus	0.0078	0.1338*	-0.0633	0.0416	0.0453	-0.0903	0.0898
c. Yam	-0.0616	-0.1678*	-0.0756	-0.1143	0.0554	-0.1071	-0.0538
d. Beet root	0.0757	-0.0703	0.1750	-0.0348	-0.0367	0.0046	-0.0202
5. Other Vegetables							
a. Plantain	0.0230	-0.0438	0.1547*	0.0195	-0.0001	0.0686	-0.0066
b. Cucumber	0.0558	-0.1438*	-0.1949**	0.0606	-0.0521	0.0293	-0.0789
c. Ladies finger	-0.0330	0.0685	0.1331*	0.0647	0.0850	0.0546	-0.0671
6. Fruits	-0.0295	-0.0450	-0.0226	-0.1252	-0.1736**	-0.1057	-0.0316
7. Poultry products							
a. Egg	0.0738	0.1437*	-0.0390	0.0010	-0.0015	-0.0308	0.0477

* Significant at 5 percent level ** Significant at 1 percent level.

APPENDIX IX

RELATIONSHIP BETWEEN MEAN FOOD INTAKE AND SELECTED SOCIO ECONOMIC VARIABLES

Food Items	Socio Economic Variables							
	Family size	Family income	No.of employed persons in the family	No. of highly educated members	Educational status of the respo-dent	Educational status of mother	Knowledge score	PQLI
Cereals	-0.1834**	0.0282	-0.0329	-0.1591*	0.0280	-0.1158	0.0521	0.0373
Pulses	0.0277	-0.0370	-0.027	40.0588	-0.0588	-0.0725	-0.065	30.0566
Green leafy vegetable	-0.1972**	-0.0731	-0.037	10.0119	-0.0602	-0.0339	-0.0260	0.0117
Other vegetables	0.0904	0.0235	-0.0458	-0.006	90.1175	0.1915**	-0.1038	0.0150
Roots & Tubers	0.0239	0.1052	0.1447*	-0.050	90.0285	0.0412	0.0076	0.0664
Milk	-0.1275	0.0971	0.0103	0.2674*	0.0494	0.2083**	-0.0193	0.2004**
Nuts & Oil seeds	-0.0256	0.0561	-0.0228	0.0915	-0.0312	0.0578	-0.1075	0.0679
Fats and Oils	-0.0768	0.0874	-0.0573	0.0905	0.1323*	-0.0124	-0.0228	0.1566*
Fish	0.1080	-0.0842	0.0356	-0.1689*	-0.2624**	-0.2427**	0.0037	-0.1207
Sugar & Jaggery	-0.0552	0.0950	0.0070	0.1651*	0.1703*	-0.0341	0.0430	0.1654*
Fruits	0.0543	0.0950	0.0144	0.0071	0.0036	0.1323*	-0.0418	0.0834
Meat	0.0407	0.1816**	0.1239	0.0879	0.1168	0.1476*	0.0708	0.1644*
Egg	-0.0334	0.0592	-0.0615	0.1411*	0.1654*	0.0579	0.1234	0.0349

* Significant at 5% level ** Significant at 1% level

APPENDIX X

KNOWLEDGE SCORE WORKED OUT FOR THE RESPONDENTS

Sl. No.	Knowledge score	Sl. No.	Knowledge score	Sl. No.	Knowledge score
001	87.88	019	63.64	037	90.91
002	90.91	020	69.70	038	93.94
003	60.61	021	78.79	039	75.76
004	69.70	022	60.61	040	72.73
005	57.58	023	63.64	041	75.76
006	96.97	024	69.70	042	66.67
007	63.64	025	72.73	043	78.79
008	90.91	026	66.67	044	78.79
009	69.70	027	66.67	045	75.76
010	66.67	028	78.79	046	39.40
011	48.49	029	63.64	047	45.45
012	39.40	030	75.76	048	96.97
013	93.94	031	45.45	049	96.97
014	69.70	032	84.85	050	93.94
015	69.70	033	96.97	051	81.82
016	66.67	034	93.94	052	78.79
017	66.67	035	57.58	053	75.76
018	69.70	036	39.40	054	78.79

