AVAILABILITY TO SCHOOL CHILDREN, OF IRON FROM AMARANTHUS COOKED IN TWO DIFFERENT UTENSILS

By

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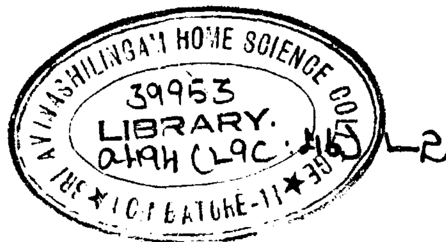

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I. INTRODUCTION

The welfare of a nation rests on the health of its people. The foundation for health are laid in early childhood. School going children are in a stage of rapid growth. Their nutritional needs are far greater than those of other segments of the community, (Swaminathan, 1970). Only when their nutritional needs are met good growth can be ensured. Good nutrition in childhood and throughout the life span is of paramount importance in fostering the physical, mental, emotional and social growth of the population (Devadas,1968,1970 and Ray,1971).

In the world today there are nearly one billion children under 15 years of age,(UNICEF, 1970). In India, the child population below 14 years constitutes approximately 40 per cent of the total population, (Gopalan and Vijayaraghavan, 1971, India, 1971). Malnutrition is the most important health problem among this vulnerable group.

It has been estimated that nearly 300 million children in the world today are physically and perhaps mentally retarded due to malnutrition,(Nutrition Bulletin, 1971). The diet and nutrition surveys carried out by the

Indian Council of Medical Research, indicate that many children are victims of frank cases of nutritional disorders (Gopalan, 1969; Gopalan et al, 1971). Iron deficiency anaemia is one of the widely prevalent nutritional disorders among children. According to Reddy, (1969) 50 per cent of our children have haemoglobin levels below 10 g. per cent due to inadequate intake of iron. The high incidence of iron deficiency anaemia in India inspite of the seemingly satisfactory dietary intake of iron suggests that perhaps much of the iron in the diet is not absorbed. The phytates, phosphates and oxalates in cereals which dominate the Indian diets appear to interfere with iron absorption, Apte (1970). The Joint FAO/WHO Expert Committee (1970) has rightly pointed out the importance of studying the nature and availability of iron from dietary sources.

Prevention and control of nutritional disorders call for the application of such specific measures. Much can be done to promote the nutritional well being of children through the provision of adequate school lunch and school health programme. The free school lunch programme operating in the primary schools of Tamil Nadu aim at providing one nutritious meal free of cost.

During the recent years, considerable interest has been shown in our country towards evolving and using suitable supplementary foods from indigenous food resources for improving the nutritional status of the children. Devadas et al (1969) point out that indigenous nutritious supplements will help to improve the nutritive value of the low cost school meals.

Green leafy vegetables are one of the most inexpensive nutritionally rich resources. Amaranthus, which is a locally available and commonly used green leafy vegetable, is rich in iron, calcium, vitamin A and vitamin C. Hence supplementation of Amaranthus to the school lunch can be an effective and inexpensive way of improving the iron intake of school going children. The beneficial effect of iron supplementation through Amaranthus for school children has been demonstrated by Anandam et al (1966), Nirmala et al (1968), Devadas et al (1969, 1970, 1971).

How far the qualities of cooking utensils and the methods of cooking employed have an effect on the nutritive value of the vegetable has been a question. Vegetables are cooked in different types of metallic utensils. Studies reported by Devadas et al (1965) indicate that the iron content of the Amaranthus cooked in an iron utensil, increased to a greater extent over that cooked in aluminium and brass

utensils. How far the enhanced amount of the iron is available to the body is a question. This study aims to answer the question. It is an attempt to evaluate the availability to the children of iron, from amaranthus cooked in iron and aluminium utensils and supplemented to a school lunch.

II. REVIEW OF LITERATURE

The literature pertaining to this study, "Availability to school children, of iron from amaranthus cooked in two different utensils" is reviewed under the following headings:

A. Nutrition and health of the child.

B. Nutritional disorders of children in India.

C. Iron deficiency anaemia.

D. Role of iron in child nutrition.

E. Green leafy vegetables as a source of iron.

F. Effect of cooking utensils on the iron content of vegetables.

G. School Lunch as a medium of supplementation of iron.

A. Nutrition and Health of the Child

The 20th century can be considered as the era of the child, because of the emphasis and consideration child health has received from all quarters. Children form a very sizable segment of India's population, accounting for about 40 per cent of its population (India, 1971; Dhar, 1971). The problem of finding sufficient food of good nutritional quality to feed the continously increasing population is tremendous, (Visweswara Rao, 1969). Among the

several target groups for whom good nutrition is important school age children are in a crucial position, (Subramanian and Thekkamalai (1967) and Mittal (1971).

As Carter (1968) states, fulfilling the child's right to health has been one of the most complex and difficult problems faced by independent India. Several millions of children may not be sick but may be handicapped physically and mentally due to poor health and nutrition (Trivedi, 1971).

Good health is a natural corollary of good nutrition. The importance of and need for good nutrition during early childhood have been universally accepted and emphasised by Devadas (1968), (1970), Gopalan (1970), Boerma (1971), Candau (1971), and Subramanian (1971).

Ghosh (1966), Dhar (1971) and Gyorgy (1967) point out that no single factor in child's life determined his normal growth and development as decisively as proper nutrition. Devadas _et al_ (1968) and Fernando (1971) stress that healthy children make a healthy nation. Therefore securing optimum health for children through adequate nutritional feeding programme should be the major goal for all those who are planning for progress.

Alert mind in a strong body is the most favourable

condition for effective learning (Cravioto, 1970, Monckebery, 1970 and Fernando, 1971). Neither mental alertness nor bodily strength will be possible, when children do not get the right kind of foods in adequate quantities and may permanently reduce his intellectual capacity, (Teply, 1970; Cravioto, 1970, 1971; Frisch, 1970, 1971; Devadas *et al*, 1971; Srikantia, 1971).

Growth is a complex process with wide variability in its manifestations, (Ghai and Sandhu 1968). As Chandran *et al* (1966) note growth is not merely a physical phenomenon but involves intellectual, emotional and social development. Each child has a unique pattern of growth, and make a great demand on calories, proteins and other essential nutrients in the diets, (Leverton, 1962 and Nutrition Reviews, 1969). Thus as Bhalekar and Phadnis (1966) claim, the rate of growth is an index of the nutritional status of children.

B. Nutritional Disorders of Children in India

Out of the [illegible]67 million children under the age of 14 years living in developing countries, 269 millions are undernourished, (WHO,,1970). Malnutrition is the most crucial malady affecting the health of children in India, (Lathens, 1966). Srikantia and Yogananda Sastri (1971) report that the growth performance of most children belonging to the

poor income groups is suboptimal in India. Surveys conducted in several parts of our country show that a high proportion, namely 1,00,000 to 3,00,000 of our school children manifest frank signs of nutritional deficiencies, Prasada Rao and Gupta (1968), Reddy (1969) and Gopalan (1969), (1970). Vijayaraghavan et al (1971) conducted studies on 7,000 school children and found that 20 per cent of the children belonging to the poor income group had one or more deficiency diseases. The Coimbatore District Secondary School Medical Aid Committee (1971) reported that out of a total of 41,182 children examined, 36 per cent suffered from malnutrition, 19.5 per cent from defects in teeth and gums, 3.6 per cent from anaemia, and 35.6 per cent from other deficiency disorders.

One of the underlying causes of malnutrition among children is the ignorance on the part of the mothers, of the need for hygienic care and nutritional requirements of young children (Bower et al 1964, Mac Laren, 1964 and Devadas and Easwaran, 1968). According to Devadas (1970) and Pascual (1971) the prevailing food habits, traditions, customs, and beliefs are some of the most important social cultural factors affecting the nutritional status.

Rao et al (1965) report that in the regions where food production is low in relation to population, the diets especially of the low income groups are often deficient in many essential nutrients. A series of nutritional surveys carried out in the different parts of India by Aykroyd (1948), Patwardhan (1952), Mitra (1953), Radhakrishna Rao (1954), Gopalan and Ramalingaswami (1955) Rao and Rao (1958), Rao et al (1959), (1961), WHO (1963), (1966), Devadas et al (1964), Devadas (1965), Gopalan (1970) Bailur (1970) Gopalan et al (1971) and Dhar (1971), have shown that deficiencies of protein, calories, iron, calcium, vitamin A and B complex are prevalent among growing children.

Studies conducted by Narasinga Rao et al (1969) on preschool children indicate that their mean daily intake of calories was 725, while that of protein was 1.9 gram per kilogram body weight. While the protein intake was similar to the recommended allowance calorie intake was far below the recommended allowance of the Indian Council of Medical Research.

Most children suffering from Kwashiorkor have anaemias of varying degree, exhibiting low levels of haemoglobin, serum iron, elevated levels of vitamin B_{12} and low levels of folic acid (Reddy and Srikantia, 1970).

C. Iron Deficiency Anaemia

Iron deficiency anaemia is a term that is indiscriminately applied to microcytic, hypochromic anaemia. WHO (1968) defines nutritional anaemia as a condition in which the haemoglobin content of the blood is lower than normal, as a result of a deficiency of one or more essential nutrients. Haemoglobin values lower than 10 g/100 ml of blood for children aged 6-14 years are considered to be anaemic, (WHO, 1966 and Pennsylvania Department of Health, 1971).

Anaemia caused by iron deficiency has been reported to be a very common nutritional disorder in India, Ramalingaswami and Patwardhan (1949), (1965), Moore and Dubatch (1956) Woodruff (1961), FAO (1963), Chandran (1965), Elwood (1965), Berry and Mac Williams (1967), Routh and Agarwal (1967) Sood (1967), Chatterjee (1967), Banerji (1968), Mittal and Agarwal (1969). Several workers like Smith (1966), Venkatachalam (1968), WHO (1968), NRL (1968), Venkatachalam (1971) and Vijayaraghavan et al (1971) have indicated that anaemia is particularly prevalent among growing children. ICMR (1966) and Reddy (1969) have reported that more than 50 per cent of the infants and children have haemoglobin values below 10 gram per cent, the standard accepted for the age group.

1. Causes of iron deficiency anaemia:

The causes of iron deficiency anaemia in children are many and varied, (Guha and Rasbmi, 1967 and Sood *et al* 1968). Some of the etiological factors listed by Apte and Venkatachalam (1963) chandra (1965), Conrad (1967) and Venkatachalam (1968) are:

a. Protein calorie malnutrition
b. Haemorrhage
c. Hook worm infestation
d. Malabsorptive syndrome
e. Composition of the diet
f. Increased requirement during growth period.

a. Protein Calorie Malnutrition:

For a long time anaemia was thought to be the result of protein deficiency, (Sandozai *et al* 1963). Narasinga Rao (1970) holds that anaemia is one of the important clinical features of kwashiorkor. Halsted *et al* (1969) and Woodruff (1969), Srikatanaban and Thayer (1971) have also emphasised that anaemia and iron deficiency are common in Protein Calorie Malnutrition.

Haematological studies carried out on 200 children suffering from kwashiorkor by Reddy and Srikantia (1970) reveal that a great majority of the children exhibits moderate degrees of anaemia, the mean level of haemoglobin being 8.8 ± 0.37 g/100 ml. Although it has been recognised that anaemia is frequently associated with kwashiroker, it does not appear to be due to defective production of erythropoietin which influences bone marrow activity (Murthy, 1965). It has now been recognised, that in cases of Protein Calorie Malnutrition, deficiency of other haematopoietic factors like iron (Trowell and Simkiss, 1957), folic acid and vitamin B (Patwardhan, 1961 ; Chandra, 1965 Periera and Baker, 1966) and vitamin E (Majaj <u>et al</u> 1963) coexist and may contribute to the anaemia. The haematological and biochemical study of Chandran <u>et al</u> (1966) on Indian school children revealed that protein deficient diet is simultaneously deficient in iron also.

