AVAILABILITY OF IRON FROM AMARANTHUS FLAVUS, IRON SALT AND TONIC TO CHILDREN IN A SCHOOL LUNCH PROGRAMME

By

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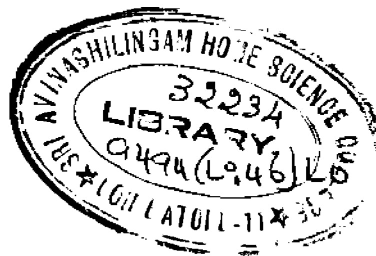

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I INTRODUCTION

Today's children are tomorrow's citizens. Hence, children who are our cherished possessions need to be given ample scope for maximum allround development. Among the environmental factors which influence their mental, social and emotional growth, good nutrition is of paramount importance, (Swaminathan, 1967).

Children are the most vulnerable segment of the population (Jelliffe, 1967; Rao, 1967; Gopalan, 1968, 1970). As King (1968) warns, today, nearly three-hundred million children in the world are physically, and perhaps mentally retarded due to malnutrition. In several parts of India, a considerable number of pupils enrolled in primary and secondary schools are victims of malnutrition, (Pandit and Rao (1960) and Bagchi (1968). Gopalan (1968, 1970) points out that about 40 per cent of the total mortality in India are among children below five years. The nutrition surveys conducted among school children have shown that nearly 25 percent suffer from frank nutritional deficiency diseases (Gopalan, 1970). Of the various manifestations of nutritional deficiencies, protein-calorie malnutrition, anaemia and vitamin-A deficiency claim a heavy toll.

The World Health Organization's Expert Committee (WHO, 1968) studied the relevance of the problems of malnutrition and undernutrition to anaemia, as anaemia constitutes a public health problem of great magnitude, particularly in the underdeveloped and tropical areas of the world. They were convinced that malnutrition and undernutrition were the pre-disposing factors.

Swaminathan (1968) claims that diseases due to vitamin-B complex and iron are widely prevalent amont the low income groups who subsist mainly on cereal diets. Patwardhan (1965), Chandra (1965), Elwood (1965), Sood (1967) and Chatterjee (1967) observe that anaemia is the most common manifestation of malnutrition in India. At least 60 per cent of all young children in India suffer from nutritional anaemia. Patwardhan (1954), Pandit and Rao (1960), Sood (1967) and Gopalan (1968) stress that a majority of these anaemias are of the iron deficiency type.

Green leafy vegetables furnish liberal quantities of iron in the vegetarian diets. They are easily available at low cost, (Nirmala *et al*, 1968). They also supply considerable quantities of vitamin A (β carotene), folic acid, ascorbic acid and calcium, (Iyengar, 1967; Jelliffe, 1968). They provide a good supplement in the school lunch programme (Anandam *et al*, (1966).

Studies concerning the incidence of iron deficiency anaemia in relation to the actual intake of 'absorbable' iron through foods, are meagre, (Finch, 1965; Apte and Venkatachalam, 1962). Since, the nation wide Applied Nutrition Programme advocates the cultivation and consumption of leafy vegetables and since supplementation of iron in the form of "tonics" and "salt" is becoming common, information regarding the availability of iron from such supplements in comparison with that utilised from leafy vegetables would be of immense practical value in the economic context.

The present investigation is an effort in that direction. It aims at comparing the availability of iron from a green leafy vegetable namely, *Amaranthus flavus* and iron supplements in the form of a salt and tonic in the school lunch of selected groups of children, as assessed through, changes in their height, weight and blood picture.

II REVIEW OF LITERATURE

At the aim of this study was the to evaluate the availability of iron from <u>Amaranthus flavus</u> and an iron supplement, the pertinent literature reviewed is discussed under the following headings:

A. Nutritional Problems of Children in India,

B. Role of the School Lunch Programmes in Overcoming Nutritional Problems,

C. Prevalence of Iron Deficiency Anaemia in India,

D. Factors Affecting the Absorption and Utilisation of Iron,

and E. Supplementation Studies with Iron.

A. Nutritional Problems of Children in India

The nutritional problems of children in India are reviewed under the following headings:

1. Malnutrition and undernutrition in infancy and childhood,
2. Protein - calorie malnutrition,
3. Vitamin-A deficiency,
4. Nutritional anaemia,
5. Other nutritional problems.

1. <u>Malnutrition and Undernutrition in Infancy and Childhood:</u>

Malnutrition in young children is a major public health problem in many areas of the world. The Food and Agricultural Organization (FAO, 1963) and Freedom From Hunger Campaign (FFHC, 1965) have defined malnutrition as a condition resulting from diets which are incapable of providing the minimum requirements of essential nutrients, and undernutrition as the sustained failure to supply the energy needs of the body.

There is evidence that early malnutrition and undernutrition may exert adverse effects permanently on the mental and physical development of the child (Lauw <u>et al</u>, 1967; Hein <u>et al</u>, 1967; and Rao, 1969).

Early malnutrition is likely to be the most detrimental to brain development and will not disappear as a consequence of later adequate diets. (Coursin, 1965; Champakam and Balasubramanian, 1968; Antoun <u>et al</u>, 1968; and Winnick, 1968). Scrimshaw (1967) warns that malnutrition reduces learning ability, memory and motivational drive to learn. Nutrition Reviews, (1968) and Swaminathan (1968) also endorse the view that malnutrition especially protein malnutrition may result in intellectual dwarfism.

Alan Berg (1968) cautions that malnutrition decreases working capacity and lowers the resistance to diseases. According to his estimate, in India alone, there are at least one million preventable cases of blindness attributable to malnutrition. Nutritional

assessment all over India shows that due to the deficiency of one or more specific nutrients, diseases like beri-beri, angular stomatitis, cheilosis, pellagra and xerophthalmia result (ICMR 1969).

2. Protein-Calorie Malnutrition:

'Protein-calorie deficiency' is an expression which denotes a syndrome in which marasmus, marasmic kwashiorkor and kwashiorker conditions are included. Protein-calorie deficiency indicates that the two dietary factors, namely, protein and calories are involved (Platt and Heard, 1965). According to the FAO (1965) protein-calorie deficiency can occur in all age groups, but the incidence is greatest during the weaning and immediate post weaning periods. Gopalan (1966) has pointed out that the incidence of protein-calorie malnutrition is high in the South East Asian region, particularly in India.

In recent years, the possible effects of protein malnutrition in early childhood on mental development has attracted considerable attention (ICMR, 1968). Children suffering from severe protein-calorie malnutrition exhibit abnormal behaviour. Reddy (1968) observes that inadequate supply of protein and calories has been the major cause of illness and even death in extreme cases among children of the age group one to five years in India. The Nutrition Research Laboratories (NRL, 1968) reports that kwashiorkor and marasmus are common pediatric problems among pre-school children.

3. Vitamin-A Deficiency:

Reddy (1969) regards vitamin-A deficiency as a major pediatric nutritional problem in India. Reports of vitamin-A deficiency in children suffering from protein-calorie malnutrition indicate that the incidence varies in different parts of the world. Venkatachalam (1967) is of the opinion that among the nutritional disorders affecting infants and children in India, vitamin-A deficiency comes second in importance to protein-calorie malnutrition. Achar and Benjamin (1951) found that 37 per cent of a series of 150 patients with kwashiorkor exhibited signs and symptoms of vitamin-A deficiency. Venkatachalam and Gopalan (1960), have reported that 32 per cent of the children with kwashiorkor at Hyderabad and 36 per cent of children at Coonoor had signs of vitamin-A deficiency. Pereira et al, (1966) recorded incidence of occular manifestations, of vitamin-A deficiency, in 175 children with kwashiorkor, and the low serum vitamin-A levels associated with the occular signs in 136 children with protein-calorie malnutrition. In a survey conducted at Calcutta, Soundarajan (1963) noted signs of vitamin-A deficiency in 35 - 40 per cent of the school children. Mclaren (1968) has estimated that 80,000 children in the world go blind every year because of vitamin-A deficiency. Among these in India alone, out of the four million blind people 12,000 to 14,000 are children going blind due to malnutrition.

4. Nutritional Anaemia:

Patwardhan (1966), Gopalan (1968), Patwardhan and Darby (1969) have revealed that nutritional anaemias are major health problem of considerable importance among children. Apte (1967) has estimated that 10 to 30 per cent of world's population suffer from iron deficiency anaemia. Of the various types of anaemias encountered in infants and children, iron deficiency anaemia is the most frequent (Chandra, 1965). In India, the three vulnerable groups of population, namely the pregnant women, lactating mothers and children suffer from nutritional anaemias which in turn is aggrevated by hookworm infestation. In a study on pregnant women in South India 96 per cent of the women in lower and middle socio-economic groups in their last trimester of pregnancy were grossly deficient in iron; 45 per cent were deficient in folate. A higher incidence of megaloblastic anaemia has been reported from Bengal and other parts of the country (Parekh, 1969).

5. Other Nutritional Problems:

Apart from vitamin-A deficiency, protein-calorie malnutrition and nutritional anaemia, several millions children in the Himalayan region suffer from goitre-a condition caused by Iodine deficiency (Bagchi, 1968). Gastro-intestinal infections and respiratory diseases have continued to take a heavy toll of malnourished pre-school children. Gopalan (1968) reports that out of 570 samples, above 4 years had 7 per cent angular stomatitis.

B. Role of the School Lunch Programmes in Overcoming Nutritional Problems

During the last decade, the Government of India has been implementing various ameliorative measures for improving the nutritional status of the vulnerable section of the population through the production of protein rich foods and promotion of their consumption. Of the several feeding programmes in operation, the mid-day meals programme deserves special mention because of its wide coverage. Hill (1960) stresses that the school lunch is a vital part of the educational programme. Simpson (1963) views the school lunch as one, offering opportunities to educate children, to acquire a knowledge of sound dietary principles and form desirable habits of food intake, personal cleanliness and hygiene which will be retained throughout life. Devadas and Radharukmani (1964) and Anandam et al (1967) have pointed out that the school lunch is an excellent medium to establish social values. Devadas et al (1967, 1968) have reported the beneficial effects of school lunch programme on the nutritional status of children.

C. Prevalence of Iron Deficiency in India

Numerous haematological and nutrition surveys carried out during the last three decades in India, have revealed that different types of anaemias of varying degrees of severity are prevalent, the commonest being iron deficiency anaemia (Patwardhan, 1962; 1965; Pandit and Someswara Rao, 1960; Chandra, 1965; Sood, 1967; and

Apte, 1967). Surveys conducted on the prevalence of anaemia in different parts of the country have shown that 50 per cent of the pre-school children have levels below 10 g./100 ml. (Menon, 1967 and Chatterjee, 1967). Rao's (1960) survey in Bombay have also shown that 10 per cent of the total children were suffering from anaemias mainly due to iron deficiency. Nirmala et al (1968) report that among the 84 adolescent girls surveyed in Coimbatore, 24 had haemoglobin levels below 115 g./100 ml. Severe iron deficiency during early growth may lead to tissue depletion of iron containing or iron dependent enzymes and may lead to secondary phenomenon including malabsorption. (Nutrition Reviews, 1969).

Gopalan (1967) has warned that anaemia ranks as a major factor in the current high rate of parental mortality. In the low income groups anaemia is extremely wide spread among women of the child bearing age and children in India. The causative factors of anaemia have been enumerated as inadequate dietaries, unsatisfactory methods of preparation, blood less, malabsorption and low dietary protein and iron. (Chatterjee, 1967; NRC, 1968). Mehta and Patel, (1967) state that subnormal intake of foods because of poverty, ignorance, food fads or religious beliefs, recurring pregnancies within a short span of period and chronic blood loss due to worms contribute to the development of anaemia.