055	72.73	078	39.40	101	96.97
056	75.76	079	51.52	102	48.49
057	75.76	080	75.76	103	90.91
058	42.42	081	72.73	104	78.79
059	90.91	082	90.91	105	75.76
060	78.79	083	87.88	106	72.73
061	54.55	084	93.94	107	78.79
062	78.79	085	78.79	108	78.79
063	75.76	086	75.76	109	57.58
064	78.79	087	75.76	110	93.94
065	39.40	088	48.49	111	96.97
066	69.70	089	96.97	112	81.82
067	66.67	090	78.79	113	96.97
068	60.61	091	78.79	114	75.76
069	66.67	092	96.97	115	78.79
070	60.61	093	63.64	116	96.97
071	60.61	094	60.61	117	78.79
072	63.64	095	60.61	118	39.40
073	66.67	096	63.64	119	93.94
074	60.61	097	60.61	120	75.76
075	60.61	098	90.91	121	63.64
076	78.79	099	75.75	122	66.67
077	96.97	100	75.76	123	60.61

124	75.76	147	72.73	170	69.70
125	90.91	148	78.79	171	66.67
126	78.79	149	96.97	172	66.67
127	78.79	150	92.73	173	63.64
128	39.40	151	78.79	174	66.67
129	96.96	152	45.45	175	57.58
130	93.94	153	78.79	176	57.58
131	96.97	154	72.73	177	87.88
132	45.45	155	75.76	178	78.79
133	75.76	156	87.88	179	75.76
134	78.79	157	78.79	180	75.76
135	75.76	158	72.73	181	66.67
136	78.79	159	78.79	182	69.70
137	87.88	160	75.76	183	75.76
138	57.58	161	78.79	184	63.64
139	96.97	162	72.73	185	78.79
140	69.70	163	39.40	186	66.67
141	66.67	164	63.64	187	69.70
142	69.70	165	66.67	188	78.79
143	90.99	166	69.70	189	66.67
144	93.94	167	60.61	190	69.70
145	90.91	168	63.64	191	78.79
146	75.76	169	66.67	192	48.49

193	78.79	209	69.70
194	75.76	210	69.70
195	39.40	211	60.61
196	66.67	212	66.67
197	69.70	213	39.40
198	75.76	214	60.61
199	66.67	215	75.76
200	69.70	216	69.70
201	78.79	217	75.76
202	67.70	218	66.67
203	63.64	219	75.76
204	57.58	220	69.70
205	75.76	221	48.49
206	78.79	222	78.79
107	75.76	223	66.67
208	75.76	224	75.76
		225	69.70

APPENDIX XI

CALORIE CONSUMPTION INDEX(CCI) WORKED OUT FOR THE RESPONDENTS

Sl No.	CCI	Sl No.	CCI	Sl No.	CCI
001	0.54	019	0.91	037	1.04
002	0.55	020	0.73	038	1.11
003	0.57	021	0.81	039	1.33
004	0.49	022	0.99	040	1.18
005	0.70	023	1.02	041	1.02
006	0.75	024	0.77	042	1.57
007	0.93	025	0.83	043	1.11
008	0.82	026	0.95	044	1.03
009	0.97	027	1.06	045	0.96
010	0.83	028	0.97	046	0.88
011	0.77	029	1.01	047	1.04
012	0.75	030	0.97	048	1.23
013	0.85	031	0.82	049	0.94
014	0.78	032	0.94	050	1.10
015	0.83	033	0.99	051	1.24
016	0.68	034	1.00	052	1.10
017	0.89	035	0.96	053	1.00
018	0.89	036	1.07	054	1.23

055	0.94	079	1.07	102	0.73
056	0.93	080	0.99	103	0.54
057	0.86	081	0.97	104	1.06
058	0.93	082	0.83	105	1.10
059	0.81	083	0.97	106	0.86
060	1.89	084	0.99	107	1.14
061	1.25	085	0.96	108	0.83
062	1.06	086	1.04	109	1.23
064	0.92	087	1.00	110	1.19
065	1.09	088	0.55	111	0.82
066	1.55	089	0.96	112	0.70
067	1.12	090	0.82	113	0.94
068	1.06	091	1.57	114	0.49
069	0.95	092	0.78	115	0.95
070	1.05	093	1.12	116	0.83
071	1.02	094	0.75	117	0.68
072	1.14	095	1.03	118	0.81
073	0.81	096	0.94	119	1.02
074	1.33	097	1.04	120	0.57
075	1.02	098	0.70	121	0.89
076	1.01	099	1.57	122	1.23
077	0.99	100	1.04	123	1.00
078	1.18	101	1.11	124	0.93