During the early phases of nutritional rehabilitation with high protein diets, of children suffering from kwashiorkor, the already low levels of haemoglobin show a further fall in a great majority of children. Edozein and Khan (1968) ascribe this drop to haemodilution.

b. <u>Haemorrhage:</u>

Only a few workers, Hoag *et al* (1961), Naiman *et al* (1962) and Wilson *et al* (1962) have studied the evidence of occult blood in iron deficiency anaemia, both before and after correction of anaemia. Guha and Rashmi (1967) showed that 34.4 per cent of the children observed with anaemia, had occult blood in faeces. After iron therapy and disappearance of anaemia, the benzidine test was repeated and found to be negative in all the cases recorded. Trauma and coagulation defect have also been reported to cause haemorrhage sometimes, (Conrad, 1967).

c. <u>Hookworm Infestation:</u>

In the pathogenesis of anaemia, iron deficiency has been recognised associated with hook worm infestation, Roche and Layrisse (1966) and Farid *et al* (1969). Saraya *et al* (1970) conducted studies on 104 patients with stools positive for hook worm ova, with regard to anaemia, iron and protein deficiency. Iron deficiency anaemia was observed in 80 of the 104 patients.

The relationship between hook worm infestation and anaemia, depends upon the number of worms present in the gut, the iron stores of subjects and the amount of available iron in the diet. Foy and Kondi (1960), Mehamood (1966)

and Matrinez-Torris *et al* (1967) have shown that intestinal blood loss is associated quantitatively with hook worm load. Gilles *et al* (1964) estimate that each worm causes a daily blood loss of 0.05 ml. It has also been inferred that hook worm produces interference with the reabsorption of iron, (Sheehy *et al* 1962).

Intestinal changes in hook worm infestation have been found to correlate with hypo albuminaemia, (Tandon *et al*, 1969). Salem and Truelove (1964), Tandon *et al* (1966), Rai *et al* (1968) and Burman *et al* (1970) found correlation between hookworm infestation and structural derangement of small intestine. Saraya *et al* (1971) reported the prevalence of vitamin B_{12} and folic acid deficiency in patients with hook worm infestation.

d. Malabsorptive syndrome:

Malabsorption disorders, in the small intestine such as sprue, decrease the absorption of iron, Badenoch and Callender(1954). Acute infection also causes decreased absorption of iron, (Saylor and Finch, 1953; Jeffrey, 1955 and Conrad *et al*, 1970). It has been postulated that this decrease is caused by a loss of absorptive surface in the small intestine which loses its characteristic villous appearance and becomes fluttered and atrophic, Sheehy and Flock (1964).

Gastrectomy and atrophic gastritis decrease iron absorption and lead to iron deficiency, (Hobbs, 1961), partly due to the inability to release iron from food without acid pH of the stomach. Chronic diseases such as chronic renal failure can also cause anaemia, (Erslev, 1970 and Wallace, 1971).

e. Composition of the diet:

The quantity of iron in the diet, the chemical form in which it is present in the diet and the protein content of the diet appear to play a role in regulation of iron absorption, (Conrad 1966, 1967). Ferrous iron is absorbed in greater quantities than ferric iron from the food. (Conrad, 1962 and Callender *et al*, 1962).

f. Increased requirements during growth:

The demands for iron are increased, to meet the extra physiological needs in early life and to increase the blood volume during growth. If these requirements are not met, anaemia results. Dhar *et al* (1969) report that iron deficiency anaemia may be due also to maternal ill health, undernutrition, faulty feeding and prolonged breast feeding.

2. Clinical manifestations of iron deficiency anaemia:

Severe iron deficiency is manifested by a symptomatic anaemia, shortness of breath with a rapid pulse with mild exertion, and a haemoglobin concentration less than 7g/100 ml (Crosby, 1958). According to Bothweel and Finch (1962) iron deficiency anaemia can be differentiated from other nutritional anaemias by the demonstration of small and pale red blood cells in the circulating blood. Conrad (1967) explains that the common complaints of iron deficiency anaemia are fatigue, weakness, headache, dizziness, exertional dypsnea, palpitation and mild gastrointestinal symptoms. Furthermore as Huser et al (1967) point out circulating blood contains many minute and deformed red blood cells with a shortened life span which worsens the anaemia.

D. Role of Iron in Child Nutrition

The role of iron in child nutrition is reviewed under the following aspects:

1. Nutritional importance of iron
2. Iron intake
3. Iron absorption
4. Utilisation and storage
5. Excretion
6. Iron requirement.

1. <u>Nutritional importance of iron:</u>

The body contains about 45 milligrams of iron per kg of body weight, in the form of transport iron, haemoglobin iron, storage iron and cellular tissue iron. The major portion of the iron, 55 to 60 per cent is in the blood. Muscle tissue contains about 3 per cent, and available iron is stored in the liver, spleen, kidney and bone marrow, (Wilson <u>et al</u> 1968, Finch, 1969).

Iron is essential for growth and maintenance of the body. The primary function of iron in the body is oxygen transport at the levels of haemoglobin and myoglobin cytochrome, (FAO/WHO group, 1970). Iron is an essential constituent of haemoglobin, (WHO, 1963). A bulk of the iron found in the blood is firmly added to the haemoglobin of Red Blood Corpuscles, (Miller, 1971). Normal persons have reserves of iron which can be drawn upon in times of deprivation or physiological stress such as pregnancy and rapid growth. When intake of nutrients is inadequate to meet the daily requirements, these stores are gradually used up (NRL, 1968). Hence the importance in building up these reserves. A depletion of iron reserves occurs during the period of rapid growth of the infant despite the considerable store of iron contained in the plethora of

haemoglobin in the blood at birth, Nutrition Reviews (1971). Most new babies begin life with 300 to 400 mg. of iron stored in their body and 2.5 to 4.5 mg iron are laid down in the tissues during the following 20 years. The latter part of the first year of life, adolescence and pregnancy are known to be the period of maximal demand on iron reserves (Woodruff, 1961).

2. Iron intake:

Hussain and Patwardhan (1959) found that the average dietary intake of iron varied from 11 to 14 mgs per day. Since availability of iron to human utilisation varies from different foods, a figure of total dietary iron without knowledge of its source is not generally informative, (Berry, 1967). Indian diets are chiefly composed of cereals like rice, wheat, sorghum and maize, which are comparatively low in their iron content, but their consumption in large quantities increases the dietary iron content, (Apte, 1970). Apte and NarasingaRao (1971) found that the average iron absorption is 33 per cent from ferrous sulphate, 8.6 per cent from rice and 12.6 per cent from wheat meals.

3. Iron absorption:

Absorption of iron takes place in the form of ferrous iron and the term "available" has been applied to the iron

present in foods which is readily converted to this form. Only about 5 to 10 per cent of the dietary iron is absorbed generally, (Berry, 1967 and WHO, 1968).

The different factors affecting the absorption of iron are:

a. Mucosal factors affecting absorption
b. Role of Phytates
c. Role of Calcium
d. Role of Ascorbic acid
e. Role of Protein

a. <u>Mucosal factors affecting absorption:</u>

The quantity of iron in the body is maintained primarily by the controlled absorption from the duodenum, and to some extent by excretion. In order to maintain the balance, the duodenal mucosa must remain attuned to the body requirements for iron (Conrad, 1967). Hahn (1943) postulated that regulation of iron absorption is accomplished by a mucosal receptor which blocks the absorption of iron when it becomes satiated with iron. The absorption of over doses of iron indicates that this "mucosalblock" can be overwhelmed, (Smith and Pannaccinlli, 1958 and Bothwell and Isaacson, 1962) but does not preclude the existence of a relative block which limits the absorption of excessive dietary iron, Conrad <u>et</u> <u>al</u>, (1964).

b. Role of phytates:

Among the several factors that interfere with the digestion and absorption of food iron, the phosphorus and phytate content of the diet seems to be the most important. The Indian diet based on cereals and pulses contains more than 40 per cent of the total phosphorus as phytin phosphorus, (Patwardhan, 1961). Hussain and Patwardhan (1959) showed that when phytate was added at eight and 40 per cent levels to a well balanced diet, iron absorption was reduced from 20 per cent, to 11 and three per cent respectively. Apte and Venkatachalam (1962) demonstrated the adverse effects of high phytate on the absorption of iron, from a diet containing 20 mg of iron by forming insoluble iron phytate complexes. Apte and Venkatachalam (1962) observed on human subjects that less than one per cent of iron was absorbed from cereal diets containing 40 per cent phytate and providing 16 to 17 mg of iron per day.

c. Role of calcium:

Conflicting views have been expressed in the literature regarding the effect of dietary calcium on iron absorption. The beneficial effect of extra dietary calcium on iron absorption in human beings has been stressed by Gubler (1956)

and Foy and Kondi (1956). They showed that moderate amounts of calcium in the diet had a favourable effect on iron absorption. According to Davis (1959), low intake of calcium would prevent iron absorption from the intestinal tract in experimental animals and cause iron deficiency anaemia.

Woodruff (1961) and Apte and Venkatachalam (1964) found that with an intake of 1000 mg. of calcium and 16.5 mg of iron, the mean absorption of the iron was only four per cent which increased above 16 per cent, when the intake of dietary calcium was raised to 1500 mg/day. The increased level of calcium can be achieved by the addition of calcium rich foods such as green leafy vegetables and milk, (Apte,1970). The beneficial effects of high levels of dietary calcium is probably mediated through the prevention of formation of insoluble iron-phytate complex. These results suggest that the absorption of iron and calcium may depend upon the relative amounts of calcium, iron and phosphates in the diet, (Apte, 1970).

d. Role of ascorbic acid:

Iron must be in the ferrous or reduced state before it can be absorbed by the mucosa of the intestinal tract.

Dietary supplements of vitamin C have been shown to facilitate the process, (Apte and Venkatachalam 1965). From their metabolic studies on human beings, Apte and Venkatachalam observed that supplementation of diets with 100 mg of ascorbic acid increased significantly iron absorption from cereal based diets. Callender (1970) puts forth that ascorbic acid incorporated in therapeutic preparations of the iron, leads to a significant increase of iron level in the patient's blood.

e. Role of protein:

Absorption tests on normal subjects and subjects with iron deficiency anaemia, using ^{59}Fe tagged wheat have shown that wheat iron is available for absorption to a very small extent and the iron deficient subjects did not show the expected increase in absorption of iron, (Hussain et al, 1965). Conrad (1970) points out that protein depletion decreases iron absorption.

4. Utilisation and storage:

The level of iron stores at all times represents a useful measure of iron balance, and storage iron serves as a buffer to protect the body against iron deficiency anaemia, (Routh and Agarwal 1967). Thirty per cent of the body's iron subserves a storage function and is found in

several sites, principally in the liver. This reserve supply of iron does not participate in any biochemical reaction but is available for haemoglobin formation, when required, (Miller,1971). Rose and Hubbel (1938) studied the capacities of male and female rats in retaining iron, and in regenerating haemoglobin. Their results revealed that there is no difference in iron utilisation due to sex.

From their investigations on rats Oldham and Schultz (1940) observed that iron retention increased when the intake was increased from 0.02 mg to 0.32 mg, but when the intake was further increased (above 0.32 mg per day) the retention remained constant.

Elwood (1968) states that the level of circulating haemoglobin is largely dependent on the body content of the iron which ultimately is dependent on the absorption and loss of iron from the body.