D. Factors Affecting the Absorption and Utilisation of Iron

In children and young women the iron content, sources and composition of the diet are important factors in the prevention of iron deficiency. The factors which influence iron absorption and utilisation can be classified as follows: (Bordon's Review, 1967).

1. Dietary factors like iron content of the diet, composition of the diet, protein deprivation, ascorbic acid deficiency and other dietary inadequacies,
2. Increased requirements during growth and pregnancy,
3. Haemorrhage due to benign and malignant leisons, trauma and coagulation defects,
4. Metabolic factors,
5. Malabsorption syndrome such as gastric and intestinal,
6. Losses through sweat, menstruation and parasitic infections.

1. Dietary Factors:

a) Phytate content of foods:

Among the several factors which appear to interfere with digestion and absorption of food iron, the phytic acid and phytate contents of the diet are important. Sharpe *et al* (1950), and Apte and Venkatachalam (1962) explain that phytic acid and phytates interfere with iron absorption by reacting with the iron as it passes through

the intestinal tract forming insoluble iron phytates and thus affect adversely iron absorption. Turnball et al (1962) have shown that the addition of sodium phytate to 5 mg. of ferrous ascorbate resulted in the reduction of iron absorption by 50 per cent. But, on the other hand Sharpe et al (1950) and Cowman et al (1966) have shown that sodium phytate had no effect on iron absorption.

Foods containing significant quantities of carbonates, oxalates, phytates or phosphates which are anions, bind iron in the duodenum to form both precipitates and macro molecular polymers. Iron absorption may be fall below three per cent in diets with a high phytic acid content. (Davidson et al, 1959; Wekes and Vesey, 1966 Nutrition Reviews, 1967).

The normal Indian diet is high in both total and phytic acid phosphorous and may contain as much as 1000 mg. phosphorous per day in the form of inorganic phosphate and 1000 mg. as phytic phosphorous. This high dietary phytate content is largely responsible for the poor absorption of dietary iron and the high incidence of iron deficiency (Nutrition Reviews, 1967 and Conrad, 1967).

b) Ascorbic acid:

There is good evidence to show that dietary ascorbic acid enhances iron absorption. In human studies the absorption of iron in foods has been improved by the addition of ascorbic acid or by foods rich in this vitamin. (Moore and Dubach, 1951; Nutrition Reviews 1955, Goratan and Bradley, 1959; Braise and Hallburg, 1962; Apte and

Venkatachalam, 1965; Rajalakshmi et al 1967). The addition of ascorbic acid facilitates the reduction of ferric iron to ferrous iron, the state at which it is more readily absorbed. Banerjee (1965) noted that all haemotological changes due to anaemia in scorbutic monkeys were abolished by iron supplementations. Apte and Venkatachalam (1965) also observed that ascorbic acid content of the diet had a significant increase in the absorption of dietary iron in human subjects. Bothwell et al (1964) suggest that ascorbic acid may be involved in several of the phases of iron transport.

c. Pyridoxine:

Increased iron absorption has been reported in pyridoxine deficient rats, while administration of high doses of pyridoxine has been found to reduce absorption of iron in pregnant women (Mashhare and Migicovsky,1963). However, Beaton and McHenry (1964) express that there is no clear evidence to prove this relationship.

d. Dietary proteins:

Studies have revealed that children consuming diets low in protein suffer from severe or moderately severe anaemia of hypochromic and microcytic type. Dietary protein of less than 15 to 18 per cent has been shown to result in impaired absorption of iron in rats. (Klavins et al 1962; Reissmann 1964; Sood et al 1965). Thus iron absorption appears to be influenced by the protein intake. (Abernathy et al 1965).

According to Klavins et al (1963) and Vohra et al (1965) the amino acid composition of the dietary protein may influence iron absorption. On the contrary, Pandit and Rao (1960) report that there was no correlation between protein intake and iron absorption. Proteins of either vegetable or animal origin had very little influence on the iron absorption.

e) Calcium - phosphorus ratio:

The beneficial effect of extra dietary calcium on iron absorption in human beings has been stressed by Apte and Venkatachalam (1964). This would be expected because of the low solubility of iron phosphate and the alkalinity, characteristically associated with the presence of calcium (Beaton and McHenry, 1964). Absorption of iron, calcium and phosphorus depends upon the relative amounts of each of these substances in the diet. (Nutrition Reviews, 1967).

f) Sugars:

Simeon et al (1964), state that fructose increases the iron absorption, whereas, glucose and galactose have no effect on iron absorption. These findings suggest that the metabolism of fructose is responsible for changing iron absorption in the rat, since it is metabolised during its absorption, while glucose and galactose are not. Pyruvate and lactate, the final product of glycolysis also increase iron absorption in the rat. Loria et al (1962) observe that sorbitol improves iron absorption. absorption.

g) <u>Form of dietary iron</u>:

There is strong evidence that iron is better utilised in the ferrous state than in the ferric state in man. (Moore, 1955; Venkatachalam, 1956; Duckworth, 1961; Brown, 1963; Apte, 1967; James and Pader, 1967). It is probable that the phenomenon of oxidation reduction is involved in the energetics of the absorption process (Apte, 1967).

h. <u>Tropical dietaries</u>:

Tropical diets are characterised by high cereal content. Therefore iron absorption from tropical dietaries would be interfered by several factors. Although they contain a satisfactory iron content of 15 mg./day, there is still be a large population suffering from anaemia. The etiology of iron deficiency anaemia is infinitely more complex than would be explained by the deficiency of the mineral alone. (Wardsworth, 1955).

In most of the foods probably half of the iron is in the free state (Bergein and Kirch, 1949) and the absorption and utilisation of this ionisable iron is probably similar to that of inorganic iron salts. The remainder is in the form of insoluble complexes, the absorptive mechanisms of which are not understood, but which might vary for different foods (Callender <u>et al</u>, 1957; Turnball <u>et al</u>, 1962) The haem iron which is a complex form of iron, eventhough absorbed directly, might not be utilised efficiently for haemoglobin synthesis as the ionisable portion of the total food iron (Wardsworth, 1955).

Because of the complexity of the factors facilitating iron absorption, estimation of iron availability from a single foodstuff is of only limited value. Since many factors are related to the total meal or diet in which a food is consumed and the subjects and age groups who consume the food, the total amount and relative availability of iron from food sources have to be considered from these perspectives.

2. <u>Metabolic factors</u>:

Iron absorption is related to haemoglobin level both in those with normal gastic acidity and in those with reduced or excess acid secretion. Moore (1955); Choudhary and Williams (1959) and Nutrition Reviews (1966) suggest that gastic juice which is acidic, releases iron from protein and helps to maintain both ferrous and ferric iron in solution, at the pH of the duodenum. Under normal circumstances, absorption of iron by the intestinal muscosa appears to be controlled chiefly by body iron stores and by the erythropoietic activity of the bone morrow. (Izak, 1966). Weintraub <u>et al</u> (1965) report that the reduction in iron absorption is directly parallel to the decrease in erythropoetic activity which is associated with an increased deposition of iron in the gut. Weintraub <u>et al</u> (1964) and Izak (1960) have proved that absorption of iron does not increase until five days after blood loss. Hence the response to change in the body iron stores or rate of erythropoiesis are delayed.

Whely and Crosby (1962) conclude that animals deficient in iron, concentrate little iron in their gut and absorb increased amount of iron from the diet. All these interpretations are based on the 'mucosal block theory' regarding iron metabolism. Callender (1967) emphasises the role of mucosal cell in the controlled absorption of iron and its limited excretion.

3. Iron Losses:

a) Sweat loss:

In tropical climates losses of iron by excessive sweating can be considerable. (Apte, 1963; and Parekh, 1969). Without any induced sweating the total iron losses have been estimated to be 0.4 mg/day (Finch, 1965).

b) Hookworm infestation loss:

Hookworm infestation is wide spread in many tropicaland semi-tropical countries associated with severe anaemia which are often fatal. Studies with radio isotope techniques have shown that patients with heavy hookworm infestation can lose upto 250 ml. of blood daily (Patwardhan and Darby, 1969). Intestinal blood loss was determined in hookworm infested subjects with counts of varying from 1000 to 97,000 per gram of faeces. The loss of blood ranged from 2 to 100 ml. per day, and bore no relationship to the magnitude of the worm load (WHO, 1965). Similar results have been obtained by Gilles *et al* (1964) on Nigerian patients. The relationship between

infestation and anaemia depends upon the number of worms present in the gut, the individual's iron stores and amount of available iron in the diet (Indian Pediatrics, 1965). A new version of pica, pagophagy is reported to be associated in the USA with iron deficiency anaemia. (Nutrition Reviews, 1969).

E. Supplementation Studies with Iron

Chandra (1965) states that depending upon the age and built 10 to 50 mg. of elemental iron, besides dietary sources known to contain a large amount of iron, would suffice for the cure of iron deficiency anaemia. Menon (1967) and Roy (1966) list the disadvantage of oral iron therapy as low response to treatment and in some, it giving rise to diarrhoea, gastric upsets and vomitting. Sood (1967) states that parental iron therapy does not offer any particular advantage over the oral therapy. He also adds that iron given orally is safe, effective, inexpensive and usually the treatment of choice too.

Eventhough, Marchasin and Wallerstein (1964), Gartlan (1965) and Elhence _et al_ (1966) successfully used single does of intravenous iron dextron in treating iron deficiency anaemia, various local side effects due to such treatment have been reported by Goodman and Gillman (1965); Chandra (1965) and Sood (1967).

McCurdy (1965) reports the beneficial effects of oral iron therapy in the form of ferrous sulphate to patients suffering from iron deficiency anaemia. Many students have been carried out as an attempt to cure anaemia by administration of various forms of iron salts. (Pritchard and Manson, 1964; JAMA, 1968).Solanki, 1968).

The dosage of the different iron salts may vary, but the aim should be to provide 4 to 6 mg. of elemental iron/kg of body weight to prevent anaemia (Chandra, 1965). Favourable effects can be achieved by giving iron salts containing elemental iron upto 60 mg. (Bose et al, 1969; Tripathy et al, 1969; and WHO, 1968).

Green leafy vegetables such as amaranthus and drumstick leaves are among the low cost sources of iron. Anandam et al (1967) have demonstrated the beneficial effects of supplementing the school lunch with greens. Nirmala et al (1968) studied the effects of amaranthus in the diets of selected adolescent anaemic school girls and compared them with those of iron salt, furnishing similar quantities of iron. The haemoglobin and PCV values of the group of fed amaranthus were higher than those of the group fed on oral iron tonic.

III EXPERIMENTAL PROCEDURE

The aim of the present investigation was to evaluate the availability of iron from *Amaranthus flavus* (Amaranthus) and from iron compounds in the form of a colloidal iron tonic and an iron salt, as supplements to a school lunch. The experimental procedure included:

A. Selection of the School and the Subjects,

B. Formulation of the Menu and Standardisation of the Cooking and Serving Processes,

C. Introduction of the Supplements,

and D. Selection of the Criteria for Evaluation.

A. Selection of the School and the Subjects

1. Selection of the school:

Sri Avinashilingam Trust Basic Elementary School which has a school lunch programme operating under the Tamil Nadu Midday Meals Scheme, was selected for the study because of the willingness of the management and readiness of the teachers to cooperate in the research project.