125	0.89	148	0.78	171	0.81
126	0.94	149	0.57	172	0.96
127	0.93	150	1.09	173	0.96
128	0.97	151	0.73	174	1.18
129	0.91	152	1.00	175	0.93
130	1.11	153	1.55	176	0.92
131	1.10	154	1.24	177	1.24
132	0.77	155	1.06	178	0.99
133	1.19	156	0.83	179	0.83
134	0.49	157	0.95	180	1.09
135	0.89	158	0.96	181	1.02
136	0.88	159	1.05	182	0.75
137	1.19	160	0.54	183	1.00
138	0.82	161	1.14	184	1.07
139	0.81	162	0.55	185	0.83
140	1.33	163	1.10	186	1.01
141	1.25	164	0.78	187	0.93
142	0.75	165	0.82	188	1.05
143	0.89	166	0.70	189	0.99
144	1.06	167	1.04	190	1.04
145	0.75	168	1.10	191	0.89
146	0.85	169	0.68	192	0.88
147	0.92	170	1.57	193	0.96

194	0.75	210	1.33
195	1.02	211	0.97
196	0.83	212	0.86
197	0.93	213	0.82
198	0.97	214	0.83
199	1.04	215	0.89
200	1.12	216	0.94
201	0.95	217	1.10
202	0.94	218	0.88
203	1.07	219	1.25
204	0.96	220	0.85
205	1.06	221	0.73
206	1.23	222	0.70
207	1.19	223	0.89
208	1.14	224	0.83
209	0.83	225	1.07

APPENDIX XII

BODY MASS INDEX (BMI) OF THE RESPONDENTS

Sl No	BMI	Sl No	BMI	Sl No	BMI
001	71.83	020	16.65	038	19.02
002	16.89	021	20.48	039	17.58
003	18.73	022	18.86	040	19.98
004	17.10	023	18.11	041	18.67
005	17.78	024	15.98	042	18.35
006	16.65	025	20.89	043	17.53
007	15.75	026	18.92	044	18.67
008	15.98	027	17.94	045	18.03
009	17.78	028	19.11	046	17.78
010	18.73	029	17.90	047	16.89
011	16.65	030	17.31	048	18.22
012	15.07	031	18.97	049	17.75
013	16.89	032	20.61	050	17.94
014	15.98	033	19.39	051	18.75
015	15.56	034	16.46	052	18.31
016	15.98	035	19.39	053	17.90
017	19.29	036	19.39	054	17.58
018	17.78	037	19.11	055	18.73
019	18.67				

056	15.70	080	19.11	103	18.67
057	19.39	081	20.89	104	21.33
058	18.73	082	17.31	105	18.67
059	17.78	083	19.39	106	16.89
060	19.98	084	19.39	107	17.31
061	18.73	085	19.11	108	19.39
062	18.73	086	16.46	109	17.56
064	17.78	087	16.89	110	20.31
065	21.33	088	18.03	111	17.12
066	20.48	089	18.97	112	21.64
067	17.94	090	18.35	113	17.78
068	18.92	091	15.75	114	16.89
069	19.02	092	18.67	115	19.02
070	15.98	093	16.67	116	18.67
071	16.65	094	18.67	117	19.07
072	20.48	095	20.61	118	18.26
073	17.58	096	16.89	119	18.67
074	18.11	097	17.78	120	21.33
075	17.90	098	18.35	121	18.67
076	19.39	099	19.11	122	17.83
077	19.98	100	17.53	123	16.89
078	19.39	101	19.07	124	18.73
079	18.86	102	18.26	125	17.10