5. <u>Excretion:</u>

The human body's capacity to excrete iron is very limited since once iron has been absorbed it remains in the body for prolonged periods and undergoes transformations. Under normal physiological conditions, the loss of body

iron is small. The main route of iron excretion are the skin and gastro-intestinal tract, (Apte, 1970). Many investigators (Hussain et al, 1959, 1960; Moore, 1950, 1961; Dubatch et al 1955; Foy and Kondi, 1957) have reported that iron losses in the range 0.5 mg to 6.5 mg through skin. Apte and Venkatachalam (1962 and 1963) and Apte (1963) carried out several studies to determine the dermal loss of iron in Indians and found that it varied from 0.58 to 3.22 mg/day. Analysis of urine may provide useful information about the dietary intake of nutrients. But in the case of iron the results are very meagre (Wadsworth, 1963), since very few detailed investigations of the normal loss of iron in the human urine, especially, in relation to the diet, have been made.

Radio-active studies using ^{59}Fe, on the total body content combined with faecal collection by Nasser and Baird (1968) have shown that the faecal iron loss is largely in the form of haemoglobin iron. The mean loss in a normal person was found to be 0.23 to 0.46 mg/day.

Taking into consideration the losses through the urine and faeces and individual variabilities the non-haemoglobin loss of iron in Indians has been estimated to be 2 mg by Apte and Venkatachalam (1965), and Apte (1968). In children six to 12 years old, Leifhallberg (1971) has

reported a basal iron loss of 0.65 mg to 0.75 mg per day for boys and 0.65 mg to 0.8 mg for girls.

6. Iron requirement:

The body requires only a small quantity of iron, most of which is found in the RBC, (Pandit, 1963). The growing child must absorb on an average 0.5 milligram of iron daily, in excess of body losses, to fulfil the requirement, (Hawkin et al 1956, Schulman, 1961).

Factors which influence iron requirement in children as described by Leifhallberg (1971) are:

a. Need to cover the losses and growth, that is for expanding the blood volume (Red cell mass) and for supplying the growing organs with iron.

b. Building up iron stores in childhood for future demands, especially, of girls.

c. Total body iron loss and body iron increment.

With these considerations a total requirement of nearly 0.95 mg to 1.6 mg/day was arrived at for children six months to 12 years. The FAO (1957) calculated the iron requirement in terms of calories and reported an intake of 0.45 mg iron/ 1000 calories for an eight year old child. According to the ICMR (1971) the iron requirement of the school going children is 15 to 20 mg/day, whereas the FAO/WHO group (1970) have presented a requirement of only 10 mg per day for children consuming diets which include animal foods contributing 10 per cent of calories.

E. Green Leafy Vegetables as a Source of Iron

Several workers have called attention to the highly nutritious but inexpensive and protective qualities of green leafy vegetables, (Singh and Joshi, 1960; Devadas et al, 1968, 1969, 1970, 1971; Schmidt, 1971).

Green leafy vegetables are protective and regulatory foods (Devadas et al, 1961) because they give:

Calcium to build bones and teeth and thereby promotes growth;

Phosphorus which is required by every cell in the body;

Iron to enable the blood to make red corpuscles;

Other minerals necessary for the growing child and for aiding digestion;

Regulatory factors for the processes such as circulation; assimilation and maintenance of body temperature and alkalinity of blood and other fluids;

The cellulose which help to prevent Constipation, and prevent over eating; and

Vitamin A good for eye.

Thus leafy vegetables constitute one of the best tonics of nature and help children grow with alertness and ability to resist diseases. The use of green leafy vegetables all the year around is a wise practice to secure iron, and other nutrients.

Amaranthus species are one of the annual herbs of the

tropics (Nutrition, 1972). Green leafy vegetables in general are rich sources of iron, calcium, Vitamin A and ascorbic acid (Swaminathan and Bhagavan, 1964; WHO, 1969) and that Amaranthus is a rich source of these minerals and vitamins is evident from the values reported by ICMR (1971). Devadas et al (1969) observed that there is no significant variation in the iron content of the amaranthus during different seasons.

F. Effect of Cooking Utensils on the Iron Content of Vegetables

Lal and Mitra (1952) and Chakravarti and Maiti (1959) reported that iron content of the vegetables increased when cooked in iron vessels. Devadas et al (1965) prepared amaranthus leaves using utensils made of different metal and alloy such as iron pans aluminium and tin coated brass. They found that amaranthus cooked in cast iron pans showed an increase in iron content from 11.32 mg to 110.7 mg/100 g. Sethi et al (1967) also advocates cooking leafy vegetables in iron pans, because of the subsequent increase in the iron content.

G. School Lunch as a Medium for Supplementation of Iron:

Tamilnadu Midday meal scheme provides midday meals to 18.2 Lakhs of pupils, (Government of Tamil Nadu, 1972).

Devadas et al (1965, 1967, 1968, 1969); Devadas and Radharukmani (1966); Kamalanathan et al (1969); Devadas et al (1970), (1971) and Gopalan (1970) have pointed out the beneficial effects of school lunch programme in improving the nutritional status of the children.

Studies by Devadas et al (1968) have shown that green leafy vegetables and fruits are consumed only by 0.5 per cent of the school children. Sundararaj et al (1969) noted that the quantity of leafy vegetables commued by our children is too small to make a significant contribution to their requirement. Saroja (1966) exhorts that green leafy vegetables are one of the richest sources of iron in a high cereal diet. The school meal can thus be made nutritious by including foods to supply protein, vitamin A and minerals such as sprouted green gram, leafy vegetables, carrot, tomato and papaya.

As Apte and Venkatachalam (1962) state only few studies have been carried out in India on the availability of iron from green leafy vegetables. Nirmala et al (1968) have shown that addition of green leafy vegetables can supplement the Indian rice diet for iron and calcium. Kamalanathan et al (1965), Anandam et al (1966) and Devadas et al (1971) have demonstrated that children receiving leafy

vegetables along with school lunch registered significant improvements in growth and nutritional status. Devadas *et al* (1971) noted a significant increase in the haemoglobin and PCV values of a group of elementary school children fed amaranthus along with school lunch diet, when compared to that of a group fed iron tonic instead of amaranthus. Similar findings were also reported by Nirmala *et al* (1968) on pre-adolescent girls.

III. EXPERIMENTAL PROCEDURE

The experimental procedure is discussed under the following headings:

A. Selection of school and children

B. Standardisation of cooking and serving processes

C. Selection and introduction of the supplement

D. Assessment of the nutritional status

A. Selection of School and Children

Sri Avinashilingam Trust Basic Elementary School which has a school lunch programme operating under the Tamil Nadu Mid-day Meals Scheme, was selected for the study because of the willingness and co-operation of the management and authorities.

Out of the 110 children, in the age range five to ten years, who were participating in the mid-day meals programme, 105 children comparable in age, height, weight and haemoglobin level were selected. According to their initial height, weight, haemoglobin level and age, they were divided into three groups with 35 children each. A comparable group of 35 children, who were not participating in the

school lunch programme were selected as the control group.

The groups were designated as:

Group I	..	Control group (Non-school lunch)
Group II	..	Basal diet
Group III	..	Basal diet + Amaranthus cooked in aluminium utensil
Group IV	..	Basal diet + Amaranthus cooked in iron utensil

The mean initial height, weight and haemoglobin levels of the four groups of children are given in Table I with the details for the individual children given in Appendices B, C and D.

TABLE I

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

	Groups	Height cms	Weight kgs.	Haemoglobin levels g/100 ml
I	Control Group	115.67	18.15	11.37
II	Basal diet	115.66	18.10	11.37
III	Basal diet + Amaranthus cooked in aluminium utensil	115.67	18.13	11.37
IV	Basal diet + Amaranthus cooked in iron utensil	115.70	18.20	11.44

B. Standardisation of the Procedures for Cooking and Serving:

1. Planning the basal diet:

The basal diet was formulated on the basis of the following criteria:

a) Meet one-third of the day's recommended allowances suggested for five to 10 year old children by Indian Council of Medical Research (1968).

b) Maintain the cost within ten pase per child per day as stipulated in the Tamil Nadu Mid-day Meal Scheme

c) Provide an attractive, appetising and good nutritious meal

and d) Accommodate the supplements.

The basal diet was common to all the three experimental groups. A week's basal menu, thus planned, is given in Table II.

TABLE II

THE WEEKLY MENU FOR THE SCHOOL LUNCH (BASAL DIET)

DAYS	MENU
MONDAY	Wheat uppuma, Carrot dhal kootu, Tomato salad, C.S.M. Payasam.
TUESDAY	Tamarind rice, Carrot dhal kootu, Tomato salad, CSM Payasam.
WEDNESDAY	Wheat uppuma, Carrot dhal kootu, Tomato salad, CSM Payasam.
THURSDAY	Dhal rice, Carrot dhal kootu, Tomato salad, CSM Payasam.
FRIDAY	Wheat uppuma, Carrot dhal kootu, Tomato salad, CSM Payasam.
SATURDAY	Lime rice, Carrot dhal kootu, Tomato salad, CSM Payasam,

Amaranthus cooked in an aluminium utensil was given to group III and amaranthus cooked in an iron utensil was given to group IV, as supplements.

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

TABLE III

THE COST AND QUANTITIES OF THE FOOD STUFFS USED PER CHILD PER MEAL

No.	Foodstuff	Amount (g)	Cost Rs. ps.
1.	Rice	75	0.09≠
2.	Bulgar wheat	75	Free*
3.	Red gram dhal	20	0.02
4.	Carrot	20	0.01
5.	Tomato	20	
6.	Corn soya Milk (CSM)	30	Free*
7.	Salad oil	10	Free*
8.	Lime	5	0.01
9.	Tamarind	3	
10.	Jaggery	10	0.01

* Supplied free by CARE for the entire programme in Tamil Nadu.

≠ On days when rice formed the basal cereal, the cost of the menu worked out to be 14 paise. But when bulgar wheat was used, the cost of the menu was only 5 paise. Hence, on an average the cost of a day's lunch works out to be 10 paise.

The nutritive value of the basal midday meal as compared to one-third of the recommended allowances, ICMR (1968) is given in Table IV.

TABLE IV

NUTRITIVE VALUE OF BASAL DIET AS COMPARED TO THE RECOMMENDED ALLOWANCES

Particulars	Calories	Protein (g)	Calcium (mg)	Iron (mg)	Retinol (µg)	Thiamine (mg)	Riboflavin (mg)	Ascorbic acid (mg)
1/3rd of the recommended allowances	500 to 600 ie (550)	7 to 11	133 to 166	5 to 7	100 to 200	0.3	0.3 to 0.4	10 to 15
Basal diet	566	14	188	10	237	0.4	0.4	8

The basal diet thus met all the nutrient requirements and the calorie needs for children of five to 10 years of age.

2. Standardisation of cooking and serving:

The recipes for the different items on the school lunch menu were standardised in terms of proportion of ingredients, amount of water used and length of time of cooking. The raw as well as cooked weights of the preparations of the whole lunch were noted. The volumetric equivalents in terms of cups and spoons for a standardised serving of cereal preperation, payasam and vegetable prepration were determined. This facilitated quick serving and controlled the quantity of foods given. Record of attendance at school and at lunch were kept daily by the investigator.

C. Selection and Introduction of Supplements:

The basal diet of the school lunch provided 9.5 mgs of iron. To supplement this iron, amaranthus, a commonly grown leafy vegetable in South India, was selected because of its availability in all seasons. The amaranthus used in this study was cultivated on the same plot, and picked at uniform stage of maturity.

The recommended allowance for greens by ICMR (1968) for a school going child is 75 gs. Therefore half that amount was selected to be given along with the lunch.

Groups III and IV were given the same amount of amaranthus, but cooked in aluminium and iron utensils respectively. The basal group was given the basal lunch alone. The amaranthus in the raw form and as cooked in alumium and iron utensils was analysed for its iron, calcium (AOAC, 1960) and ascorbic acid (Hawk et al 1965) contents.