2. Selection of the subjects:

Sixty children in the age range 5 - 10 years were selected from a total of 105 children who were participating in the school lunch programme. The children selected were comparable in age, sex initial height, weight and blood haemoglobin level. They were divided into four groups, each consisting of 15 children. One more comparable group of 15 children who were not participating in the school lunch was selected as the control group. Hookworm infestation test was done on all these children in the beginning of the experiment. It was ensured from the parents that these children did not receive iron tonics at home during the experimental period.

The five groups of children were designated as S_1, S_2, S_3, S_4 and C respectively, for the dietary supplements as indicated below:

C - Control group (non-school lunch)

S_1 - School lunch with amaranthus.

S_2 - School lunch with colloidal iron tonic.

S_3 - School lunch with iron salt.

S_4 - School lunch without iron supplementation (basal diet).

The mean initial height, weight and haemoglobin levels of the children are given in Table I and their individual height, weight and haemoglobin levels are given in Annexure I.

TABLE I

MEAN INITIAL HEIGHT, WEIGHT AND HAEMOGLOBIN LEVELS OF THE FIVE GROUPS OF CHILDREN

Group	Height cm.	Weight Kg.	Haemoglobin g/100 ml.
C	112.01	16.95	9.44
S_1	113.10	18.15	9.22
S_2	113.10	17.79	9.41
S_3	113.10	18.05	9.69
S_4	111.90	17.84	9.33

B. Formulation of the Menu and Standardisation of the Cooking and Serving Processes

1. Formulation of the menu:

The school lunch menu was planned to:

a. Provide one-third of the day's recommended allowances suggested by the ICMR (1968),

b. Maintain the cost within 10 paise per child/per day,

c. Provide a colourful, attractive, appetising lunch,

and d. Accommodate the supplements.

The basal diet was the same for all the four groups. A week's basal menu planned to provide one-third of the day's requirement is given in Table II.

Table II

THE WEEKLY MENU FOR THE SCHOOL LUNCH (Basal Diet)

Days	Menu
Monday	Wheat uppuma, Carrot kootu, Tamato/Papaya, CSM Payasam.
Tuesday	Tamarind rice, Carrot kootu, Tomato/Papaya, CSM Payasam.
Wednesday	Wheat uppuma, Carrot kootu, Tomato/Papaya, CSM Payasam.
Thursday	Dhal rice, Carrot kootu, Tomato/Papaya, CSM Payasam.
Friday	Wheat uppuma, Carrot kootu, Tomato/Papaya, CSM Payasam.
Saturday	Lime rice, Carrot kootu, Tomato/Papaya, CSM Payasam.

Apart from the basal diet, group S_1 was given amaranthus as an iron supplement. The groups S_2 and S_3 received the iron tonic and iron salt as supplements respectively. Group S_4 was not given any supplement.

The cost and quantity of the foodstuffs used for the school lunch per child per day are presented in Table III.

TABLE III

THE COST AND QUANTITY OF THE FOODSTUFFS USED PER CHILD PER LUNCH

Foodstuffs	Amount g.		Cost (paise)
Rice	75		8.4*
or			
Bulgar wheat	75		free from CARE
Redgramdhal	20		2.3
Carrot	20		2.0
Skim milk powder	5		free from UNICEF
CSM	20		free from CARE
Jaggery	10		1.1
Papaya/Tomato	20		free from Garden
Oil	10		free from CARE
		Total	13.8

* For one day. Since this was used on alternate days , the cost comes to 4 paise only.

Wheat or rice was used as the cereal on alternate days. The bulgar wheat, CSM and salad oil were free of cost, supplied by CARE. When rice was used, the cost of the meal per day per child was 13.8 paise. When bulgar wheat was used instead of rice the cost of the day's menu was 5.4 paise per child. Therefore, on an average the cost of a day's lunch per child was within 10 paise.

The nutritive value of the school lunch calculated and compared with one-third of the Recommended Daily Allowances of Nutrients (ICMR, 1968) is presented in Table IV.

TABLE IV

COMPARISON OF THE NUTRITIVE VALUE OF THE SCHOOL LUNCH WITH THE RECOMMENDED ALLOWANCES

	Calories	Protein g.	Calcium mg	Iron mg.	β-Carotene µg	Thiamine mg.	Vit.C mg.
One-third of the day's requirement (ICMR, 1968)	500to 600	7 to 11	133 to 166	5 to 7	400 to 533	0.30	10 to 16
Basal diet	585	16	154	7	571	0.64	36

The basal diet met one-third of the day's requirement for all the nutrients for children of the age group 5 - 10 years. An extra serving of the cereal preparation was given to those children who asked for it. This ensured caloric sufficiency, especially among elder children.

2. Standardization of cooking and serving processes:

The recipes for the different items on the school lunch were standardised. The raw as well as cooked weights of the preparations and the whole school lunch were noted. The volumetric equivalents in terms of cups and spoons which were used for serving the cereal preparations, and vegetable preparations, were determined respectively in

order to facilitate quick serving. Record of attendance at school and at lunch were kept daily by the investigator.

C. Introduction of the Supplements

The basal school lunch provided 7 mg. of iron which provides one-third of the day's iron requirement for children of this age group. The supplements were introduced to provide 13 mg. of iron, thus making a total of 20 mg. of iron which is a day's iron requirement for children of this age group.

1. Selection of the supplements:

a. Amaranthus:

The variety of greens known as Amaranthus specially cultivated for this purpose under controlled conditions and picked at uniform stage of maturity from the experimental plots of the State Agricultural College, Coimbatore was used. The selected Amaranthus was analysed for iron content which was found to be 25 mg. per 100 g. of the sample. Therefore, 52 g. of greens was supplemented to each child in group S_1 in order to provide 13 mg. of iron. The greens were analysed every week throughout the study to get the actual iron content. The quantity of the supplement was adjusted accordingly.

b. Iron compounds:

For the supplementation of elemental iron, a colloidal non-irritant form of iron tonic called 'Colliron' with pleasant flavour and tablets of "Fersolate" were selected. The tonic contains iron in the form of iron hydroxide and the tablet contains iron in the form of ferrous sulphate. Both were analysed for their total iron content. The iron content of the tonic was 97.5 mg/ml. Therefore, 4 ml. of the tonic was diluted to 50 ml. with water and 1.7 ml. of the diluted solution was given daily for a child in the group S_2 to supply 13 mg. of iron. The tablet was found to contain 61.83 mg. of iron tablet and therefore to provide 13 mg. of iron per child per day, 113.4 mg. of the tablet powder was weighed out accurately daily and given to the children in the group S_3. Both the supplements were given directly to the children. A placebo of jaggery water was given to the other groups. The details of the calculation regarding tonic and iron salt are given in Annexure II.

D. Selection of the Criteria of Evaluation

The nutritional status of children were evaluated through anthropometric, biochemical, clinical and dietary methods. The nutrient intake was assessed through food analysis method.

1. Anthropometric measurements:

The anthropometric measurements used were height and weight.

a. Height:

The height was taken twice a month, using stadiometer, during the experimental period of six months with the subjects standing erect and barefeet, on a platform. The height was recorded to the nearest centimeter.

b. Weight:

The weight was recorded every fortnight for the experimental period with the subjects wearing minimum clothing and barefoot. Prior to the weighing, the subjects were asked to empty their bladder. The weight was recorded using Avery single beam balance to the nearest gram, during the morning hours.

2. Biochemical:

a. Haemoglobin level:

Haemoglobin was estimated every fortnight for the experimental period by the cyanmethemoglobin method as described by the ICNND (1966).

b. Packed Cell Volume (PCV) and Red Blood Cell (RBC) Count:

The Packed Cell Volume and Red Blood Cell Count were done inthe beginning and end of the experiment by drawing venous blood from randomly selected four children from each group, using haematocrit tubes and Neubaur ruled counting chamber respectively.

c. Other blood indices:

Other blood indices namely, mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (M.C.H.C.) and mean corpuscular haemoglobin (M.C.H.) were calculated using haemoglobin level, packed cell volume and red blood cell counting. The formulae used for these calculations as per the procedure outlined by Green (1964) were:

i. Mean corpuscular volume (μ^3) (M.C.V.)

$$M.C.V. = \frac{\text{Volume of red cells in ml. per 100 ml. blood}}{\text{Number of red cells per 100 ml. blood}}$$

ii. Mean corpuscular haemoglobin concentration (per cent) (M.C.H.C)

$$M.C.H.C = \frac{\text{Haemoglobin in grams per 100 ml. blood}}{\text{Volume of red cells in ml. per 100 ml.blood}}$$

iii. Mean corpuscular haemoglobin ($\mu\mu g$) (M.C.H.)

$$M.C.H. = \frac{\text{Haemoglobin in grams per 100 ml. blood}}{\text{Number of red cells per 100 ml. blood}}$$

3. Clinical assessment:

The clinical assessment was carried out in the beginning and end of the study by a trained physician using the ICMR schedule given in Annexure III.

4. Home diet analysis:

The home diets were analysed in order to find out the effect of home diets on the nutritional status ofchildren. From each group five children were selected randomly to carry out the home diet

analysis. The individual consumption at each meal was weighed out and from that, a one-tenth aliquot was collected for analysis. Ascorbic acid was estimated every day, after collection using the method of Hawk et al (1954). The remaining samples were preserved in the refrigerator after adding concentrated $H_2 SO_4$. After four consecutive days of collection, the diets were homogenised in a waring blender and aliquots taken for nutrient analysis. The nutrients analysed were protein, iron and calcium by the method described by Hawk et al (1954).

A nutrition education programme was carried out once in a month in the school itslef with the aid of the charts in order to make the children realise the importance of school lunch and good nutrition. The school garden formed an integral part ofthe nutrition education programme.

IV RESULTS AND DISCUSSION

The results of the present investigation on the availability of iron from Amaranthus, and iron supplements on the nutritional status of children are presented and discussed in the following order:

A. Nutrient Intake of the Children

B. Assessment of the Nutritional Status

1. Height
2. Weight
3. Blood picture
4. Clinical examination.

A. Nutrient Intake of the Children

The groups S_1, S_2, S_3 and S_4 received their lunch in the school and consumed rest of the day's meal from their home. But the children in group C consumed all their diets in their homes.

The average nutrient intake of children in the present study was estimated by analysing the whole day's diet of children for protein, iron, calcium and ascorbic acid. The details of their nutrient intake are given in Table V.