126	17.78	149	18.67	172	15.75
127	17.78	150	18.35	173	17.58
128	16.89	151	19.39	174	20.48
129	18.22	152	18.32	175	17.94
130	17.75	153	19.02	176	19.39
131	17.78	154	16.65	177	20.89
132	16.89	155	17.78	178	17.78
133	17.31	156	17.90	179	18.11
134	19.39	157	19.11	180	16.65
135	17.56	158	18.73	181	16.46
136	20.31	159	18.86	182	16.46
137	18.73	160	18.67	183	20.89
138	17.78	161	19.39	184	18.03
139	21.33	162	19.39	185	19.39
140	20.48	163	18.10	186	19.02
141	17.94	164	17.53	187	18.86
142	18.92	165	18.73	188	18.86
143	19.48	166	20.48	189	17.78
144	17.12	167	19.39	190	17.78
145	21.64	168	19.39	191	18.03
146	17.78	169	15.98	192	16.65
147	16.89	170	17.53	193	18.67
148	19.02	171	19.39	194	20.89

195	18.73	211	20.31
196	18.86	212	16.89
197	18.86	213	18.67
198	20.48	214	18.73
199	18.91	215	18.20
200	20.61	216	19.39
201	19.39	217	21.33
202	18.03	218	17.12
203	17.94	219	18.67
204	18.22	220	19.48
205	17.78	221	17.78
206	16.65	222	15.56
207	20.89	223	19.39
208	17.58	224	17.94
209	19.11	225	15.56
210	18.67		

APPENDIX XIII

NUTRITIONAL STATUS INDEX (NSI) OF THE RESPONDENTS

Sl. No.	NSI	Sl. No.	NSI	Sl. No.	NSI
001	239.89	019	258.57	037	257.75
002	260.75	020	243.86	838	283.54
003	275.78	021	240.56	039	254.61
004	239.09	022	253.96	040	291.94
005	240.75	023	235.14	041	284.55
006	240.17	024	225.22	042	274.68
007	259.53	025	251.65	043	276.89
008	286.07	026	254.98	044	275.51
009	253.94	027	254.11	045	272.80
010	257.19	028	247.02	046	243.47
011	250.30	029	246.38	047	464.66
012	255.22	030	248.61	048	248.74
013	250.93	031	248.96	049	249.47
014	247.33	032	249.03	050	267.61
015	249.98	033	280.48	051	257.07
016	245.87	034	257.71	052	267.83
017	268.50	035	257.75	053	264.45
018	273.95	036	268.01	054	273.90

055	257.17	078	267.87	101	256.23
056	277.10	079	253.96	102	271.93
057	250.66	080	247.02	103	285.26
058	241.39	081	251.65	104	284.37
059	261.28	082	248.61	105	278.52
060	278.21	083	280.48	106	265.28
061	257.69	084	257.92	107	251.15
062	262.75	085	257.75	108	289.09
063	248.16	086	257.71	109	266.15
064	465.27	087	260.61	110	251.72
065	246.68	088	272.80	111	254.38
066	247.75	089	278.96	112	243.82
067	254.11	090	274.68	113	257.83
068	254.98	091	264.43	114	242.05
069	282.15	092	286.87	115	262.40
070	231.03	093	225.14	116	255.32
071	253.38	094	225.51	117	277.91
072	240.39	095	249.03	118	282.96
073	254.61	096	264.66	119	273.77
074	235.14	097	240.75	120	282.00
075	246.14	098	274.68	121	287.45
076	280.48	099	257.75	122	250.62
077	291.18	100	277.00	123	269.65

124	282.99	147	253.85	170	270.09
125	249.70	148	271.69	171	257.97
126	290.98	149	269.29	172	268.94
127	244.89	150	255.13	173	250.63
128	261.75	151	280.71	174	243.29
129	267.76	152	274.22	175	249.86
130	253.68	153	286.61	176	286.34
131	259.95	154	251.08	177	255.08
132	266.66	155	261.56	178	259.28
133	243.26	156	244.98	179	236.82
134	281.31	157	246.74	180	231.29
135	258.85	158	251.06	181	252.18
136	260.15	159	243.74	182	257.71
137	245.61	160	287.44	183	256.83
138	258.93	161	270.26	184	269.84
139	241.63	162	260.94	185	243.41
140	250.66	163	229.56	186	277.77
141	247.19	164	270.05	187	255.19
142	253.14	165	271.93	188	256.56
143	285.00	166	245.73	189	277.32
144	255.32	167	283.31	190	243.20
145	239.48	168	258.90	191	271.33
146	276.60	169	266.36	192	231.21