D. Assessment of the Nutritional Status of the Children

The nutritional status of the children was assessed by the following methods:

1. Anthropometric measurements.
2. Estimation of the haemoglobin level.
3. Clinical picture.
4. Food consumption pattern and analysis of nutrients.

1. Anthropometric measurements:

Grading the rate of growth on the basis of age, height and weight is one of the means to arrive at the nutritional status, (Bhalekar and Phadnis, 1966). Hence these measurements were used as one of the criteria for evaluation of nutritional status in this study.

a. Height:

A stadiometer was used for the purposes. The subjeet was made to stand on the platform errect, with heels together, legs and neck straight and eyes horizontal. Then, the horizontal lever was lowered so as to rest firmly on the crown of the head (Jelliffe, 1966 and WHO, 1969). Thereafter, height was recorded to the nearest centimetre. This measurement was done every month.

b. Weight:

The subjects were weighed every month between 9 AM and 12 AM, with recently emptied bladder and having minimum clothing with no shoes and sock, (WHO, 1969). The weights were recorded to the nearest 0.5 kg.

2. Estimation of the haemoglobin level:

Haemoglobin determination was carried out every month by the cyanmeth haemoglobin method, (Varley, 1968).

3. Clinical picture:

Clinical examinations were done in the beginning and end of the experimental period using the ICMR schedule.

4. **Food consumption pattern and analysis of the nutrients:**

a. **Food consumption pattern:**

To obtain the food consumption pattern at home and to assess the contribution of home lunch, a threeday weighment survey, which is considered as the most reliable method by many authors (Swaminathan et al, 1966; WHO, 1966; Devadas, 1970; Miller, 1970) was conducted. From each group, five children were selected randomly using the random table. For the weighment, the home of each subject was visited during his/her meal hours (Breakfast, lunch, tea and dinner) and the foods eaten were weighed and recorded. Care was taken to record also the foods eaten from external sources by the children if any. One-tenth of the total food consumed at each meal was collected, and preserved for analysis. The midday meals eaten at school was also collected separately for analysis, and this formed the intake at lunch for children participating in the school lunch programme.

b. **Analysis of nutrients:**

The food thus collected was homogenised everyday, five gram aliquots were taken and estimated for ascorbic acid content daily by the method of Hawk et al (1965) to minimise the vitamin loss during storage. The homogenised sample was digested and analysed for protein,(Hawk et al method 1965

modified by NIN), calcium and iron (AOAC, 1960). The basal midday meal collected from the school was also analysed for ascorbic acid, protein, calcium andiron using the same procedures.

IV. RESULTS AND DISCUSSION

The results of the present investigation on the availability of iron to school children, from amaranthus cooked in two different utensils are presented and discussed in the following order:

A. Effect of different cooking utensils on the iron, calcium and ascorbic acid content of amaranthus.

B. Food consumption pattern of the children.

C. Nutritional status of the children.

1. Height
2. Weight
3. Haemoglobin levels
4. Clinical examination

A. Effect of Different Cooking Utensils on the Iron, Calcium and Ascorbic Acid Content of Amaranthus

The amaranthus used for the supplementation was analysed for iron, calcium and ascorbic acid in the raw stage as well as after cooking in two different utensils made of iron and aluminium. Table V gives the data thus obtained. The replicate values obtained for the analysis are given in Appendix A.

TABLE V

MEAN IRON, CALCIUM AND ASCORBIC ACID CONTENT OF RAW AND COOKED AMARANTHUS

Nutrients	Variations			Sources of Comparison	't' value
	Raw (U)	Cooked in Aluminium Utensil (A)	Cooked in iron Utensil (I)		
Iron(mg)	25	23	118	U Vs A	1.81
				U Vs I	90.29**
				A Vs I	96.26**
Calcium(mg)	390	383	385	U Vs A	1.79
				U Vs I	1.25
				A Vs I	0.39
Ascorbic acid(mg)	96	39	54	U Vs A	18.85**
				U Vs I	14.54**
				A Vs I	7.24*

* Significant at 5 per cent level
** Significant at 1 per cent level

1. Iron:

The iron content of raw amaranthus was 25 mg/100 gm. The value reported by Gopalan et al (1971) is 25.5 mg/100 g. When cooked in an aluminium utensil the iron content was reduced to 23 mg/100 g. This may be due to the possible oxidation of iron, while in the case of amaranthus cooked in the iron utensil, there was a big increase in iron content of 118 mg/100g.

This increase is comparable to that reported by Devadas et al (1965). Similar trials in increases due to cooking in iron utensils have been reported also by Lal and Mitra (1952) and Chakravarthi and Maiti (1959). The statistical treatment indicated that the loss of iron due to cooking in aluminium utensil was not significant when compared with the raw sample. On the other hand, the increase in iron content of amaranthus due to cooking in iron utensil was highly significant ($P < 0.01$) when compared with the raw sample or the sample cooked in the aluminium utensil.

2. Calcium:

The analysis of raw sample ~~cooked~~ showed that the calcium content of amaranthus was 390 mg/100 g. During cooking there was a slight reduction in the calcium content. The calcium content of the amaranthus cooked in the iron utensil was 385 mg, while that cooked in the aluminium utensil registered 383 mg.

The differences between the raw and cooked samples however were not statistically significant. Hence the cooking losses in calcium is negligible and the utensil in which it is cooked does not have any effect on the calcium content of amaranthus.

3. <u>Ascorbic acid:</u>

Ascorbic acid is a thermolabile nutrient. Ascorbic acid content of amaranthus as reported by ICMR (1971) is 99 mg/100 g of the sample. Amaranthus used in the present study had an ascorbic acid content of 96 mg/100 g in the raw stage, cooking seemed to cause a great degree of destruction of this nutrient. Pasricha (1967) also reported the same result. This loss was lesser in the case of amaranthus cooked in iron utensil 44 per cent) whereas the loss was 59 per cent when cooked in the aluminium utensil.

Statistical treatment showed that the loss of ascorbic acid between the raw and the cooked sample (cooked both in iron and aluminmium utensils), were highly significant at one per cent level. While comparing the efficiency of the two utensils in minimising the loss of ascorbic acid due to cooking it was found that cooking in iron utensils preserved the ascorbic acid content to a greater extent and the differences between the utensils in that respect was significant at five per cent level.

B. Food Consumption Pattern of the Children:

All the children, except those in the control group, received lunch in the school and consumed the rest of the meals in their homes. The contribution of the home diet to the food consumption pattern of the children was assessed by analysing the nutrient content of the home diet of five randomly selected subjects from each group. The nutrient intake thus obtained was added to the intake through the school lunch which was also collected and analysed to arrive at the food consumption pattern of the school lunch children. In the case of the children in the control group who were not participating in the midday meals, their home lunches were collected and analysed, and added to the home intake for the day.

The average protein, calcium, iron and ascorbic acid content as analysed and the calculated calories, of the basal school lunch and the supplement were added to the nutrient intake from home diets, to arrive at the food consumption pattern of the children and the results are presented in Table VI.

TABLE VI

MEAN INTAKE OF CALORIES, PROTEIN, CALCIUM, IRON AND ASCORBIC ACID

Group No		Calories (k.cal)			Protein (g)			Calcium (mg)			Iron (mg)			Ascorbic Acid (mg)		
		Home diet	School lunch	Total	Home diet	School lunch	Total	Home diet	School lunch	Total	Home Diet	School lunch	Total	Home diet	School lunch	Total
I	Control group (non school lunch)	1400	-	1400	15	-	15	199	-	199	11	-	11	12	-	12
II	Basal diet	1092	747	1839	11	17	28	190	192	382	11	10	21	12	5	17
III	Basal diet + Amaranthus cooked in aluminium utensil	1220	757	1977	13	18	31	216	195+ 119 (a)	530	12	11+ 7 (a)	30	16	5+12 (a)	33
IV	Basal diet + Amaranthus cooked in iron utensil	1150	755	1905	11	17	28	174	194+ 120 (a)	488	11	11+ 37 (a)	59	13	5+17 (a)	35
	Recommended allowance		1500 to 1800			22 to 33			400 to 500			15 to 20			30 to 50	

(a) = additional nutrients due to Amaranth supplementation

1. Calories:

The calorie intake of the groups ranged from 1400 k.cal to 1977 k. cal. Children in the school lunch groups recived adequate amounts of calories, comparable to the allowance recommended by the ICMR (1971). Children in the control group who were not receiving school lunch were found to be inadequate in their calorie intake. The highest calorie intake was shown by the group III, receiving amaranthus cooked in aluminium utensil used as supplement, when compared to the other groups and the minimum by the control group (1440 K cal). These findings are in line with those reported by Devadas et al (1969) and Gopalan et al (1971) that the diets of school children are inadequate in calories and protein.

2. Protein:

The total protein intake of the groups ranged from 15 to 31 g. The contribution of the home diet to the protein intake of all the children was low. The additional protein supplied by the school lunch fulfilled the requirement of protein (ICMR 1971), for groups II, III and IV. The weighment survey revealed that the major part of the protein, the children got through the home diet was cereal based. Similar findings have been reported by Narayana Rao et al (1963), Swaminathan et al (1971), Devadas et al (1969).

The highest intake of protein was recorded by the children in Group III receiving amaranthus cooked in aluminium utensil as the supplement. Group IV ranked second in protein intake. The protein content of the diets of children in the control group (Non school lunch) was the least.

3. Calcium:

The home diets provided 174 to 216 mg of calcium daily. Analysis of the intake from school lunch showed that it provided 192 - 195 mg of calcium. In the case of amaranthus supplemented groups III and IV there was an extra intake of 119 - 120 mg of calcium. Thus, the intake of calcium varied from 199 mg to 530 mg daily. Here also Group III was found to be receiving the highest quantity. The weighment survey revealed that cereals were the main source of calcium in the home diets.

It was observed that the children receiving amaranthus as supplement had an adequate intake of calcium as recommended by ICMR (1971). The children in the school lunch alone fell short of the calcium requirement by 4.5 per cent, whereas children in the homelunch group had a very low intake of calcium amounting to 199 mgs. It was approximately only half the daily requirement.

4. Iron:

The collection and analysis of home diets indicated that the iron intake of children through the home diet ranged from 11 to 12 mg. The intake from the school lunch alone (as analysed) ranged from 10 to 11 mg. Amaranthus supplementation further increased the intakes of iron by adding 7 mg of extra iron for group III (amaranthus cooked in aluminium utensil) and 37 mg of extra iron for Group IV (amaranthus cooked in iron utensil).

Hence Group IV was receiving the highest amount (59 mg) amounting to be more than double the requirement, (ICMR, 1971) with the same amount of greens as supplemented for Group III. Group III ranked second in its iron and the non school lunch group of children had the minimum iron intake.

5. Ascorbic acid:

The total intake of ascorbic acid by the four groups of children ranged from 12 to 35 mg per day. The contribution of home diets to the ascorbic acid content of the diet was meagre (12 to 16 mg). The highest intake was registered by children in group IV who received amaranthus cooked in iron utensils as a supplement and this is due to the fact that cooking loss of ascorbic acid was less in the iron utensil (Table V). Group III

ranked next in ascorbic acid intake, while Group I had the least intake. The intakes of Groups III and IV met the recommended allowances (ICMR, 1971) whereas those of groups I and II fell short of the requirements by 60 per cent and 43 per cent respectively.

C. Nutritional Status of the Children

1. Height:

The mean increase in height of the four groups of children along with the statistical treatment is given in Table VII. The monthly heights of these children taken during the seven months of the experimental period is given in Appendix B.