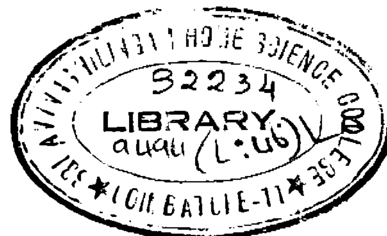
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TABLE V

MEAN PROTEIN, IRON, CALCIUM AND ASCORBIC ACID INTAKES OF CHILDREN
(as analysed)

CODE	Group	Protein (g)			Iron (mg)			Calcium (mg)			Ascorbic Acid (mg.)		
		Whole Day	School Lunch	Home Diet	Whole Day	School Lunch	Home Diet	Whole Day	School Lunch	Home Diet	Whole Day	School Lunch	Home Diet
C	Non School Lunch	33.0	--	33.0	10.3	--	10.3	623	--	623	6.6	--	6.6
S_1	Basal diet + Amaranthus	41.7	12.1	29.6	24.84	5.6 + 13 from amaranthus	6.24	846 1036	200 + 190 from supplement	646	23.3	9.4 + 8.9 from supplement	5.0
S_2	Basal diet + Tonic	40.8	12.1	28.7	26.41	5.6 + 13 from Tonic	7.81	802	200	602	13.6	9.4	4.2
S_3	Basal Diet + Salt	33.0	12.1	20.9	25.54	5.6 + 13 from Salt	6.94	737	200	537	14.2	9.4	4.8
S_4	Basal Diet	32.8	12.1	20.7	11.34	5.6	5.74	651	200	451	13.8	9.4	4.4
	ICMR (1968) Allowances		22 to 33			15 to 20			400 to 500			30 to 50	

The basal school lunch was planned to provide 7 mg. of iron, but when analysed it was found to provide 5.6 mg. of iron per day. The protein content ofthe basal school lunch as analysed was found to be 12.1 g/day, and the analysed values for calcium and ascorbic acid were 200 mg. and 9.4 mg. respectively.

1. Protein intake:

The whole day's diet of groups S_1, S_2, S_3, S_4 and C provided adequate quantity of protein, the range being 32.8 g. to 41.7 g. These intakes met the requirement set by the ICMR (1968) for the children of this age group. The home diets of group S_1 (29.[illegible] g.) and S_2 (28.7 g) were found to be almost similar in their protein contents, whereas the protein intake of the groups S_3 and S_4 was similar 20.9g. and 20.7 g. respectively. The protein intake of the groups S_1, S_2, S_3 and S_4 were increased due to the protein received at school lunch (12.1 g.).

2. Iron intake:

The iron content of the home diets of children in the four school lunch groups ranged from 5.74 mg. to 7.81 mg. But the groups S_1, S_2 and S_3 received iron supplements (13 mg. of iron) thus, increasing the whole days' iron intake to 24.8 mg, 26.4 mg. and 25.5mg respectively, which is higher than the ICMR (1968) recommended allowance. Apte (1962) has stated that, as far as iron is concerned, the Indian dietaries are adequate quantitatively, but in the predominantly cereal based diets the biological availability of iron is

questionable. The whole day's iron intake of group S_4 and C amounts to only 11.34 mg. and 10.03 mg. respectively which is lower than that ofthe ICMR (1968) recommendations.

3. Calcium intake:

Calcium intake of all the children int the five groups exceeded the ICMR (1968) recommendations.

4. Ascorbic acid:

The ascorbic acid content of the home diets in all the groups was found to range from 4.2 mg. to 6.6 mg./day, but the experimental group received 9.4 mg./day from the basal school lunch. The group S_1 received another 8.9 mg. of ascorbic acid from the amaranthus, thus amounting for a whole days' intake of 23.3 mg. The other three groups S_2, S_3 and S_4 had a total intake ranging from 13.6 mg to 14.2 mg for the whole day. The control group received only 6.6 mg of ascorbic acid. All these values are below the recommended allowance of ICMR (1968).

B. Assessment of the Nutritional Status

1. Height:

The mean increases in heights of the five groups of children along with the statistical treatments is presented in Table VI. The individual height, weight and haemoglobin levels is given in Annexure I. The procedure used for statistical analysis is given in Annexure IV.

TABLE VI

MEAN INCREASE IN HEIGHTS OF THE CHILDREN IN FIVE GROUPS

CODE	Source of Iron Supplementation	Height (cm) Initial	Final	Mean Increase	Source of Comparison	't' Value
C	Nil	112.01± 7.691	114.86± 7.370	2.85 ± 0.618	C vs S_1	1.230
					C vs S_2	0.673
					C vs S_3	0.914
					C vs S_4	0.990
S_1	Greens (Amaranthus)	113.10± 8.296	116.31± 8.316	3.21 ± 0.618	S_1 vs S_2	0.547
					S_1 vs S_3	0.084
					S_1 vs S_4	0.059
S_2	Tonic (Colliron)	113.10± 8.680	116.10± 7.856	3.00 ± 0.618	S_2 vs S_3	0.360
					S_2 vs S_4	0.406
S_3	Salt (Fersolate)	113.10± 8.356	116.30± 7.958	3.20 ± 1.212	S_3 vs S_4	0.025
S_4	Nil	111.90± 9.361	115.09± 8.890	3.19 ± 1.036		

All the five groups had shown increases in their heights. The group S_1 receiving the Amaranthus as the supplement had shown the greatest increase (3.21 cm.). Even though, there was an increase in height in all the five groups, the differences in the increase were not significant statistically.

2. <u>Weight</u>:

The mean increases in the weight of the five groups of children and the statistical analysis are given in Table VII.

TABLE VII

MEAN INCREASE IN WEIGHTS OFTHE CHILDREN IN FIVE GROUPS

CODE	Supplementary Source of Iron	Weight (Kg.)		Mean Increase	Source of Comparison	't' Value
		Initial	Final			
C	Nil	16.95 ± 1.899	18.46 ± 2.645	1.51 ± 1.109	C vs S_1 C vs S_2 C vs S_3 C vs S_4	0.355 0.600 0.225 0.879
S_1	Greens (Amaranthus)	18.15 ± 3.358	19.78 ± 3.584	1.63 ± 0.219	S_1 vs S_2 S_1 vs S_3 S_1 vs S_4	0.407 0.990 2.333*
S_2	Tonic (Colliron)	17.79 ± 2.864	19.52 ± 3.159	1.73 ± 0.628	S_2 vs S_3 S_2 vs S_4	1.120 1.850
S_3	Salt (Fersolate)	18.05 ± 3.188	19.50 ± 3.210	1.45 ± 0.244	S_3 vs S_4	1.028
S_4	Nil	17.84 ± 2.865	19.23 ± 3.011	1.39 ± 0.399		

* Significant at 1% level

All the five groups registered an increase in weight showing the trends of the growing stages. The group S_2 had shown the greatest mean increase (1.73 kg.) followed by group S_1 (1.63 kg.). However, the differences between the increases in weight between S_1 and S_4 were statistically significant, and those of the others were not significant. The higher increases in weights in groups S_1 and S_2 may be attributed to the higher protein intakes.

3. Blood picture:

a. Haemoglobin:

The mean increases in the haemoglobin levels ofthe five groups and the statistical treatments are given in Table VIII.

TABLE VIII

MEAN INCREASE IN HAEMOGLOBIN LEVELS OF THE CHILDREN IN FIVE GROUPS

CODE	Supplementary Source of Iron	Haemoglobin(g/100ml) Initial	Final	Mean Increase	Source of Comparison	't' Value
C	Nil	9.44 ± 0.584	10.35 ± 0.280	0.91 ± 0.158	C vs S_1	6.400**
					C vs S_2	5.280**
					C vs S_3	3.233**
					C vs S_4	3.398**
S_1	Greens (Amaranthus)	9.22 ± 0.403	11.13 ± 0.194	1.91 ± 0.267	S_1 vs S_2	1.210
					S_1 vs S_3	2.105*
					S_1 vs S_4	3.470**
S_2	Tonic (Colliron)	9.41 ± 0.987	11.06 ± 0.469	1.65 ± 0.113	S_2 vs S_3	1.250
					S_2 vs S_4	2.954**
S_3	Salt (Fersolate)	9.69 ± 1.209	11.17 ± 3.001	1.48 ± 0.231	S_3 vs S_4	1.80
S_4	Nil	9.33 ± 0.520	10.59 ± 0.338	1.26 ± 0.1323		

** Significant at 1% level; * Significant at 5% level.

All the groups of children had shown an average increase in haemoglobin levels. The group S_1 had registered the greatest increase (1.91 g./100 ml.) followed by S_2 (1.65 g./100 ml.) and S_3 (1.48 g./100 ml.) respectively. It is notable that the increases in the haemoglobin level in all the school lunch groups are significantly ($P < 0.01$) higher than that ofthe non-school lunch group. This may be attributed to the higher iron content of the school lunch. The differences between the increases in the haemoglobin levels of the groups $S_1 - S_3$ were significant at 0.05 per cent level and those between $S_1 - S_4$ and $S_2 - S_4$ at 0.01 per cent level. This again could be attributed to the fact that both S_1 and S_2 received iron supplements. However, there were no significant increase between groups $S_1 - S_2$, $S_2 - S_3$ and $S_3 - S_4$. The increases in haemoglobin level is not only due to iron supplemented, but also due to the adequate amount of protein in the diet.

b. Packed Cell Volume:

The packed cell volume was measured in the beginning and end of the experiment. Table IX gives the changes in the haematocrit values of the four randomly selected children from each of the five groups, and the statistical treatments.

TABLE IX

MEAN INCREASE IN PACKED CELL VOLUME OF CHILDREN IN FIVE GROUPS

Code	Supplementary Source of Iron	Packed Cell Volume% Initial	Packed Cell Volume% Final	Mean Increase	Source of Comparison	't' Value
C	Nil	29.75 ± 3.112	30.75 ± 2.861	1.0 ± 0.829	C vs S_1	1.666
					C vs S_2	1.207
					C vs S_3	1.350
					C vs S_4	0.3334
S_1	Greens (Amaranthus)	29.00 ± 4.389	31.00 ± 3.774	2.0 ± 1.0	S_1 vs S_2	0.5964
					S_1 vs S_3	0.9223
					S_1 vs S_4	0.225
S_2	Tonic (Colliron)	32.50 ± 3.741	33.50 ± 2.236	1.0 ± 0.723	S_2 vs S_3	0.4223
					S_2 vs S_4	1.074
S_3	Salt (Fersolate)	31.75 ± 4.768	33.00 ± 1.118	1.25 ± 0.10	S_3 vs S_4	1.090
S_4	Nil	30.50 ± 2.007	30.75 ± 1.639	0.25 ± 0.098		

Though all the groups had shown a mean increase in the haematocrit value, the increases were not statistically significant. The greatest increase was recorded in group S_1, which had amaranthus as the iron source. Jelliffe (1966) has reported 33 per cent to be the normal PCV vaues for children. In the present study the final average PCV values (31.8 per cent) approximates the standards of Jelliffe.

C. Red Blood Cell Count:

The Red Blood Cell Counting was done in the beginning and end of the experimental period. The mean values along with its statistical analysis is given in Table X.

TABLE X

MEAN INCREASE IN THE RED BLOOD CELL COUNT OF CHILDREN INTHE FIVE GROUPS

Code	Supplementary Source of Iron	R.B.C.(mm^3)		Mean Increase	Source of Comparison	't' Value
		Initial	Final			
C	Nil	3.50 ± 0.707	3.72 ± 0.707	0.22 ± 0.289	C vs S_1	0.4951
					C vs S_2	0.003893
					C vs S_3	1.075
					C vs S_4	0.3358
S_1	Greens (Amaranthus)	3.88 ± 0.415	4.13 ± 0.211	0.75 ± 0.248	S_1 vs S_2	0.1228
					S_1 vs S_3	0.6096
					S_1 vs S_4	0.2899
S_2	Tonic (Colliron)	4.00 ± 1.500	4.29 ± 1.076	0.29 ± 0.523	S_2 vs S_3	0.7399
					S_2 vs S_4	0.1109
S_3	Salt (Fersolate)	4.00 ± 1.118	4.25 ± 0.829	0.25 ± 0.397	S_3 vs S_4	0.4300
S_4	Nil	3.75 ± 0.829	4.08 ± 0.829	0.33 ± 0.199		

No significant increases in the RBC count was noticed among the five groups. However the highest increase was registered by S_1 (0.75 mm^3), followed by S_2 (0.29 mm^3) and S_3 (0.25 mm^3) respectively.

d. Other Blood Indices:

The other blood indices MCV, MCHC and MCH were calculated using the haemoglobin levels, packed cell volume and red blood cell counts in order to evaluate the effects of iron supplementation on the haematological picture. The mean MCV values of the five groups of children are given in Table XI.