193	274.00
194	255.78
195	274.95
196	245.84
197	256.21
198	245.62
199	258.75
200	249.76
201	264.88
202	275.19
203	251.95
204	244.13
205	263.39
206	254.32
107	258.95
208	243.06
209	325.08
210	281.19
211	253.37
212	239.20
213	279.81
214	283.21
215	241.46
216	286.85
217	230.80
218	266.98
219	264.00
220	276.84
221	269.76
222	251.37
223	262.49
224	254.34
225	251.90

APPENDIX XIV

BASAL MENU (CYCLIC & VEGETARIAN)

DAY	BREAK FAST	LUNCH	EVENING TEA	DINNER
Sunday	Wheat,Puutu, Green gram, curry, Coffee	Rice,Beetroot pugath,Chekkurmans pugath, Rasam	Tapioca, Chutney Coffee	Rice,Rasam, Avial. D1
Monday	Wheat Puttu, Bengal Gram curry, coffee	Rice,curd, Bengal gram pugath,Chekkurmanis pugath	Ragi porridge, Dhal Coffee,	Rice,Rasam Green grampugath D2
Tuesday	Idli,Chudtney, Coffee	Rice,Cabbage pugath Curd,Chekkurmanis pugath	Munthirikothu Coffee	Rice,Rasam, Cabbage pugath D3
Wednesday	Rice puttu,Bengal gram Curry, Coffee	Rice, Potato curry, Chekkurmanis pugath, curd	Biscuits, Coffee	Rice, Rasam Potato curry D4
Thursday	Bread,Potato curry, coffee, Bengal gram,	Rice, Avial, Chekkurmanis pugath, Curd	Banana chips, Coffee, Green gram	Rice,Rasam Brinjal mezhukkupuratti D5
Friday	Dosa,Chutney, coffee	Rice, Green gram, pugath, Chekkurmanis pugath, Rasam	Tapioca, Chutney, coffee	Rice Green gram pugath,Rasam D6
Saturday	Tapioca, green gram pugath, chutney, coffee	Rice,chekkurmanis Cabbage pugathu, Curd	Wheat Kozhukkata Coffee	Rice,Rasam Cabbage pugath D7

APPENDIX XV

NUTRIENT COMPOSITION OF BASAL MENU

Day	Protein (g)	Fat (g)	CHO (g)	Energy (kcal)	Ca (mg)	P (mg)	Fe (mg)	Carotene (µg)	Thiam-ine(mg)	Ribo-flavin (mg)	Niacin (mg)	Folic acid (µg)	Vit C (mg)
Sunday	61.30	90.08	458.51	2812.7	1223.40	1678.10	31.122	3448.90	2.59	3.52	39.45	152.95	200.10
Monday	64.92	60.13	418.87	2401.6	1083.39	1624.05	31.640	3913.76	2.108	2.90	18.85	198.03	166.60
Tuesday	64.20	74.90	434.87	2365.56	1216.00	1542.30	38.16	6250.40	1.95	1.20	19.08	185.55	384.80
Wednesday	61.40	64.17	481.21	2699.70	1284.94	1539.00	37.29	6235.9	2.06	1.20	20.90	161.40	291.30
Thursday	63.13	70.30	414.30	2341.60	944.01	1361.10	44.70	3947.20	2.02	3.05	16.08	209.47	175.35
Friday	66.12	63.80	466.57	2629.80	1438.60	1518.90	39.11	6220.20	2.19	1.26	18.89	149.55	308.40
Saturday	63.56	80.31	454.59	2549.96	1280.40	1627.10	40.796	6334.90	2.28	2.32	19.16	117.70	422.50
MEAN	63.52	71.96	446.99	2531.99	1210.11	1555.78	37.55	5193.04	2.17	2.21	19.06	167.81	278.44
RDA	62.00	22.00	402.55	2050.00	550.00	550.00	30.00	2400.00	1.00	1.20	14.00	100.00	40.00

APPENDIX XVI

FORMUMATED RECIPES TO DEVELOP SUPPLEMENTARY FOODS RICH IN IRON VITAMIN A, B_2 AND C.