TABLE VII

MEAN INCREASE IN HEIGHTS OF CHILDREN IN THE FOUR GROUPS

Groups	Diet and supplements	Height in centimeters			Source of comparison	't' value
		Initial mean	Final mean	Mean difference		
I	Control group (non school lunch)	115.69 ± [a] 1.26	118.93 ± 1.31	3.24 ± 0.93	GI Vs GII	0.61
II	Basal diet	115.82 ± 1.62	119.66 ± 1.64	3.84 ± 0.03	GI Vs GIII GI Vs GIV	0.85 0.37
III	Basal diet + Amaranthus cooked in aluminium utensil	115.80 ± 1.51	119.90 ± 1.50	4.10 ± 0.09	GII Vs GIII GII Vs GIV GIII Vs GIV	0.76 0.48 0.92
IV	Basal diet + Amaranthus cooked in iron utensil	115.76 ± 1.80	119.39 ± 2.74	3.63 ± 0.17		

a = Standard error of the mean

The mean height of the children in all the four groups registered an increase. When compared with the control group (GI) the children in the other groups (GII, GIII and GIV) had greater increases in the heights, with the highest increase registered by children in group III. This may partly be due to the higher intake of calcium protein and calories. (Table VI).

These differences in heights between the groups, however were not statistically significant. The greater increase evidenced by the children participating in the school lunch programme may be partly due to the effect of the nutritionally adequate lunch provided for them.

2. Weight:

The mean increase in the weight of the children in the four groups along with their statistical analysis are presented in Table VIII. The individual monthly weights are given in Appendix C.

TABLE VIII

MEAN INCREASE IN WEIGHTS OF CHILDREN IN THE FOUR GROUPS

Groups	Diet and Supplements	Weight in Kilogram			Sources of comparison	't' value
		Initial Mean	Final Mean	Mean difference		
I	Control group (non school lunch)	18.16[a] ± 0.48	19.56 ± 0.54	1.40 ± 0.02	G I Vs G II G I Vs G III G I Vs G IV	2.14* 4.65** 7.06**
II	Basal diet	18.10 ± 0.60	19.97 ± 0.75	1.87 ± 0.03	G II Vs G III G II Vs G IV	2.00* 3.48*
III	Basal diet + Amaranthus cooked in aluminium utensil	18.12 ± 0.55	20.46 ± 0.56	2.33 ± 0.02	G III Vs G IV	1.89
IV	Basal diet + Amaranthus cooked in iron utensil	18.20 ± 0.30	20.87 ± 0.62	2.67 ± 0.01		

* = Significant at 5 per cent level

** = Significant at 1 per cent level

a = Standard error of the mean

An increase in weight was registered by all the four groups. The heighest increase was registered by children in group IV, Groups III and II ranking next inorder respectively.

The results of the statistical anaysis indicated that the differences in weight registered in Groups IV and III (children supplemented with greens) were significantly higher than that of GI (non school lunch group) at one per cent level, where as the difference between the groups GI and GII was significant at five per cent level. The differences between groups II and III; and Groups II and IV were also significant at five per cent level. The difference in weight between groups III and IV however, was not statistically significant.

These results indicate the beneficial effects of the school lunch and the possible enhancement of utilisation of protein by iron from amaranthus. When co-related with the nutrient intake also, it is evident that children in Group I, had an inadequate calorie and protein intake along with calcium and ascorbic acid. Children in Groups II, III and IV had an enhanced intake of calories and protein and they were also receiving a nutritionally adequate lunch at school. This adequate intake of calories along with other essential nutrients might be the contributory factor for the better growth pattern of children in the school lunch groups. As reported by

many workers, only if the calorific intake is adequate, protein and other nutrients will be utilized for body building purposes (Swaminathan, 1968, Narasinga Rao, 1969 and Sukhatme, 1970).

3. **Haemoglobin level:**

The mean increases in the haemoglobin levels of all the four groups of children with the statistical treatment is given in Table IX and monthly record is given in Appendix D.

TABLE IX

MEAN INCREASES IN THE HEAMOGLOBIN LEVELS

Groups	Diet and supplements	Haemoglobin level (g/100 ml) Initial mean	Final mean	Mean difference	Sources of comparison	't' value
I	Control group (non school lunch)	11.37 ±[a] 0.20	11.49 ± 0.20	0.12 ± 0.001	GI Vs GII GI Vs GIII GI Vs GIV	5.60** 11.00** 17.40**
II	Basal diet	11.37 ± 0.18	12.05 ± 0.18	0.68 ± 0.01	GII Vs GIII GII Vs GIV	3.60** 7.87**
III	Basal diet + Amaranthus cooked in aluminium utensil	11.37 ± 0.20	12.59 ± 0.15	1.22 ± 0.01	GIII Vs GIV	4.27**
IV	Basal diet + Amaranthus cooked in iron utensil	11.44 ± 0.15	13.30 ± 0.10	1.86 ± 0.012		

** = Significant at 1 per cent level
a = Standard error of the mean

The mean haemoglobin level for all the four groups of children had increased. Children in Group IV had the maximum increase (1.86 $\pm$ 0.012) in haemoglobin level. Group III ranked next (1.22 $\pm$ 0.01) followed by Group II (0.68 $\pm$ 0.01). The least increase in haemoglobin level was shown by the control group GI (0.12 $\pm$ 0.001). The mean increases in the haemoglobin levels of the four groups of children is graphically represented in Fig. 1.

The statistical analysis of the data indicated that the differences in the increase in the haemoglobin level between the four groups were highly significant ($P < 0.01$). When the non school lunch group was compared with Groups II, III and IV the differences were significant at one per cent level. This may well be correlated with the food and nutrient intake of these groups, of children. Children in the school lunch groups were receiving adequate quantities of protein of a good quality and as reported by Klavins et al (1962) Reissman (1964) and Abernathy et al (1965) good quality protein provided in adequate amounts, enhances iron absorption.

Children in groups III and IV were also receiving amaranthus as supplements, providing 7 mg and 37 mg of extra iron respectively. Along with excess amount of iron supplied by amaranthus, it may also be mentioned that amaranthus is also a good source of calcium and ascorbic acid which has

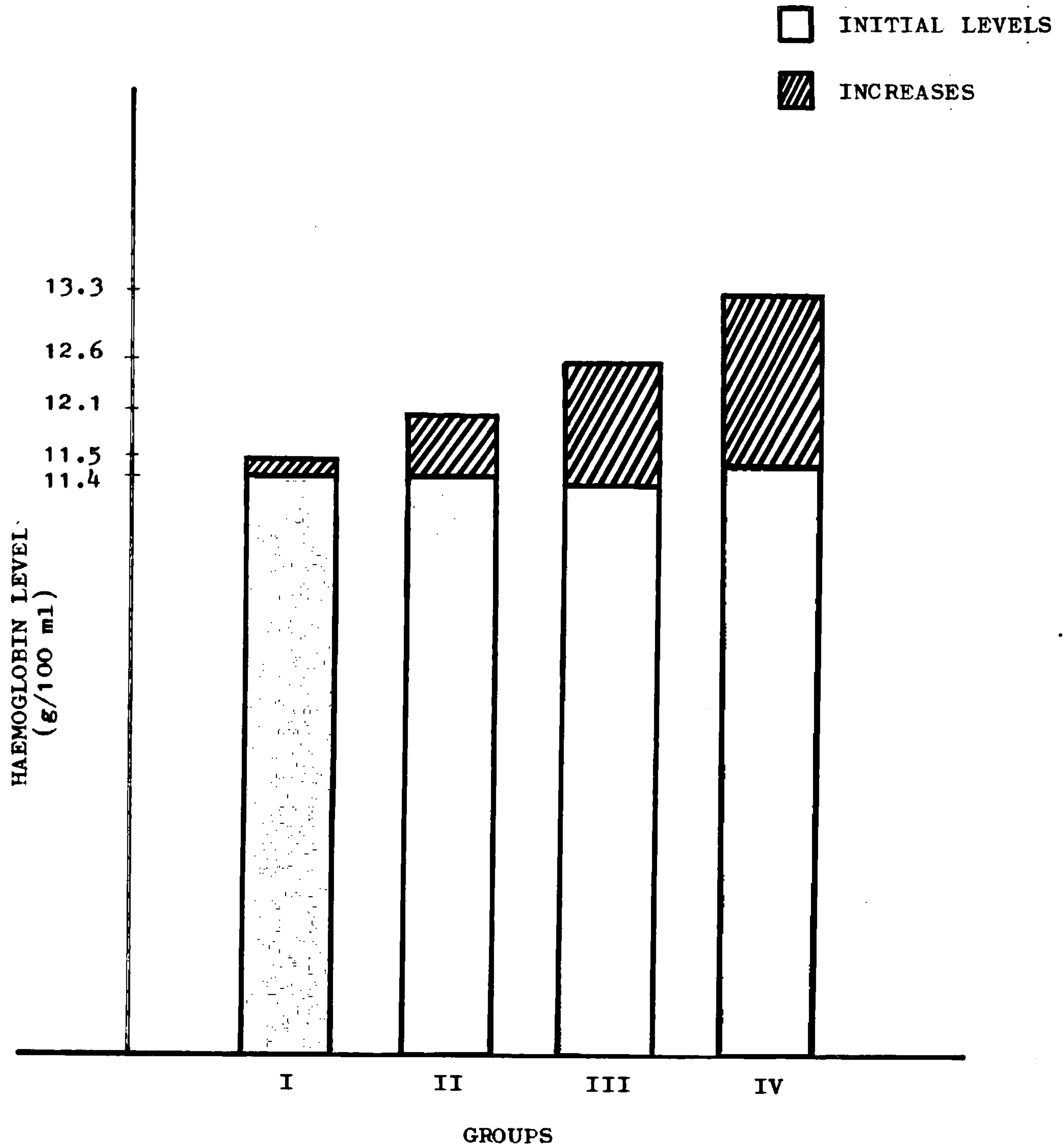


Figure - 1

MEAN HAEMOGLOBIN LEVELS OF THE CHILDREN IN THE FOUR GROUPS

a beneficial effect on iron absorption and utilisation as stressed by Guha (1956), Foy and Kondi (1956), Nasser and Platt (1968), Callender (1970), Apte (1970) and Devadas *et al* (1971). The phytate content of amaranthus is also less than that in cereals (Gopalan *et al*, 1971). That phytates interfere with the absorption of iron especially in cereal based diets has been stressed by many workers (Apte and Venkatachalam, 1962, 1964). In case of Group IV another contributory factor favourable to the utilisation of iron is that as indicated earlier (Table V) the loss of ascorbic acid was less when cooked in the iron utensil and ascorbic acid provides a favourable medium for the maximum absorption of iron from the gut, (Apte and Venkatachalam, 1965 and Callender, 1970).

The extra amount of calories, protein and calcium provided by the diets might also have had a beneficial effect in improving the iron nutritional status as indicated by their haemoglobin picture. It is commendable that because of the synergistic effect of the higher quantities of iron, calcium and ascorbic acid furnished by the amaranthus cooked in iron utensil with the adequate protein and calorie intake resulted in the best blood picture among the four group of children. It is also notable that the iron gained by cooking in iron utensil has been found to be utilisable as indicated by the haemoglobin picture.

4. Clinical examination:

The clinical examination carried out on all the children at the beginning and end of the experimental period, showed no signs of clinical manifestations either in the beginning or at the end of the investigation.

V. SUMMARY AND CONCLUSION

This study on the availability to the school children, of iron from amaranthus cooked in two different utensils was conducted for a period of seven months. The children participating in the school lunch programme were grouped into three groups of 35 children each. They were comparable in age, height, weight and haemoglobin levels. Another group of 35 children who were not participating in the school lunch programme formed the control group. The groups were designated as:

Group I	..	Control group (Non school lunch)
Group II	..	Basal diet
Group III	..	Basal diet + Amaranthus cooked in aluminium utensil
Group IV	..	Basal diet + Amaranthus cooked in iron utensil

The basal school lunch was planned to provide one third of the day's allowances recommended by ICMR (1971) for children of this age group, and to accommodate the iron supplement.