TABLE XI

MEAN MCV VALUES OF THE CHILDREN IN THE FIVE GROUPS

Group	MCV Values (μ^3)		Increase	Standard Value
	Initial	Final		
C	79.8 ± 4.47	80.5 ± 4.48	+ 0.7	
S_1	75.0 ± 3.45	72.5 ± 5.93	- 2.5	
S_2	74.00± 4.012	74.86± 4.723	+ 0.86	
S_3	77.6 ± 4.402	78.1 ± 3.476	+ 0.5	80μ^3 (Beaton and McHenry)
S_4	76.4 ± 4.39	76.9 ± 4.37	+ 0.5	

The MCV values did not show a considerable increase, but the corpuscles were not macrocytic. When compared with themnormal values for children as given by Beaton and McHenry (1964) the values of the persent study is slightly lower.

The MCHC values of the randomly selected children in the five groups are presented in Table XII.

TABLE XII

MEAN MCHC VALUES OF THE CHILDREN IN THE FIVE GROUPS

Group	MCHC Values (%) Initial	MCHC Values (%) Final	Increase	Standard
C	31.9 ± 2.82	34.0 ± 2.92	+ 2.1	
S_1	31.8 ± 2.82	35.5 ± 2.98	+ 3.7	
S_2	29.9 ± 2.86	33.4 ± 2.87	+ 3.5	
S_3	31.7 ± 2.82	32.3 ± 2.84	+ 0.6	34% (Beaton and McHenry)
S_4	30.3 ± 2.75	33.6 ± 2.89	+ 3.3	

The normal range for MCHC for children as given by Beaton and McHenry (1964) is 34 per cent. The final MCHC values obtained in the present study is comparable to that of the normal range of children. The increases were however not appreciable.

Table XIII gives the mean MCH values for the randomly selected children of the five groups.

TABLE XIII

MEAN MCH VALUES OF THE CHILDREN IN THE FIVE GROUPS

Group	MCH Values ($\mu\mu g.$)		Increase	Standard
	Initial	Final		
C.	27.7 ± 2.64	29.2 ± 2.70	+ 2.0	
S_1	23.6 ± 2.43	25.9 ± 2.55	+ 2.3	
S_2	20.5 ± 2.26	24.5 ± 2.47	+ 4.0	
S_3	29.6 ± 2.72	26.1 ± 2.52	- 3.5	28 $\mu\mu g$ (Beaton and McHenry)
S_4	25.4 ± 2.52	27.2 ± 2.61	+ 1.8	

The normal MCH values for children was reported to be 28 $\mu\mu g$. (Beaton and McHenry, 1964). The mean initial and final values of all the five groups were 25.4 $\mu\mu g$ and 26.6 $\mu\mu g$ respectively. The mean MCH values for groups S_1 and S_2 showed increase of 2.3 $\mu\mu g$ and 4.0 $\mu\mu g$ respectively, indicating that there was an increase in the haemoglobin content per unit of RBC count in children given Amaranthus and Tonic respectively.

4. Clinical Examination:

The clinical examination of all the children was done in the beginning and end of the study period, to evaluate their health status. No signs of clinical manifestations were evinced by the children both in the beginning and at the end of the study.

V SUMMARY AND CONCLUSIONS

The availability of iron from Amaranthus flavus, 'Colliron' and 'Fersolate' used as supplements to the school lunch was studied over a period of six months. A basal school lunch was planned to provide one-third of the day's recommended allowances (ICMR, 1968), for children of this age group, and to accommodate the iron supplements. The basal diet provided 5.6 mg. of iron and the supplements provided 13 mg. of iron. Five groups of children, 15 in each, comparable in age, sex, initial height, weight and blood haemoglobin level were selected for the study and the details of their grouping are as follows:

C - Control group (non school lunch).

S_1 - School lunch with amaranthus.

S_2 - School lunch with iron tonic.

S_3 - School lunch with iron salt.

S_4 - School lunch without iron supplementation (basal diet)

Height, weight haemoglobin levels, PCV, RBC counts and other blood indices were the criteria used to evaluate the nutritional status of the children.

The findings reveal that:

1. The whole day's intake of protein ranged from 32.8 g.(S_4) to 41.7 g.(S_1); iron from 10.03 mg. (C) to 26.41 mg.(S_2); calcium from 623 mg. (C) to 1036 mg. (S_1); and ascorbic acid from 6.6 mg. (C) to 23.3 mg (S_1). The protein and calcium intake were adequate when compared with the ICMR (1968), Recommended Allowance. But the intakes of iron in groups S_4 and C and that of ascorbic acid in all the groups fell short of the recommended figures.

2. Children in all the five groups registered a mean increase in heights ranging from 2.85 cm (C) to 3.21 cm. (S_1). The difference in the increases were however not statistically significant.

3. The mean increase in weights ranged from 1.39 kg. (S_4) to 1.73 kg. (S_2). The group S_1 had registered a mean increase of 1.63 kg. which was statistically significant ($P < 0.05$) when compared to the increases in group S_4. The difference between the increases, in the other groups was not significant statistically.

4. The groups C, S_1, S_2, S_3 and S_4 showed a mean increase in the haemoglobin level of 0.91, 1.91, 1.65, 1.48 and 1.26 g. /100 ml. respectively. Increases in the haemoglobin level in all the school lunch groups were significantly higher

($P < 0.01$) over that of the non-school lunch (C) group. Groups S_1 and S_2 ~~and~~ exhibited significantly higher ($P < 0.01$) increases than S_4 indicating the beneficial effects of the iron supplements. Groups receiving amaranthus registered the highest increase and was statistically significant ($P < 0.05$) from S_3 receiving the iron salt as the supplement.

5. All the five groups had registered a mean increase in haematocrit values, the highest being S_1 (2.0%) and the lowest being S_4 (0.25%). However, the differences were not statistically significant.

6. The RBC Counts of all the groups of children showed an increase, the greens group registering the highest increase and the control group lowest. The differences however, were not statistically significant.

7. The MCV, MCHC and MCH values calculated for the randomly selected children of all the five groups did not show any considerable increase.

8. The clinical examinations in the beginning and end of the study did not reveal any deficiency signs.

Amaranthus flavus, tomic and salt ranked first, second and third respectively, when the changes in the nutritional status of children were assessed in terms of height, weight and blood picture.

Further research needs to be done to evaluate the availablity of iron from amaranthus and tomic paying due attention to control the calcium and ascorbic acid intakes and also determining the factors which may interfere with the availability of iron from the food sources.

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A N N E X U R E S

ANNEXURE I

INDIVIDUAL HEIGHTS, WEIGHT AND HAEMOGLOBIN LEVEL AND OTHER BLOOD INDICES OF THE FIVE GROUPS OF CHILDREN

HEIGHT RECORD OF GROUP 'C' (CONTROL) (in cms)

Sl. No.	Class	Age Yr.Mth	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-7	112.00	112.0	112.0	112.2	112.5	113.0	113.0	113.8	113.8	114.0	114.0	115.2
2.	II	6-7	117.7	118.3	118.8	118.9	118.9	119.2	119.3	119.3	119.8	119.8	120.6	120.6
3.	II	6-0	105.3	105.3	105.3	105.4	105.7	105.7	107.2	107.2	107.5	107.6	107.6	108.0
4.	II	6-11	111.1	111.1	111.2	111.8	111.8	111.8	111.9	111.9	112.0	112.0	112.3	112.5
5.	II	5-11	116.0	116.8	116.8	117.5	117.5	118.0	118.1	118.2	118.7	118.9	119.0	119.3
6.	II	6-5	102.3	102.3	102.6	102.6	102.6	102.7	103.7	103.7	103.7	104.0	104.0	105.0
7.	III	7-2	115.0	115.8	115.8	115.8	115.8	116.0	116.8	116.8	116.8	117.0	117.0	117.1
8.	III	7-2	109.2	109.2	109.5	109.5	109.8	109.8	110.1	110.1	110.3	111.4	112.0	112.2
9.	IV	8-5	109.2	109.2	109.3	109.7	109.7	109.9	109.9	109.9	110.5	110.5	110.8	111.0
10.	I	5-5	101.0	101.0	109.0	109.0	109.2	109.3	109.8	109.8	109.8	110.0	110.0	110.1
11.	V	10-2	119.5	119.5	119.7	119.7	119.7	119.7	121.0	121.6	121.6	121.6	121.6	122.0
12.	IV	8-0	123.1	123.6	123.6	123.6	125.0	125.1	125.8	126.2	126.7	126.9	128.0	128.1
13.	V	9-0	117.4	117.4	117.5	118.3	118.5	118.5	118.5	118.5	118.6	119.0	119.0	119.3
14.	IV	8-7	119.9	120.1	121.1	121.4	122.0	122.0	122.0	122.0	122.0	122.0	122.7	123.0
15.	I	5-2	95.9	95.9	95.9	96.7	96.7	97.0	98.4	98.4	98.6	99.00	99.4	99.4

WEIGHT RECORD OF GROUP 'C' (CONTROL) (in Kg.)

Sl. No.	Class	Age Yr.Mth	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-7	15.73	15.45	15.06	15.59	15.62	15.51	15.10	16.04	15.69	15.32	15.92	15.88
2.	II	6-7	18.27	18.32	18.64	19.05	18.87	19.14	19.45	19.14	19.32	19.54	20.36	20.46
3.	II	6-0	15.73	15.07	15.82	15.52	16.28	16.65	16.14	16.82	16.77	16.82	17.18	17.28
4.	II	6-11	16.09	16.09	15.52	15.96	15.82	16.41	16.45	16.28	16.30	15.96	16.00	16.42
5.	II	5-11	17.64	17.32	17.91	18.57	17.82	18.19	18.41	18.24	18.82	18.24	18.62	18.73
6.	II	6-5	14.05	14.06	14.45	14.36	14.82	15.14	15.37	15.37	15.00	15.18	15.45	14.69
7.	III	7-2	18.23	18.24	18.68	19.18	18.68	19.50	19.15	19.82	19.63	19.91	19.90	20.00
8.	III	7-2	15.18	15.04	15.45	15.06	16.04	15.54	15.64	15.64	15.60	15.92	16.43	16.18
9.	IV	8-5	18.65	18.69	19.59	19.14	19.15	19.62	19.61	19.91	19.91	19.90	20.36	22.27
10.	I	5-5	16.18	16.00	16.13	16.14	16.04	15.52	15.95	15.50	16.36	15.92	16.28	16.36
11.	V	10-2	18.27	17.78	18.59	19.54	18.75	18.70	19.32	19.36	20.18	19.91	20.09	21.89
12.	IV	8-0	18.70	19.14	19.17	18.44	19.09	19.15	19.16	19.16	19.72	20.04	21.27	21.22
13.	V	9-0	18.65	19.61	20.09	20.00	19.61	19.65	20.05	19.14	19.91	20.82	20.64	20.05
14.	IV	8-7	20.00	20.18	20.06	20.08	21.51	21.09	21.09	20.32	20.73	21.09	20.52	21.22
15.	I	5-2	12.80	12.81	12.81	13.09	12.63	13.23	13.50	13.77	14.01	13.69	14.09	14.28

1

HAEMOGLOBIN LEVEL OF GROUP 'C' (CONTROL) g/100 ml.