1. **Soya Puttu**

Ingredients

Defatted soyaflour	-	50g
Chopped Chekkurmanis	-	25g
Grated carrot	-	20 g
Salt	-	to taste

Method

Wet all the ingredients with a little water and steam it in a puttu steamer.

2. **Soya - pakkavada**

Ingredients

Defatted soya flour	-	25 g
Bengal gram flour	-	25 g
Chekkurmanis (chopped)	-	25 g
Carrot (grated)	-	25 g
Oil	-	to fry
Salt	-	to taste

Method

Steam and cook grated carrot and chopped chekkurmanis. Mix it with

defatted soya flour, begal gram flour and salt with a little water to form a dough. Put the dough in a seva and press it and deep fry till brown.

3. **Bonda**

Ingredients

Bengal gram dhal flour	-	20g
Grated carrot	-	20g
Tapioca	-	20g
Chekkurmanis (chopped)	-	20g
Chopped Big Onion	-	20 g
Salt	-	to taste
Masala	-	to taste
Oil	-	to fry

Method

Cook tapioca and mash it. Season grated carrot, chekkurmanis and big onion. To this add masala powder and salt and mix it with the mashed tapioca and roll into small balls. Make a paste with Bengal gram dhal flour and salt. Dip the prepared balls into this paste and deep try till brown.

4. **Soya cookies**

Ingredients

Defatted soya flour	-	50g
Chopped chekkurmanis	-	25g
Gratted carrot	-	20g
Ginger paste	-	1g

Oil	-	10 ml
Salt	-	to taste

Method

Steam and cook chekkurmanis and carrot. Mix defatted soya flour, salt, oil and ginger paste and to this add cooked carrot and chekkurmanis. Mix well to form dough and roll into small balls and press it in the shape of cookies and bake it in a pre-heated oven till done.

5. **Wheat - soya - dates idli**

Ingredients

Soya flour	-	20g
Atta	-	25g
Dates	-	10g
Salts	-	to taste

Method

Deseed dates and chop it into small pieces. Mix soya flour, atta, dates and salt with a little water to form a paste. Pour this into a idli steamer and steam it till done.

6. **Soya vegetable cutlet**

Ingredients

Potato	-	100g
Soya beans	-	50g
Beans	-	25g
Grated carrot	-	25g

Chekkurmanis	-	50g
Bengal gram flour	-	20g
Bread crumbs	-	100g
Masala powder	-	1 tb sp
Salt	-	to taste
Oil		

Method

Cut the vegetables into small pieces and shallow fry with the masala powder and chekkurmanis. Mix it with the boiled potato. Make it into round shaped cutlets. Dip the cutlets into bengal gram flour paste and roll into the bread crumbs. Deep fry the cutlets.

7. **Gingelly balls**

Ingredients

Gingelly seeds	-	50g
Jaggery	-	50g
Dried coconut	-	10g

Method

Grind gingelly seeds and to this add grated jaggery and dried coconut. Mix all the ingredients well and roll into small balls.

8. **Amaranth bengal gram dhal pugath**

Ingredients

Amaranth	-	100g
Bengal gram dhal	-	25g

Coconut	-	10g
Masala powder	-	to taste
Salt	-	to taste

Method

Cook bengal gram dhal with salt. Grind coconut and masala. Season chopped amaranthus, when it is done add cooked bengal gram dhal and coconut paste. Cook till well done.

9. **Rice flakes (1 serving)**

Ingredients

Rice flakes	-	25 g
Coconut	-	20g
Jaggery	-	50g

Method

Melt jaggery and to this add rice flakes and grated coconut. Mix well and serve.

10. **Black gram dhal vadai**

Ingredients

Black gram dhal	-	100g
Salt	-	to taste
Oil	-	to fry

Method

Soak decutinized black gram dhal and grind into a thick paste with salt and little water. Roll into small balls and shape in the form of vadai and deep fry till brown.