Half the daily requirement of green leafy vegetable recommended by the ICMR (1971) was supplemented to Groups III and IV. Group III was given amaranthus cooked in aluminium utensil and Group IV, the same amount of amaranthus cooked in iron utensil.

The analysis of the amaranthus for its iron, calcium and ascorbic acid content showed that the iron content increased to 118 mg/100 g (from 25 mg/100 g in the raw state) when cooked in iron utensil, whereas when cooked in an aluminium utensil the value obtained was 23 mg/100 g. This increase in the iron content, when cooked in the iron utensil was significant at one per cent level. The cooking loss in ascorbic acid was also significantly ($P > 0.01$) less when cooked in the iron utensil (44 per cent) as compared to that cooked in the aluminium utensil (59 per cent). The value obtained for calcium did not show any difference due to cooking, or due to utensil.

The height, weight and haemoglobin levels of the children were recorded every month. The food consumption pattern of the children was also assessed through a three-day weighment survey. The results of the study revealed that:

1. The day's intake of calories ranged from 1400 (GI) to 1977 (G III); protein from 15 g (G I) to 31 g (G III); calcium from 199 mg (G I) to 530 mg (G III); iron from 11 mg (G I) to 59 mg (G IV) and ascorbic acid 12 mg (G I) to 35 mg (G IV). The intakes of calories, protein and iron were adequate for all the groups of children participating in the school lunch when compared with the allowances recommended by ICMR (1971). But the intake of calcium and ascorbic acid was adequate only for the children receiving amaranthus as supplement, whereas for group GII, it fell short of the recommended figure mainly because the home diets were deficient in these nutrients. For the control group intake of all the nutrients fell short of the recommended allowances.

2. Children in all the four groups registered increases in height typical of this age group of children and the mean increase ranged from 3.24 ± 0.93 cm (G I) to 4.01 ± 0.09 cm (G III). The mean differences in heights however were not statistically significant.

3. The increase in weights ranged from 1.40 ± 0.02 kg (G I) to 2.67 ± 0.01 kg (G IV). The children participating in the school lunch programme had a significantly higher weight increase when compared to the non-school lunch group. The difference between G I and G II was significant at five per cent level, whereas those between GI and GIII, and GI and G IV were significant at one per cent level. The difference between the basal group (G II) and that of amaranthus supplemented groups(GIII AND G IV) was also significant at five per cent level. The differences between G III and G IV, however, was not significant.

4. The mean increase in the haemoglobin levels, registered by groups G I, G II, G III and G IV were 0.12, 0.68, 1.22 and 1.86 g/100 ml respectively. The highest increase as recorded by group G IV (amaranthus cooked in iron utensil) was significantly greater ($P < 0.01$) than that of all the other groups. The increases in the haemoglobin lwvel recorded by groups of children (GII, G III and G IV) participating in the school lunch was significantly higher ($P < 0.01$) than that of the children belonging to the non-school lunch group. The fact that the differenco in the haemoglobin level between G II and G III; and G II and G IV was also significant at one per cent level indicated that the supplementation of amaranthus improved the blood picture considerably.

5. The clinical examination conducted at the beginning and end of the study did not reveal any deficiency signs.

Thus <u>Amaranthus flavus</u> improved the nutritional status of the primary school children. The beneficial effect of the school lunch is also reiterated. The fact that children receiving amaranthus cooked in an iron utensil had the highest increase in the haemoglobin level indicates, the possible

utilisation of iron obtained from the iron utensil. Apart from the iron *per se*, the calcium and ascorbic acid supplied simultaneously must had a beneficial effect on iron utilisation.

Children in the school lunch group were also receiving adequate amounts of calories and good quality protein, which might have had a synergistie effect on iron utilisation. In addition of being a good source of iron, calcium and ascorbic acid *Amaranthus flavus* is also a rich source of vitamin A. Hence, from the utilisation point of view, the availability of iron along with other nutrients from amaranthus, is of great significance. Cooking in an iron utensil further improve the iron availability. This finding is of great practical value.

It would be interesting to study the possibility of iron utilisation from other foods cooked in iron utensils. Further studies with labelled iron are recommended to throw more light on the mechanism of iron utilisation under these circumstances.

LITERATURE CITED

Abernathy, R.P., Miller, J., Went Worth, J., and Speirs, H. (1965).Effects of Amount and Sources of Dietary Protein on Absorption of Iron. Journal of Nutrition, 85, p. 87.

Anandam, K., Susheela, A., and Devadas, R.P.(1965)."Efeect of incorporation of leafy vegetables and non-leafy vegetable in the School Lunch on the growth and nutritional status of children". Journal of Nutrition and Dietetics, 2, pp. 202 - 205.

AOAC.(1960). "Official Methods of Analysis". Medical Association of Official Agricultural Chemists, Washington, D.C.

Apte, S.V. and Venkatachalam, P.S.(1962) "Iron Absorption in Human Volunteers using High phytate Cereal Diet". Indian Journal of Medical Research, 50, p. 516.

Apte, S.V. and Venkatachalam, P.S.(1962) "Factors Influencing Dermal loss of Iron in Human Volunteers". Indian Journal of Medical Research, 50, p. 817.

Apte, S.V.(1963) "Dermal Loss of Iron in Indian adults". Indian Journal of Medical Research, 51, p. 1101.

Apte, S.V. and Venkatachalam, P.S. (1963). "Iron Losses in Indian Women". Indian Journal of Medical Research 51, pp. 958 - 962.

Apte, S.V. and Venkatachalam,PS(1964). "The Influence of Dietary Calcium on Absorption of Iron". Indian Journal of Medical Research, 52, p. 213.

Apte, S.V. and Venkatachalam,PS(1965). "The effect of Ascorbic acid on the absorption of iron". Indian Journal of Medical Research, 53, p. 1084.

Apte, S.V. (1968). "Iron Nutrition and Requirements". Proceedings of Nutrition Society of India, 2, pp. 46 - 66.

Apte, S.V. (1970), "Studies on Iron Metabolism". A Decade of Progress, National Institute of Nutriton, p. 103.

Apte, S.V. (1971). "Observations on iron Requirement". Proceedings of Nutrition Society of India, 10, p. 49.

Apte, S.V. and Narasinga Rao (1971). "The Absorption of Iron from Rice and Wheat". First Asian Congress of Nutrition Abstracts, p. 87.

Aykroyd, W.R. (1948). "Note on the Results of Diet Surveys" Indian Research Fund Association Special Report, No. 16, New Delhi.

Badenoch, I. and Callender, S.T. (1954). "Iron Metabolism in Steatorrhea; The use of Radio Active iron in Studies of Absorption and utilisation". Blood, 9, p. 123.

Bailur, A. (1970), "Studies on Nutrition of preschool children" A Decade of progress, National Institute of Nutrition, p. 40.

Banerji, L., Sood, S.K. and Ramalingaswamy, V. (1968). "Geographic pathology of iron deficiency with special reference to India (I) Hito chemical quantitation of iron stores in population Group". American Journal of Clinical Nutrition, 21, pp. 1139 - 1148.

Bhalekar, K. and Phadnis, L. (1965). "Standard Height, Weight Survey". Indian Journal of Home Science, 1, pp. 26 - 29.

Berry, W.T.C. and Williams, M. (1967). "Iron Deficiency Anaemia". Review of Nutrition and Food Science, 6, pp. 11 - 15.

Boerma, A.H. (1971), "Keynote Address to the First Asian Congress of Nutrition". Nutrition News Letter, 9, pp. 1 - 7.

Bothwell, T.H. and Issaacson, C. (1962). "Siderosis in the Bantu". British Medical Journal, 1, p. 522.

Burman, N.N., Sehgal, A.K., Chakravarti, R.N., Sodhi, J.S., and Chhuttani, P.N. (1970). "Morphological and Absorption Studies of Small Intestine in Hook Worm Infestation". Indian Journal of Medical Research, 58, p. 317.

Callender, S.T., Mallett, B.J., and Smith, M.D. (1962). "Absorption of Haemoglobin iron". J. Clin. Invest. 4, p. 1897.

Callender, S.T. (1970). "Annotation - Oral Iron Therapy". British Journal of Haemotology, 18, p. 123.

Candau, M.G. (1971). "Socio Economic Development". WHO Chronicle, 25, pp. 441 - 444.

Carter, G. (1968). "The Right to Health, Meeting the Challenge in India". The Children's Annual, pp. 40 - 42.

Chakravarti, R.N. and Maiti, P.C. (1959). "Analysis of Some Cooked Diets - Bengali". Indian Medical Gazette, LLVIII, pp. 626 - 638.

Chandra, R.K. (1965). "Iron deficiency Anaemia in Infant and Children". Indian Journal of Pediatrics, 32, pp. 20 - 22.

Chandran, S., Ghosh, P., and Tapasuri, P. (1966). "Anthropometric, Haematological and Biochemical Study of Indian School Children of two Communities in Culcutta". Indian Pediatrics, 3, pp. 217 - 220.

Chatterjee, J.B. (1967). "Some Aspects of Nutritional Anemia In India". Proceedings of the Nutrition Society of India, 2, p. 67.

Coimbatore District Secondary Medical Aid Committee. (1971). "Second Annual Report 1970 - 1971". pp. 6, 7.

Conrad, M.E. (1962), "Iron Kinetic in Laenneis Cirrhosis". Gestroentikology, 43, p. 385.

Conrad, M.E., Weinteraub, L.R. and Crosby, W.H. (1964). "The Role of the Intestine in Iron Kinetics". J. Clin. Invest., 43, p. 963.

Conrad, M.E., (1966). "Polymerisation and Intraluminal factors in the Absorption of Haemoglobin Iron". J. Lab. Clin. Med., 68, p. 659.

Conrad, M.E. (1967). "Iron Balance and Iron Deficiency Status". Borden's Review of Nutrition Research, 20, pp. 49 - 63.

Conrad, M.E., Williams, H.L. and Knsope, W.H. (1970). "Effect of starvation and Protein Depletion upon Ferrokinetics and iron Absorption". American Journal of Physiology, 65, p. 112.

Cravioto, J. (1970), "Brains trust on nutrition". Nutrition, 4, p. 26.

Cravioto, J., Elsar Delocardie, Carmen Pine Ro, Martha Lindoro, Margarita Arroro and Emma Alcalde. (1971). "Mental development and Malnutrition Neurointegrative Development and Intelligence in School Children Recovered from Malnutrition in Infancy". Proceedings of the Nutrition Society of India, 10, p. 197.

Cravioto, J. (1970). "1969-70 Report". The Nutrition Foundation INC, Ninety Nine Park Avenue, New York, p. 27.

Crosby, W.H. (1958). "The Partial Masking of Anaemia by Contracted Blood Volume". UA Armed Forces Medical Journal, 10, p. 1456.

Davis, G.K. (1959). "Effect of High Calcium Intake on the Absorption of Other Nutrients". Fed-Pro, 18, pp. 1119 - 1123.

Devadas, R.P. (1961). Why Leafy Vegetables ?" Home Science Series, 4, pp. 1 - 23.

Devadas, R.P. Rohini Sambamurthy, Devadas, M.V., Mira Bai, R., and Radharukmani, A. (1964). "A Dietary and Nutritional Survey of a Small Village Community in South India, Journal of Nutrition and Dietetics, 1, p. 110.

Devadas, R.P., Mangala, G., Babtiwala, and Chandrasekaran. (1965). "Iron and Organoleptic Acceptability of Amaranth Leaves Cooked in Iron, Aluminium and Brass Vessels". Journal of Nutrition and Dietetics, 2, p. 88.