Sl. No.	Class	Age Yr.Mth	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-7	8.69	9.09	9.28	9.30	9.49	9.59	9.61	9.60	9.75	9.80	9.78	9.95
2.	II	6-7	9.09	9.30	9.54	9.60	9.67	9.71	9.81	9.91	9.98	9.91	10.00	10.02
3.	II	6-0	10.00	10.00	10.08	10.11	10.12	10.21	10.30	10.33	10.33	10.50	10.50	10.57
4.	II	6-11	9.30	9.49	9.51	9.54	9.54	9.80	9.90	10.00	10.00	10.01	10.12	10.00
5.	II	5-11	10.00	10.00	10.00	10.02	10.02	10.05	10.11	10.20	10.42	10.50	10.40	10.45
6.	II	6-5	9.00	9.50	9.50	9.54	10.00	10.00	10.02	10.05	10.24	10.20	10.26	10.42
7.	III	7-2	9.09	9.50	9.50	9.51	9.51	9.60	9.62	9.71	9.89	9.91	9.98	10.00
8.	III	7-2	10.20	10.20	10.23	10.30	10.33	10.55	10.55	10.60	10.60	10.61	10.54	10.48
9.	IV	8-5	10.00	10.00	10.07	10.11	10.11	10.28	10.29	10.33	10.33	10.55	10.54	10.67
10.	I	5-5	8.09	8.29	8.29	8.54	8.60	9.00	9.64	9.79	9.80	9.91	9.90	9.95
11.	V	10-2	9.71	9.81	10.00	10.21	10.21	10.30	10.30	10.33	10.55	10.70	10.69	10.72
12.	IV	8-0	9.71	9.80	9.89	9.89	9.91	9.93	10.07	10.11	10.20	10.33	10.42	10.45
13.	V	9-0	10.21	10.21	10.28	10.28	10.30	10.34	10.43	10.55	10.55	10.60	10.54	10.76
14.	IV	8-7	9.50	9.57	9.73	9.87	9.89	10.00	10.01	10.05	10.11	10.20	10.35	10.42
15.	I	5-2	9.00	9.00	9.12	9.33	9.50	9.80	9.91	10.00	10.00	10.28	10.26	10.33

WEIGHT RECORD OF GROUP S_1 (GREENS) (IN CMS.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	112.2	112.0	112.0	112.3	112.9	112.9	113.3	113.3	113.5	113.6	113.8	114.0
2.	IV	8-0	118.6	118.6	118.6	119.5	119.5	119.6	119.6	119.6	120.0	120.0	121.0	121.0
3.	V	9-2	125.0	125.7	126.0	126.0	126.0	126.1	126.1	127.3	127.3	127.5	127.7	129.0
4.	V	8-10	125.1	126.0	126.0	126.7	126.7	126.7	127.5	127.5	127.7	127.7	128.8	129.1
5.	IV	9-2	119.6	119.7	120.0	120.0	120.0	120.1	120.7	121.2	120.5	120.8	121.2	121.6
6.	II	7-1	106.0	106.0	106.7	106.8	106.9	106.9	107.0	107.8	107.8	107.8	108.0	108.2
7.	III	8-11	116.0	117.0	117.1	117.5	117.5	118.0	118.0	118.4	118.6	119.0	119.0	119.2
8.	IV	8-1	118.2	118.2	118.3	118.7	118.7	118.7	120.0	120.0	120.4	120.4	120.6	121.0
9.	IV	9-5	111.2	112.0	112.6	112.6	112.8	112.8	112.8	112.9	112.9	112.9	113.2	114.1
10.	V	11-0	121.0	121.5	121.7	121.8	121.8	121.8	122.7	122.7	122.8	122.9	123.7	123.8
11.	I	6-6	111.9	111.9	112.2	112.2	112.9	112.9	113.5	113.5	113.6	113.8	114.7	114.7
12.	II	6-4	115.8	117.0	118.2	118.2	118.3	118.3	119.0	119.0	119.2	119.6	119.6	120.5
13.	I	5-1	99.1	99.6	99.6	99.8	99.8	100.0	100.2	100.5	101.5	101.6	101.6	102.4
14.	I	5-10	101.0	101.0	101.7	101.7	101.7	101.8	102.5	103.1	103.7	103.8	104.0	105.2
15.	I	5-0	96.3	96.3	96.3	97.0	97.3	97.3	97.8	98.4	98.4	99.0	100.2	100.3

WEIGHT RECORD OF GROUPS S_1 (GREENS) (IN KG.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	16.18	16.19	15.95	15.97	16.42	16.42	17.04	16.44	16.82	17.00	16.92	17.53
2.	IV	8-0	20.36	20.05	20.00	18.19	19.82	19.61	19.60	19.54	19.54	20.18	20.00	20.46
3.	IV	9-2	23.70	23.63	24.14	24.15	24.73	24.14	24.09	24.09	24.00	24.91	25.07	25.46
4.	V	8-10	23.40	24.14	24.60	24.86	24.84	24.16	23.78	25.00	24.60	25.81	25.52	25.51
5.	IV	9-2	21.77	20.05	21.45	21.05	21.64	21.41	21.82	21.73	22.18	22.35	22.35	23.73
6.	II	7-1	13.23	13.26	13.25	13.95	13.99	13.99	14.00	14.28	14.09	14.15	14.10	14.32
7.	III	8-11	16.44	16.42	16.84	16.87	16.88	17.82	17.55	17.64	17.64	17.33	17.73	18.19
8.	IV	8-1	20.51	21.50	20.95	21.59	18.32	21.42	21.77	21.82	22.09	22.00	23.00	23.23
9	IV	9-5	17.39	16.63	16.88	17.46	17.14	17.28	17.00	16.82	16.87	17.73	17.28	18.73
10.	V	11-0	20.50	20.52	20.95	21.55	20.96	21.68	20.95	20.97	21.59	22.06	21.41	21.86
11.	I	6-6	18.70	21.15	21.10	19.08	19.59	19.61	19.59	20.00	20.46	20.80	20.06	20.51
12.	II	6-4	17.78	18.09	17.79	18.24	19.02	18.37	18.25	18.45	18.05	18.23	18.78	19.32
13.	I	5-1	14.45	13.71	13.69	14.15	14.22	14.32	14.54	14.50	14.54	13.71	15.23	15.32
14.	I	5-10	14.71	14.60	14.62	14.78	15.59	15.14	15.14	15.37	15.42	16.14	16.00	16.82
15.	I	5-0	13.09	13.09	13.19	13.18	13.48	14.01	14.00	13.63	13.82	13.91	13.70	14.69

HAEMOGLOBIN LEVEL OF GROUP S_1 (GREENS) g/100 ml

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	9.00	9.09	9.10	9.50	9.50	9.80	9.98	10.30	10.42	10.51	10.42	10.70
2.	IV	8-0	9.30	9.30	10.00	10.21	10.30	10.33	10.80	10.86	10.90	11.00	11.28	11.33
3.	V	9-2	9.71	10.08	10.11	10.25	10.28	10.30	10.30	10.43	10.90	11.70	10.23	11.39
4.	V	8-10	9.70	9.90	10.21	10.28	10.30	10.54	10.80	10.80	10.91	10.90	11.00	11.20
5.	IV	9-2	9.50	9.91	10.00	10.24	10.24	10.30	10.50	10.54	10.54	10.70	10.63	10.84
6.	II	7-1	8.89	8.89	8.96	9.01	9.75	9.98	10.00	10.00	10.05	10.21	10.45	10.80
7.	III	8-11	9.71	9.89	10.00	10.00	10.00	10.01	10.30	10.54	10.55	10.60	10.84	11.06
8.	IV	8-1	8.29	8.89	9.50	9.84	10.02	10.30	10.55	10.55	10.61	10.80	11.00	11.28
9.	IV	9-5	9.00	9.09	9.09	9.30	9.50	10.07	10.30	10.50	10.50	10.64	10.64	10.91
10.	V	11-0	9.50	9.50	9.98	9.91	9.98	10.21	10.70	10.30	10.30	10.42	10.76	10.94
11.	I	6-6	8.39	9.50	10-01	10.24	10.87	10.80	11.20	11.28	11.28	11.33	11.06	11.28
12.	II	6-4	9.54	9.71	9.85	10.00	10.81	10.80	10.29	11.30	11.30	11.06	11.33	11.59
13.	I	5-1	8.89	9.09	9.21	9.30	10.00	10.30	10.80	10.80	10.90	11.00	11.14	11.30
14.	I	5-10	8.69	8.79	9.09	9.24	10.60	10.80	11.05	11.05	11.20	11.30	11.19	11.55
15.	I	5-0	10.11	10.21	10.28	10.48	10.89	11.05	11.20	11.24	11.28	11.20	11.38	11.46

HEIGHT RECORD OF GROUP S_2 (TONIC) (IN CMS.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-11	113.5	113.5	114.1	114.9	114.9	114.9	115.0	115.0	115.3	115.3	116.0	116.0
2.	IV	8-6	113.7	113.7	113.7	116.7	116.7	116.7	116.8	116.9	116.9	117.4	118.0	118.2
3.	IV	8-12	117.2	117.2	117.8	118.5	118.5	119.2	119.5	119.7	119.7	119.7	119.8	119.9
4.	IV	9-6	113.8	114.0	114.0	114.9	114.9	114.9	114.9	115.3	115.6	115.8	116.0	116.2
5.	V	8-7	121.0	121.0	121.1	121.5	121.6	121.6	121.7	121.7	122.4	122.4	123.6	123.9
6.	III	8-0	112.0	113.3	113.4	113.7	113.7	113.3	114.3	115.2	115.4	115.7	116.1	116.2
7.	IV	10-4	116.6	117.0	117.0	117.9	117.9	118.2	118.3	118.6	118.6	118.8	118.8	118.9
8.	II	6.1	111.4	111.9	112.1	112.3	112.3	112.3	112.3	112.6	113.2	113.3	113.4	113.7
9.	III	7-6	122.0	112.3	112.4	112.4	112.7	122.7	122.9	123.2	123.3	124.0	124.7	125.3
10.	II	6-0	112.6	112.6	112.6	112.6	112.8	113.0	113.2	113.4	113.4	113.6	114.1	114.7
11.	V	9-3	129.6	129.7	130.3	130.3	132.0	132.0	132.0	132.2	132.2	132.2	132.5	132.7
12.	II	5-10	108.0	109.1	110.0	110.1	110.1	110.1	110.3	110.3	112.3	112.3	112.4	112.6
13.	I	5-0	99.0	99.0	99.3	100.1	100.6	100.6	100.6	101.0	101.3	101.5	101.5	102.8
14.	I	5-7	103.6	103.6	103.6	103.9	103.9	10.4.0	104.0	105.5	105.7	105.8	105.8	106.0
15.	II	6-0	97.6	98.2	98.2	98.4	98.9	98.9	99.0	99.0	99.0	99.8	99.8	100.4

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WEIGHT RECORD OF GROUP S_2 (TONIC) (IN KG.)