11. Amaranth Soya pugath (1 serving)

Ingredients

Amaranth	-	100g
Soya bean	-	50g
Masala	-	20g
Salt	-	to taste

Method

Same as that of Amaranth bengal gram dhal pugath.

12. Soya Gingelly balls (2 servings)

Ingredients

Rice flakes	-	25g
Gingelly seeds	-	25g
Soya bean flour	-	25g
Jaggery	-	50g
Coconut	-	10g

Method

Grind rice flakes, gingelly seeds, jaggery and coconut. Mix well with roasted soya bean flour and roll into small balls.

13. Sweet Soya balls

Ingredients

Rice flour	-	100g
Soya flour	-	20g
Jaggery	-	75g

Coconut scrapings	-	25g
Cardamom	-	2

Method

Roast rice flour and soya flour till it becames golden brown. Add jaggery syrup and coconut scrapings to the roast flour. Mix it well and make it into small balls.

14. **Ladies finger fry (1 serving)**

Ingredients

Ladies finger	-	50g
Onion	-	20g
Oil	-	5ml
Salt	-	to taste

Method

Chop ladies fingers and onion and shallow fry till it is well done.

The foods selected for supplementation are Amaranth soya bean pugath (2 servings), soya gingelly balls (2 servings), rice flakes (1serving) and ladies finger fry (1 serving).

EFFECT OF IRON AND VITAMIN SUPPLEMENTATION ON IRON PROFILE OF ANEMIC ADOLESCENT GIRLS

BY

KAVITA M. S.

ABSTRACT OF THE THESIS

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COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

The study entitled, "Effect of iron and vitamin supplementation on iron profile of anemic adolescent girls", was conducted to assess the magnitude of iron deficiency anemia among adolescent girls; to find out the direct and indirect effects of causative factors and to evaluate the relative effect of supplementation of iron with vitamins on the iron status of anemic adolescent females.

The study was limited to Neyyattinkara, Nedumangadu and Trivandum Taluks of Trivandrum district. Rapid assessment technique was administered to determine haemoglobin and to indentify 225 adolescent girls suffering from iron deficiency anemia (with Hb $\leq$ 12g/dl).

Socio economic status of the girls was determined by using a suitably structured schedule while nutritional variables responsible for the incidence of anemia were determined through assessing their mean food intake by 24 hour recall method and by ascertaining their anthropometric measurements using universally accepted techniques. Clinical examination was conducted to assess the health variables responsible for iron deficiency anemia.

A metabolic experiment of two months duration was conducted to find the effect of iron and vitamin supplementation on iron profile of the moderately anemic girls. For this, the basal diet which gave RDA of nutrients was supplemented by 60 mg iron and 500 µg folic acid, 600 µg equivalent vitamin A, 1.2 mg equivalent vitamin B_2 and 40 mg equivalent vitamin C in different treatment groups either in the form of tablets

or in the form of food items. For this a combination of supplementary foods was developed and tested for their bioavailability of iron. The subjects were dewormed prior to the start of supplementation.

Pre and post experimental changes in haematological and iron profiles, anthropometry and physical endurance were assessed by using suitable tests.

Results of the study indicated that Trivandurm Taluk had the highest prevalence of anemia of 52 per cent with the overall prevalence of 49 per cent among adolescent girls.

Majority of the socio economic variables were observed to have little impact on the incidence of mild degree of anemia. Family size and family composition are the variables which negatively influenced haemoglobin levels. The variables which indicated positive impact on haemoglobin level were quality of life indiex, knowledge of the respondents regarding health and nutritional factors related to anemia, calorie consumption index and frequency of use of iron rich foods. Presence of mild degree of anemia was not influenced by adequate food and nutrient intake while slow growth rate, low anthropometric measurements and poor nutritional status predispose the adolescent girls to anemia.

Effect of iron and vitamin supplementation as assessed by metabolic experiment indicated that iron and vitamin supplements directly influenced food iron availability. The supplementary foods developed had bioavailability of 6.84 per cent to 13.56 per cent.

Supplements in the form of tablets produced highest and rapid changes in haematological and iron profile while the greatest positive changes in growth and physical endurance were observed when the supplements were given in the form of food. Hence for proper iron nutriture, iron source with high bioavailable iron is necessary along with balanced intake of other nutrients.