Devadas, R.P. (1965). "Some Nutritional Problems in Rural India". The Home Maker, p. 4.

Devadas, R.P. and Radharukmani, A. (1966). "The School Lunch Programme Organisation and Outcome". Ministry of Education, Government of India, p. 29.

Devadas, R.P., Girija Bai, R., Nirmala, P.S. (1968). "Diet and Eating Practices of School Children in Coimbatore". Indian Journal of Pediatrics, 25, pp. 350 - 355.

Devadas, R.P. and Parvathi Easwaran. (1968). "Eating Habits of School Children in A Village Community". Indian Journal of Home Science, 2, pp. 13 - 16.

Devadas, R.P., Anuradha, V., and Usha Chandrasekar. (1969). "Seasonal Variation in the Nutrient Content of Amaranthus Flavus". Indian Journal of Nutrition and Dietetics, 6, p. 305.

Devadas, R.P., Sundari, K., and Susheela, P. (1969). "Effect of Supplementation of Two School Lunch Programmes with Neera on the Nutritional Status of Children. Indian Journal of Nutrition and Dietetics, 6, p. 29.

Devadas, R.P., Prema, C.B., Kamala, R., and Vimalakumari, N.K. (1969). "Annual Report of ICMR Project for the Period of April 1968 to March 1969.

Devadas, R.P., Sundari, K., Jayalakshmi, V.A., Mathews, L., Rehuma Begum, Punithavathi, V.V., Usha, M.S. Usha Chandrasekhar. (1969). "Impact of Nutrition Education Programme Conducted on the Basis of Findings of a Diet and Food Consumption Survey in a Small Village Community in South India". Journal of Nutrition and Dietetics, 6, p. 115.

Devadas, R.P., Premakumari, S., Girija, M.S. and Lata, K. (1970). Annual Report of ICMR Project for the Period of April 1969 to March, 1970.

Devadas,R.P., Rama, K.R. and Premakumari, S. (1971). "Protein Intake and Mental Abilities of Selected Rural Preschool Children". Indian Journal of Nutrition and Dietetics , 8, p. 235.

Devadas, R.P. (1970), "Social and Cultural Factors Influencing Malnutrition". Journal of Home Economics, 62, pp. 164 - 170.

Devadas, R.P., Usha Chandrasekhar and Premakumari, S. (1971). "The Availability of Iron from Green Leafy Vegetables as Compared to Iron Salts for School Children". First Asian Congress of Nutrition - Abstracts, p. 88.

Devadas, R.P., Suchetha, P., Omana, P. and Roshanara Begum, S. 1971) "Annual Report of ICMR Project for the Period April, 1970 to March, 1971.

Devadas, R.P., Suchetha, P., and Sundari, K. (1971). "The Effect of Supplementation of a Rural School Lunch Programme with Green Leafy Vegetables on the Nutritional Status of Children". The Indian Journal of Nutrition and Dietetics, 8, p. 198.

Devadas, R.P., Baby Anuradha, J.R. and Sharadambal, B. (1971). "Evaluation of an Applied Nutrition Feeding Programme on the Nutritional Status of Nursing Women". Indian Journal of Nutrition and Dietetics, 8, p. 143.

Dhar, B.N. (1971). "Tackling Malnutrition among Pre-school Children" Social Welfare, Vol. XVIII No. 6, pp. 13-15.

Dhar, K.N., Agarwal, K.N., Tanja, P.N., and Gupta, S. (1969) "Iron Deficiency Anaemia in Children". Indian Journal of Pediatrics, 36, pp. 436 - 441.

Dubatch, R., Moore, C.V., and Callender, S. (1955). "Studies in Iron Transportation and Metabolism". J. Lab. Clin. Med., 45, pp. 599 - 615.

Endozein, J.C. and Rahim Khan, M.A. (1968). "Anaemia in Protein Malnutrition". Clinical Science, 34, pp. 315 - 326.

Elwood, P.C. (1965). "Availability of Minerals in Food of Plant Origin". Proceedings of the Nutrition Society of India, 1, p. 12.

Elwood, P.C. (1968). "Some Epidemological Problems of Iron Deficiency Anaemia". The Proceedings of the Nutrition Society". 27, pp. 14 - 22.

Erslev, A.J. (1970). "Anaemia of Chronic Renal Disease". Archs. Intern. Med., 126, pp. 774 - 780.

FAO. (1957). "Caloric Requirements". Food and Agriculture Origin, FAO, Nutrition Studies, 15, p. 40.

FAO/WHO. (1970). "Requirement of Ascorbic Acid, Vitamin D, Vitamin B_{12}, Folate and Iron", World Health Organisation Technical Series, No. 452, pp. 48, 49, 54.

Farid, Z., Patwardhan, V.N. and Derby, W.J. (1969). "Parasitism and Anaemia". American Journal of Clinical Nutrition, 22, p. 498.

Fernando, G.P.C. (1971). "School Lunch Programmes in Ceylon". First Asian Congress of Nutrition - Abstracts, p. 23.

Finch, C.A. (1969). "Iron Metabolism". Nutrition Today, 4, p. 2.

Foy, H. and Kondi, A. (1956). "Nutritional and Intestinal Factors and Iron Losses in the Genesis of Tropical Anaemia". Lancet, 1, pp. 423 - 424.

Foy, H., and Kondi, A. (1957). "Anaemia of the Tropics in Relation to Iron Intake, Absorption and Losses through Polynancy and Lactation". Journal of Tropical Medical Hygiene, 60, pp. 105 - 118.

Foy, H., and Kondi, A. (1960). "Hookworm in the Aetiological of Tropical Iron Deficiency Anaemia". Lancet, 2, pp. 320 - 324.

Frisch, R.E. (1970). "Present Status of the Supposition that Malnutrition Causes Permenant Mental Retardation". American Journal of Clinical Nutrition, 23, pp. 189 - 194.

Frisch, R.E. (1971). "Malnutrition and Mental Development A Critical Review". Indian Journal of Nutrition and Dietetics, 8, p. 149.

Ghai, O.P. and Shandhu, R.K. (1968). "Study of Physical Growth of Indian Children in Delhi". Indian Journal of Pediatrics, 35, pp. 91 - 108.

Ghosh, B.N. (1966). "Feeding Habits of Infants and Children in South India on 600 Families". Indian Journal of Medical Research, 54, pp. 889 - 894.

Gills, H.M., Watson Williams, E.K. and Ball, P.A.J. (1964). "Hook Worm Infection and Anaemia". Quart. Rev. Med., 33, p. 1.

Gopalan, C., and Ramalingaswamy, V. (1955). "Kwashiorkor in India". Indian Journal of Medical Research, 43, p. 751.

Gopalan, C. (1969). "Some Recent Studies in the Nutrition Research Laboratories". Nutrition, National Institute of Nutrition, 4, pp. 2 - 18.

Gopalan, C. "Science Reporter", pp. 30 - 34.

Gopalan, C. (1970). "Approaches to Feeding Programme" Nutritional Feeding in the Fourth Plan, Govt. of Tamil Nadu, p. 49.

Gopalan, C. (1970). "Paper Presented during the Nutritional Seminar on Nutritional Feeding in the Fourth Plan". Sri Avinashilingam Home Science College, Coimbatore.

Gopalan, C., Ramasastri, B.V. and Balasubramanian, S.C. (1971). "Nutritive Value of Indian Foods". Indian Council of Medical Research, pp. 45, 48.

Gopalan, C. (1971). Presidential Address First Asian Congress Held in Hyderabad, p. 4.

Gopalan, C., Balasubramanian, S.C. Ramasastri, B.V. and Visweswara Rao, K. (1971). "Diet Atlas of India". National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, p. 56.

Gopalan, C., and Vijayaraghavan, K. (1971). "Nutrition Atlas of India". National Institute of Nutrition, Indian Council of Medical Research, Hyderabad p. 96.

Government of Tamil Nadu, (1972). Personal Communication.

Gubler, C.J. (1956). "Absorption and Metabolism of Iron". Science, 123, pp. 81 - 90.

Guha, D.K. and Arun Rashmi, (1967). "Occult Blood Loss in Iron Deficiency Anaemia in Children". Indian Journal of Pediatrics, 34, pp. 1 - 5.

Gyorgy, P. (1967). "Introductions", American Journal of Clinical Nutrition, 20, pp. 1258 - 1259.

Hahn, P.F. (1943). "Influence of Anaemia, Anoxia and Antecedent Feeding Distribution in Growing Dogs". Journal of Experimental Medicine, 78, p. 169.

Halsted, C.H.N., Guindi, S., Monrad, H., Kattb, A.K., Carter, J.P. and Patwardhan, V.N. (1969). "Anaemia of Kwashiorkor in Cairo, Deficiencies of Protein, Iron and FolicAcid". American Journal of Clinical Nutrition, 22, p. 1371.

Hawk, P.B., Oser, B.C., and Summerson, W.H. (1965). "Practical Physiological Chemistry". Mc Graw Hill Book Company, Inc, New York.

Hawkins, W.W., Leonard, V.G. and Speck, E. (1956). "The Total Body Haemoglobin in Children and Its Relation to Calorie and Iron Requirement". Metabolism, 5, p. 70.

Hobbs, J.M. (1961). "Iron Deficiency After Partial Gastrectomy". Gut. 2, p. 151.

Huser, H.J., Rieber, E.E. and Berman, A.R. (1967). "Experimental Evidence of Excess Haemolysis in the Course of Chronic Iron Deficiency Anaemia". J. Lab.Clin.Med., 69, p. 405.

Hussain, R. and Patwardhan, V.N. (1959). "The Influence of Phytate on the Absorption of Iron". Indian Journal of Medical Research, 47, pp. 676 - 682.

Hussain, R., Patwardhan, V.N., and Sriramachari, S. (1960). "Dermal Loss of Iron in Healthy Indian Man". Indian Journal of Medical Research, 48, pp. 235 - 242.

Hussain, R., Walker, R.B., Laysrisee, M. and Clerk, P. (1965). "Nutritive Value of Food Iron". American Journal of Clinical Nutrition, 16, p. 464.

ICMR. (1967). "Annual Report 1966-67 National Research Laboratories". Indian Council of Medical Research, pp. 5 - 7.

ICMR. (1968). "Recommended Daily Allowances of Nutrients and Balanced Diets." National Research Laboratories, Indian Council of Medical Research p. 2.

ICMR. (1971). "Recommended Daily Allowances of Nutrients and Balanced Diets". Indian Council of Medical Research.

INDIA. (1971). "Population". The Directory and Year Book, The Times of India Press, pp. 36 - 38.

Jeffrey, M.R. (1955). "The Absorption and Utilisation of Radio Iron in Rheumatoid Disease". The Clinical Science, 14, p. 395.

Jelliffe, D.B. (1960). "Clinical Condition Associated with Iron Deficiency Anaemia". Nutrition Reviews, 24, p. 290.

Jelliffe, D.B. (1966). "The Assessment of the Nutritional Status of Community". WHO Chronicle, Geneva pp. 127 - 134.

Kamalanathan, G., Premakumari, S., and Rajammal P.Devadas (1969). "Nutrition Evaluation of School Lunch Programme in Two Selected Villages". Indian Journal of Nutrition and Dietetics, 6, p. 308.

Klavins, J.V., Kinney, T.D. and Kaufuran, N. (1962). "Influence of Dietary Protein on Iron Absorption" British Journal of Experimental Pathology, 48, p. 172.

Lal, S.B. and Mitra, A.B. (1952). "Nutritive Value of Biharee Cooked Food Preparation". Indian Journal of Medical Gazette, LLVII, pp. 172 - 174.

Lathens, M.S. (1966). "Increasing Food Production and Consumption of Dairy Products and Eggs in Developing Countries". Protein: Seventh International Congress on Nutrition, Hamberg, pp. 50 - 51.