Sl. No.	Class	Age Yr.Mths.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-11	18.64	18.72	18.72	18-95	19.18	18.78	19.54	19.15	19.09	10.09	19.54	19.43
2.	IV	8-6	17.14	17.30	17.30	17.28	17-55	17.50	18.00	17.73	18.23	18.24	19.00	19.18
3.	IV	8-2	19.91	19.70	19.83	19.00	19.85	19.87	19.59	20.00	20,14	20.00	20.96	21.27
4.	IV	9-6	17.28	17.32	20.37	17.68	18.00	17.96	17.78	17.64	17.96	18.19	18.24	18.55
5.	V	8-7	22.50	24.00	23.00	22.18	22.73	23.82	23.63	23.75	24.45	24.45	24.15	25.05
6	III	8-0	17.64	17.38	16.95	17.77	17.81	18.37	18.19	18.45	17.73	17.73	18.55	19.41
7.	IV	10-4	18.64	18.37	18.55	18.58	18.50	10.02	18.19	18.19	18.37	18.40	18.24	19.36
8.	II	6-1	14.80	17.32	16.88	18.09	17.79	17.73	17.32	18.09	18.19	18.41	18.54	18.78
9.	III	7-6	22.18	22.27	22.41	22.73	22.18	22.18	22.34	22.76	23.10	23.10	23.63	24.00
10.	II	6-0	16.82	17.64	17.86	17.18	18.50	17.33	17.60	18.00	18.12	18.37	17.76	18.64
11.	V	9-3	22.20	22.63	20,40	22.50	22.55	22.69	23.23	23.00	23.04	23.18	23.00	23.28
12.	II	5-10	17.60	17.28	17.33	18.09	17.97	17.79	17.78	18.13	17.78	18.24	18.76	18.82
13.	I	5-0	13.70	13.87	13.69	14.28	14.72	14.09	14.14	14.16	14.45	14.15	15.27	15.37
14.	I	5-7	14.01	13.82	13.93	15.45	15.82	15.00	14.45	15.00	15.45	15.00	15.45	15.64
15.	II	6-0	13.70	13.82	13.85	14.05	13.73	14.19	14.32	14.54	14.54	14.54	14.91.	15.00

HAEMOGLOBIN LEVEL OF GROUP S_2 (TONIC) g/100 ml.

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-11	9.50	9.71	9.98	9.99	10.08	10.21	10.30	10.30	10.55	10.55	10.45	10.63
2.	IV	8-6	9.09	9.50	9.71	9.89	10.30	10.55	10.59	10.33	10.64	10.74	11.00	11.18
3.	IV	8-2	9.50	9.71	9.70	9.71	10.50	10.80	10.80	10.91	11.00	11.00	11.06	11.40
4.	IV	9-6	10.15	10.28	10.52	10.54	10.81	10.80	10.80	10.94	10.96	10.90	11.06	11.48
5.	V	8-7	10-00	10.30	10.44	10.55	10.75	10.80	10.93	11.00	11.10	11.22	11.00	11.46
6.	III	8-0	10.11	10.28	10.28	10.54	10.60	10.80	10.80	11.02	11.05	11.28	11.51	11.67
7.	IV	10.4	8.89	8.98	9.09	9.33	9.75	9.82	10.00	10.00	10.00	10.21	10.20	10,38
8.	II	6-1	9.09	9.49	10.00	10.01	10.01	10.55	10.61	10.80	10.90	10.90	10.84	11.02
9.	III	7-6	9.30	9.30	9.75	9.98	9 .96	10.00	10.02	10.02	10.05	10.33	10.42.	10.57
10.	II	6-0	9.09	9.10	9,10	9.59	9.81	9.98	10.05	10.07	10.24	10.30	10.63	10.99
11.	V	9-3	10.00	10.11	10.28	10.28	10.30	10.33	10.80	10.80	11.00	11.02	11.80	11.19
12.	II	5-10	9.00	9.09	9.75	9.89	9.96	10.07	10.21	10.24	10.33	10.33	10,26.	10.72
13.	I	5-0	9.91	9.91	10.11	10.21	10.55	10.80	11.05	11.05	11.20	11.30	11.00	11.38
14.	I	5-7	9.09	9.60	10.01	10.21	10.33	11.05	11.29	11.29	11.30	11.28	11.06	11.25
15.	II	6-0	8.49	8.89	9.09	9.75	10.08	10.21	10.30	10.33	10.50	10-70	10-72	10-63

HEIGHT RECORD OF GROUP S_3 (SALT)(IN CMS.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	104.1	104.6	105.4	105.4	105.4	106.0	106.1	106.9	107.0	107.0	108.0	108.5
2.	III	7-3	109.0	110.0	110.0	110.4	110.4	110.4	110.6	111.3	111.8	111.8	112.3	113.6
3.	IV	7-11	119.2	119.2	119.6	119.6	120.0	120.2	120.5	120.5	120.5	120.6	121.2	121.8
4.	V	9-0	114.2	114.5	114.5	114.5	115.1	115.1	115.5	115.5	115.6	116.0	116.2	117.0
5.	IV	8-0	119.0	119.1	119.1	119.5	119.8	119.8	119.9	120.8	120.4	120.7	121.1	121.2
6.	III	7-5	116.0	116.4	116.4	116.4	116.4	116.4	116.5	116.6	117.0	117.5	118.0	118.3
7.	V	9-1	121.5	121.5	121.8	121.8	121.8	122.0	122.21	123.3	123.3	123.6	123.6	123.7
8.	III	8-0	118.0	118.0	118.0	118.1	118.3	118.6	118.6	118.8	119.5	119.5	119.7	120.5
9	III	7-8	117.0	117.4	117.4	118.0	118.6	118.6	118.6	118.6	119.0	119.0	119.2	119.4
10.	III	6-10	108.2	110.9	112.0	112.9	112.9	113.1	113.5	114.0	114.3	115.8	115.8	116.0
11.	V	9-7	129.0	129.0	130.7	130.7	131.4	132.2	132.2	132.3	132.3	132.3	133.2	133.5
12.	III	8-4	111.0	111.0	111.0	111.4	111.7	112.0	112.7	112.7	112.9	112.9	112.9	122.9
13.	I	5-2	108.6	108.6	108.6	109.5	109.5	110.0	111.2	111.4	111.4	111.4	112.0	112.1
14.	I	5-2	100.8	100.8	100.8	100.9	101.0	101.0	101.9	102.0	103.0	103.6	103.6	103.7
15.	I	5-0	99.5	99.6	99.7	100.0	110.2	100.3	100.5	100.5	100.9	101.2	102.0	102.6

WEIGHT RECORD OF GROUP S_3 (SALT (IN KG.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	14.91	14.60	14.53	15.18	15.59	14.60	15.12	15.23	15.37	15.45	15.52	15.92
2.	III	7-3	16.89	14.43	16.23	16.87	16.43	17.23	16.50	17.73	17.64	17.33	17.73	18.19
3.	IV	7-11	18.65	19.14	19.68	19.14	19.15	20.02	19.09	19.09	19.60	19.60	20,04	20.59
4.	V	9-0	16.89	17.55	17.68	17.86	17.87	17.66	17.73	17.86	17.33	17.73	18.37	18.55
5.	IV	8-0	19.54	19.61	20.04	19.18	19.19	19.60	19.72	19.91	20.41	20.02	20.36	20.46
6.	III	7-5	19.15	19.54	19.52	19.60	19.54	20.04	19.82	19,52	20,51	20.91	20.92	21.36
7.	V	9-1	22.60	21.05	21.95	2.097	20.58	21.68	21.87	22.05	21.36	22.27	22.33	23.04
8.	III	8-0	18.23	19.01	18.69	18.64	19.23	19.18	19.09	18.69	19.54	18.90	19.60	19.82
9.	III	7-8	20.39	21.37	20.97	20.30	21.18	20.98	21.18	21.27	22.33	21.87	22.37	22.14
10.	III	6-10	16.90	16.88	18.00	17.00	16.88	17.96	18.00	17.74	17.78	17.84.	18.24	19.05
11.	V	9-7	25.50	25.81	25.37	26.14	26.77	26.77	26.96	27.28	27.30	17.30	23.55	26.88
12.	III	8-4	18.23.	18.78	18.64	19.00	18.68	19.16	19.00	18.37	18.24	19,09	19.15	19.82
13.	I	5-2	16.89	17.18	17.36	17.34	17.33	17.64	17.91	17.33	18.09	17.73	17.64	17.77
14.	I	5-2	13.82	14.19	13.23	14.54	14.60	14.54	14.15	14.54	14.05	15.00	15.28	15.37
15.	I	5-0	12.13	12.69	12.67	13.09	12.77	12.69	12.67	12.33	13.18	12.73	13.00	13.23

HAEMOGLOBIN E VEL OF GROUP S_3 (SALT) g/100 ml.

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	8.69	8.89	9.08	9.28	10.30	10.30	10.55	10.56	10.55	10.70	10.67	10.89
2.	III	7-3	9.50	10.00	10.02	10.31	10.55	10.60	10.80	10.80	10.80	11.00	11.22	11.43
3.	IV	7-11	10-00	10-01	10-07	10-11	10-11	10-21	10-30	10-30	10.46	10.50	10.72	10.94
4.	V	9-0	10.30	10.30	10.54	10.60	11.00	10.21	11.33	11.55	11.55	11.60	11.56	11.72
5.	IV	8-0	10.00	10.28	10.33	10.54	10.57	10.57	10.80	10.80	10.87	11.00	11.27	11.48
6.	III	7-5	10.00	10.11	10.28	10.30	10.54	10.55	10.73	10.80	10.83	10.80	11.00	11.10
7.	V	9-1	10.21	10.30	10.30	10.42	10.55	10.55	10.55	10.62	10.70	10.91	10.99	11.25
8.	III	8-0	10.00	10.00	10.11	10.28	10.34	10.55	10.72	10.80	10.80	11.01	11.22	11.48
9.	III	7-8	9.50	9.71	9.98	9.98	10.00	10.21	10.30	10.50	10.43	10.55	10.69	11.00
10.	III	6-10	10.00	10.33	10.52	10.60	10.81	11.00	11.05	11.05	11.29	11.30	11.51	11.59
11.	V	9-7	9.30	9.50	9.62	9.62	9.77	9.85	9.85	9.89	9.94	10.00	10.26	10.45
12.	III	8-4	8.49	9.00	9.49	9.50	9.76	10.00	10.11	10.21	10.28	10.28	10.50	10.62
13.	I	5.2	12.39	12.40	12.40	12.55	12.60	12.63	12.74	12.74	12.76	12.70	12.66	12.74
14.	I	5-2	9.30	9.71	9.98	9.98	10.00	10.05	10.05	10.11	10.20	10.28	10.33	10.52
15.	I	5-09	8.09	8.49	8.93	9.09	9.30	9.33	9.60	9.98	10.00	10.11	10.02	10.19

HEIGHT RECORD OF GROUP S_4 (BASAL DIET) (IN CMS.)

Sl. No.	Class	Age Yr.Mth	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	105.3	106.0	107.0	107.5	108.0	108.2	108.2	108.4	108.4	108.4	108.7	110.00
2.	I$I	8-5	116.4	117.1	117.2	117.2	117.3	117.3	118.5	118.5	118.7	118.7	119.1	119.2
3.	IV	9-0	112.1	123.0	123.0	123.9	123.9	123.9	124.0	124.0	124.6	124.6	126.6	124.8
4.	III	7-0	125.0	125.2	125.2	125.8	125.9	125.9	125.9	126.0	126.1	126.1	126.6	126.6
5.	III	6-1	11.0	111.4	111.6	111.7	111.7	111.9	112.7	112.9	113.0	113.0	114.0	114.2
6.	IV	10-4	119.0	119.0	119.0	119.4	119.4	120.0	120.0	120.0	120.[illegible]	120.1	120.2	120.2
7.	IV	8-5	117.0	117.0	117.0	117.3	117.3	117.4	118.0	118.0	118.7	119.0	119.0	119.3
8.	III	6-11	116.0	117.1	117.8	118.0	118.0	118.5	118,6	119.5	119.6	119.6	121.0	121.3
9.	IV	8-5	112.8	113.2	113.2	113.7	113.7	113.7	114.0	114.3	114.4	115.0	115.8	116.0
10.	V	10-1	126.6	126.6	127.3	127.3	127.7	127.7	128.2	128.5	128.8	128.8	129.4	129.6
11.	II	6-8	106.0	106.2	107.2	107.4	107.5	107.6	108.1	108.3	108.7	108.9	108.9	109.7
12.	I	5-0	94.8	95.0	95.0	95.0	95.2	96.0	96.8	96.8	97.0	97.0	98.2	98.2
13.	II	6-0	108.0	108.6	108.6	109.0	109.3	109.3	109.5	109.5	110.0	110.0	111.0	111.2
14.	II	6-0	97.6	98.4	98.5	99.2	99.5	99.5	100.00	100.00	100.0	100.0	100.5	100.7
15.	II	6-0	101.0	101.6	101.6	102.8	102.8	102.8	104.0	104.7	104.8	105.1	105.2	105.4

WEIGHT RECORD OF GROUP S_4 (BASAL DIET)(IN KG.)

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	15.86	16.28	15.95	16.14	17.08	16.38	17.00	16.82	16.82	16.82	17.00	17.73
2.	III	8-5	20.50	20.50	19.59	21.09	24.40	20.82	20.05	19.99	20.41	20.05	20.82	21.09
3.	IV	9-0	19.50	19.45	19.86	19.62	19.86	20.05	20.73	20.00	20.82	20.91	29,94	20.51
4.	III	7-0	23.00	22.78	23.51	23.25	24.09	23.86	23.87	24.18	23.69	24.41	25.00	24.91
5.	III	6-1	17.78	18.37	18.24	18.82	19.00	19.01	18.73	19.09	19.14	18.69	19.72	19.64
6.	IV	10-4	19.60	19.32	19.19	19.28	19.14	19.15	20.00	19.45	19.54	19.54	19.54	19.68
7.	IV	8-5	18.70	20.00	19.16	19.62	20.14	20.50	20.61	19.95	20.06	20.46	20.91	21.09
8.	IV	8-5	18-37	18.73	18.45	18.24	18.19	18.90	18.87	18.82	19.41	19.45	19.77	19.36
9.	III	6-11	19.45	19.41	19.15	19.59	20.18	20.36	20.23	20.27	20.27	20.27	20.05	20.92
10.	V	10-1	22.34	22.37	23.32	22.73	22.32	23.10	22.73	22.73	22.78	22.79	24.00	24.14
11.	II	6-8	16.36	15.92	15.52	15.05	15.86	15.96	16.00	16.36	16.59	16.73	16.82	16.95
12.	I	5-0	11.87	13.14	13.23	12.50	13.00	12.50	12.80	12.88	13.09	13.00	13.21	13.09
13.	II	6-0	15.86	15.92	15.52	15.05	15.86	15.96	16.00	17.41	16.45	17.00	17.28	17.33
14.	II	6-0	16.09	15.50	15.54	15.82	16.18	16.18	15.95	16.09	16.04	15.96	16.42	16.55
15.	II	6-0	14.69	14.62	14.91	14.78	14.59	15.05	15.14	15.18	15.54	15.77	15.00	15.52

HAEMOGLOBIN LEVEL OF GROUP S_4 (BASAL DIET) g/100 ml.

Sl. No.	Class	Age Yr.Mth.	1	2	3	4	5	6	7	8	9	10	11	12
1.	II	6-1	9.28	9.49	9.70	9.89	9.91	10.00	10.05	10.20	10.33	10.40	10.40	10.54
2.	III	8-5	9.40	9.54	9.70	9.70	9.98	10.00	10.05	10.09	10.11	10.20	10.33	10.64
3.	IV	9-0	9.30	9.40	9.55	9.80	10.00	10.00	10.20	10.20	10.33	10.50	10.62	10.76
4.	III	7-0	8.89	8.98	9.09	9.49	9.70	10.00	10.00	10.33	10.42	10.35	10.50	10.84
5.	III	6-1	10.00	10.14	10.33	10.51	10.51	10.55	10.55	10.57	10.60	10.60	10.79	10.86
6.	IV	10-4	10.00	10.00	10.20	10.28	10.28	10.30	10.50	10.54	10.55	10.70	11.00	11.25
7.	IV	8-5	9.30	9.60	10.00	10.21	10.33	10.55	10.58	10.60	10.60	10.60	10.67	10.81
8.	III	6-11	10.00	10.00	10.28	10.54	10.55	10.55	10.60	10.72	10.80	10.80	10.61	10.84
9.	IV	8-5	9.09	9.09	9.29	9.60	9.98	10.00	10.00	10.05	10.09	10.21	10.26	10.33
10.	V	10-1	8.89	9.30	9.33	9.49	9.54	9.80	10.00	10.00	10.11	10.28	19.00	10.23
11.	II	6-8	10.00	10.00	10.02	10.11	10.21	10.30	10.33	10.52	10.60	10.60	10.69	10.74
12.	I	5-0	8.70	8.75	8.89	8.89	8.90	9.14	9.20	9.40	9.64	10.00	10.00	10.12
13.	II	6-0	8.09	8.29	8.49	8.54	9.09	9.50	9.80	9.80	9.80	10.01	10.00	10.05
14.	II	6-0	9.50	9.50	9.60	9.89	9.89	9.89	10.00	10.00	10.02	10.33	10.35	10.45
15.	II	6-0	9.50	9.52	9.91	10.00	10.00	10.05	10.05	10.11	10.21	10.20	10.26	10.40

INITIAL AND FINAL VALUES OF PCV (%)

Sl. No.	Group	PCV Values (Percentage)	
		Initial	Final
1.	S_1	37	38
2.		28	29
3.		25	28
4.		27	30
1.	S_2	32	33
2.		33	36
3.		35	35
4.		30	30
1.	S_3	29	32
2.		38	38
3.		25	27
4.		35	35
1.	S_4	28	30
2.		30	30
3.		34	34
4.		29	31
1.	C	28	28
2.		31	33
3.		26	27
4.		35	35

INITIAL AND FINAL VALUES OF RBC COUNT (mm^3)

Sl.No.	Group	RBC Count (millions/cubic millimeter)	
		Initial	Final
1.	S_1	4.57	4.81
2.		3.05	3.86
3.		4.25	4.32
4.		4.0	4.16
1.	S_2	4.52	4.68
2.		1.46	2.17
3.		5.75	5.88
4.		3.60	3.74
1.	S_3	4.57	4.82
2.		5.36	5.74
3.		4.01	4.61
4.		3.16	3.86
1.	S_4	3.81	3.85
2.		4.48	4.57
3.		4.07	4.83
4.		2.51	2.94
1.	C	3.23	3.43
2.		3.67	3.79
3.		4.43	4.98
4.		2.69	2.73

ANNEXURE II

The Details of the Calculations for the Supplements

1. **Tonic (Colliron):**

   1 ml. of the tonic contains ... 97.5 mg. of iron.

   ∴ 4 ml. of the tonic contains ... 390.0 mg. of iron.

   4 ml. was diluted to 50 ml.

   390 mg. is present in 50 ml.

   ∴ 13 mg. of iron will be present in 1.7 ml. of tonic.

2. **Salt (Fersolate):**

   The average weight of the tablet is 0.542 g.

   0.542 g. contains ... 61.83 mg. of iron.

   ∴ 13 mg. of iron will be present in 113.4 mg. of the salt.

ANNEXURE III

Schedule for Clinical Assessment

Date of Survey:

Serial Number
of the Family:

Name: Sex: Age:

Height: Weight: Bloo Pressure:

Hipwidth (Inter cristal):

I. General Appearance:

Grades

4 Good

3 Fair

2 Poor

1 Very Poor

II. Eyes

A. Xeresis of Conjunctiva

4 Absent - Glistening and moist

3 Slightly dry on exposure for ½ minute lack of lustre

2 Conjunctiva very dry

1 Bitot spots present

B. Pigmentation

4 Normal colour

3 Slight discolouration

2 Moderate browning in patches

1 Severe earthy discolouration

C. Discharge

4 Absent

3 Watery, excessive lachrymation

2 Micropurulent

1 Purulent

D. Xerosis of Cornea

4 Absent

3 Slight dryness and diminished sensibility

2 Haziness and diminished transparancy

1 Ulceration

E. Vascularisation of Cornea

4 Absent

3 Vascularisation present

2 Severe vascularisation present

F. Eyelids Excoriation

4 Absent

3 Slight Excoriation

2 Blepharitis

1 Severe

G. Folliculosis

4 Absent

3 A few granules

2 Lids covered with extensive granules

1 Hyper trophy

H. Angular Conjunctivity

4 Absent

3 Mild

2 Moderate

1 Severe

I. Night Blindness

4 Absent

3 Mild

2 Moderate

1 Severe

III. Mouth

A. Condition of lips

4 Normal

3 Angular stomatitis, mild

2 Angular stomatitis, moderate

1 Angular stomatitis, severe

B. Colour of Tongue

4 Normal

3 Pale but not coated

2 Red

1 Red and raw

C. Surface of tongue

4 Normal

3 Fissured

2 Ulcered

1 Grayed and atropie

D. Condition of Gums

4 Normal

3 Bleeding and/or gingivities

2 Pyorrhea

1 Rettacked

E. Teeth

4 Flourosis

3 Chalky teeth

2 Pitting of teeth

1 Mottled enamel and discoloured teeth

F. Caries

4 Absent

3 Slight

2 Moderate

G. Tonsils Enlargement

4 Absent

3 Slight

2 Moderate

1 Severe

IV. Hair

4 Normal

3 Loss of lustre

2 Discoloured and dry

1 Sparse and brittle

V. **Skin**

A. General Appearance

4 Normal

3 Loss of lustre

2 Dry and rought or crazy pavement

1 Hyperkeratosis, phrynoderma

B. Elasticity

4 Normal

3 Diminished

2 Wrinkled

1 Severely wrinkled

VI. **Face**

4 Normal

3 Nasolabial seborrhoea

2 Symmetrical sub-orbital

1 Pigmentation

VII. **Oedema:**

4 Absent

3 Oedema on dependents parts

2 Oedema on face

1 General oedema

VIII. Alimentary System

A. Appetite

4 Normal

3 Anorexia, mild

2 Moderate

1 Severe

Rating

Excellent:

Very Good:

Good:

Fair:

Poor:

Very Poor:

ANNEXURE IV

THE PROCEDURE USED FOR THE STATISTICAL ANALYSIS

Students 't' test:

The 't' value was calculated using the following formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2 + s_2^2}{n - 1}}}$$

Where $\bar{x}_1$ is the Arithmetic mean of the first group; $\bar{x}_2$ is the Arithmetic mean of the second group; s_1 is the standard deviation of the first group; s_2 is the standard deviation of the second group; n is the number of items in the sample. 't' follows t - distribution with (2n-2) degrees of freedom. If the calculated 't' exceeds the table value of 't', then there is significant difference between the two groups.