Leif Hallberg. (1971). "Iron Requirements in Children". Proceedings of the Nutrition Society of India, 10, p. 38.

Leverton, R.M. (1962). "Food Becomes You". Iowa State University Press, Iowa, pp. 135 - 136.

Mac Laren, D.S. (1964). "Malnutrition, Problem in West and Middle East, Courses and Solution". Paper Read at Journees Medical Due Proche et Du Moyen Orient Istabbal, pp. 24 - 28.

Majaj, A.S., Dinning, J.S., Azzam, S.A. and Darby, W.I. (1963). "Vitamin E Responsive Megaloblastic Anaemia in Infants with Protein Caloria Malnutrition American Journal of Clinical Nutrition, 12, pp. 374 - 379.

Martinez - Torres, C., Ojedu, A., Roche, M. and Layrisse, M (1967). "Hook Worm Infection and Intestinal Blood Loss". Trans. Roy. Soc. Trop. Med. Hyg, 61, p. 373.

Maya Natu and Deodhar, N.S. (1971). "Evaluation of Protein Biscuits as Nutritional Supplement to School Children". A Pilot Study First Asian Congress of Nutrition - Abstracts, , p. 24.

Mehmood, A. (1966). "Blood Loss Caused by Heliminthic Infections". Trans. Roy. Soc. Trop. Med. Hyg. 60, p. 766.

Miller, J.A., (1971). "Iron". Nutrition and Food Science in Association with the British Nutrition Foundation, p. 2.

Ministry of Health. (1961). "The School Health Committee Report". Govt. of India Part I, pp. 7 - 8.

Mitra, K. (1953). "The Results of the Diet Surveys in India". Indian Council of Medical Research, New Delhi, p. 10.

Mittal, U.S. and Agarwal, K.N. (1969). "Observation of Nutritional Metabolistic Anaemias in Early Childhood". Indian Journal of Medical Research, LVII, p. 730.

Mittal, O.P. (1971). "Social Planning for Children". Social Welfare, XVIII, pp. 1 - 4.

Moore, C.V. (1950). "Iron Metabolism in Hypochromic Anaemia Currnets in Nutrition". Journal of American Medical Association, 162, pp. 197 - 204.

Moore, C.V. and Dubatch, R. (1956). "Metabolism and Requirement of Iron in the Human". Journal of American Medical Association, 162, pp. 197 - 204.

Moore, C.V. (1961). "Iron Metabolism and Nutrition". The Harvey Lecture Series, 55, 1959-60, Academic Press, New York, London.

Monckeberg, G. (1970). "1969-70 Report". The Nutrition Foundation INC, Ninety Nine Park Avenue, New York, p. 27.

Murthy, D.Y.N. (1965). "Erythropoietin levels in Kwashiorkor". Indian Journal of Medical Research, 53, 1027.

Naiman, J.L., Osk, F.A. and Diamond, L.K. (1962). "Gastrointestinal Effects of Iron Deficiency Anaemia". Journal of Pediatrics, 33, p. 83.

Narasinga Rao, B.S., Visweswara Rao, K. and Nadamuni Naidu, A. (1969). "Calorie Protein Adequacy of the dietaries of preschool children", Indian Journal of Nutrition and Dietetics, 6, p. 238.

Narasinga Rao, B.S. (1970). "Protein Calorie Malnutrition in Children", A Decade of Progress 1961-70, National Institute of Nutrition, Indian Journal of Medical Research, p. 55.

Nasser, S.S., and Platt, B.S. (1968). "Development of Anaemia in Protein Calorie Deficiency". Symposium Proceeding, 21, p. 56A.

Nirmala, P.S., Jayalakshmi, and Devadas R.P. (1968). "Nutritional Evaluation of Supplementation of Iron from Amaranth to Anaemic Adolescent School Girls". Journal of Nutrition and Dietetics, 5, p. 301.

NRL. (1968). "Report of the study group on Nutritional anaemia". Nutrition Society of India, pp. 2,3.

Nutrition Reviews. (1967). "Effect of Phytates on Iron absorption", 25, p. 218.

Nutrition Reviews. (1971). "Anaemia and Iron Intake". 29, p. 246.

Nutrition Bulletin. (1971). "Church World Service, No. 10, p. 5.

Nutrition. (1972). "Amaranthus". Nutrition, National Institute of Nutrition, 6, pp. 31, 52.

Oldham, H.C. and Schultz, F.W. (1940). "Retention of Iron." Journal of Nutrition, 19, p. 569.

Pandit, S. (1963). "Eating for Health". The Home Maker, 6, pp. 41 - 47.

Pascual, C.R. (1971). "Social and Cultural Factors in Malnutrition". First Asian Congress of Nutrition - Abstracts, p. 48.

Pasricha, S. (1967). "Effect of Different Methods of Cooking and Storage on the Ascorbic Acid Content of Vegetables". Indian Journal of Medical Research, LXI, pp. 752 - 779.

Patwardhan, V.N. (1961). "Nutrition in India" Second Editaon. Journal of Medical Science, p. 931.

Patwardhan,V.N. (1965). "Nutritional Anaemias". WHO Research Programme, American Journal of Clinical Nutrition, 19, p. 53.

Pennsylvania Department of Health, (1971). "Nutrition News". Vth Issue, p. 5.

Pereira, S.M. and Baker, S.J. (1966). "Haematological Studies in Kwashiorkor". American Journal of Clinical Nutrition", 18, pp. 4 - 6.

Prasada Rao, D.C.Y and Satya Gupta.P.(1968). "Child Health in a Rural Community of South India" Indian Journal of Pediatrics. 35, pp. 327 - 330.

Radhakrishna Rao, M.V. (1954). "Report of the Nutrition Survey Committee for Dang Districts 1951-52". Govt. of Bombay, p. 7.

Rai, B., Gupta, S.P., and Sachden, S. (1968). "Intesinal Changes in Angulostomatisis". Journal Ass. Phys. India. 16, p. 505.

Ramalingaswamy, V. and Patwardhan, V.N. (1945). "Diet and Health of South Indian Plantation Labour". Indian Journal of Medical Research, 37, p. 51.

Ray, S.S. (1971). "Need for thinking on Welfare Programmes" Social Welfare. XVIII, pp. 4 - 6.

Rao, B.R.H., Klontz, C.F., Rao, P.S.S., Almas Begum and Dumm, M.E. (1961). "Nutritional Status Survey of the Rural Population in Sholavaram, Seasonal Dietary Survey". Indian Journal of Medical Research, 49, p. 376.

Rao. B.R.H. and Rao, P.S.S. (1959). "General Health and Nutrition Survey of the Rural Population in Pennathur. Part III. The Quantitative Diet Survey". Indian Journal of Medical Science, 12, p. 126.

Rao, S.K., Swaminathan, M.C., Swamy, S., and Patwardhan, V.N. (1965). "Protein Malnutrition in South India Bull: World Health Organisation, p. 603.

Reddy, V. (1969). "Common Nutritional Disorders in India". Nutrition, National Institute of Nutrition, 8, p. 6.

Reissman, R.K. (1964). "Protein Metabolism and Erythropoiesis the Anaemia of Protein Deprivation". Blood, 23, pp. 137 - 143.

Roche, M. and Layrisse. (1966). "The Nature and Cause of Hook Worm Anaemia". American Journal of Tropical Medical Hygiene, 15, p. 1032.

Rose, M.S. and Hubbel, H.J. (1938). "Capacities between Female and male Rats on Iron Retention". Journal of Nutrition, 15, p. 91.

Routh, B.R. and Agarwal, K.N. (1967). "Estimation of Tissue Iron (non beam iron in Indian Subjects". Indian Journal of Medical Research, 55, pp. 1330 - 1336.

Salem, S.N., and Truelove, S.C. (1964). "Hook Worm Disease in Immigrants". British Medical Journal, 1, p. 1074.

Sandozai, M.K., Haquani, A.H., Rajeswari, V. and Kour, J. (1963). "Kwashiorkor in Clinico-haemotological Study". British Medical Journal, 2, p. 93.

Saraya, S.K., Tandon, B.N., and Ramachandran, K. (1970). "A Study of Iron and Protein Deficiency in Hook Worm Infestation". Indian Journal of Medical Research, 158, pp. 1234 - 1243.

Saraya, A.K., Tandon, B.N. and Ramachandran, K. (1971). "Study of Vitamin B_{12} and Folic Acid Deficiency in Hook Worm Disease." American Journal of Clinical Nutrition. 24, pp. 3 - 6.

Saylor, L., and Finch, C.A. (1953). "Determination of Iron Absorption using Two Isotopes of Iron". American Journal of Physiology. 172, p. 372.

Schulman, I. (1961). "Iron Requirement in Infancy". Journal of American Medical Association, 175, p. 118.

Saroja, R. (1966). "Availability of Iron in Some Green Leafy Vegetables". The Indian Journal of Home Science, 1, pp. 8 - 13.

Schmidt, R. (1971). "Comparative Yield's and Composition of Eight Tropical Leafy Vegetables Grown at Two Soil Fertility Levels". Agronomy Journal 63, pp. 546 - 550.

Sethi, A.S. (1968). "Diet in Malnutrition". Indian Journal of Pediatrics, 35, pp. 63 - 69.

Sheehy, T.W., Meroney, W.H., Cox, R.S. and Soler, J.E. (1962). "Hook Worm Disease and Malabsorption". Gastroenterology, 42, p. 148.

Sheehy, T.W. and Flock, M.H. (1964). "The Small Intestine Its Function and Diseases". Horper and Row, New York, p. 52.

Smith, N.D. (1966). "Blood Disease of Infancy and Childhood". The C.V. Mosby Company Stlovis, p. 28.

Smith, M.D. and Pannaccinlli, I.M. (1958). "Absorption of Inorganic Iron from Graded Doses It's Significance in Relation to Iron Absorption Tests and the Mucosal Block Theory". British Journal of Haematology, 4, p. 428.

Sood, S.K. (1967). "Iron Deficiency Anaemia". Proceedings of the Nutrition Society of India, 2, p. 34.

Sood, S.K., Banerji, L., and Ramalingaswami, V. (1968). "Geographic Pathology of Iron Deficiency with Special Reference to India. 2, Quantitation of Iron Stores by Repeated Phlebotmy in Indian Volunteers". American Journal of Clinical Nutrition, 21, pp. 1149 - 1155.

Srikantia, S.G. and Yogananda Sastry, C. (1971). "Effect of Maternal Attributes on Malnutrition in Childhood". First Asian Congress of Nutrition - Abstracts, p. 50.

Sriratanaban, A. and Thayar (1971). "Small Intestinal Dissachridate Activities in Experimental Iron and Protein Deficiency". American Journal of Clinical Nutrition, 24, pp. 411 - 415.

Subramanian, R., and Thekkamalai, S.S. (1967). "School Action Programmes Study of Experience and Difficulties". Krukshetra, 15, p. 17.

Subramanian, C. (1971). "A Strategy for Fighting Protein Bungu". Indian Journal of Nutrition and Dietetics, 8, p. 268.

Sukhatme, P.V. (1970). "Incidence of Protein Deficiency in Relation to Different Diets in India". British Journal of Nutrition, 24, pp. 477 - 487.

Swaminathah, M., and Bhagavan, R. (1964). "Our Food 4th Edition Geneva and Co, Madras, p. 14.

Swaminathan, M.C., Taskar, A.D. and Mahadevan, S. (1966). "Diet Survey by Weighment Method. A Comparison of Random Day, Three Day and Seven Day Period". Indian Journal of Medical Research, 55, p. 90.

Swaminathan, M. (1968). "Diet and Nutrition in India". Journal of Nutrition and Dietetics", 5, p. 225.

Swaminathan, M.S. (1970). "School Lunch Programme". Nutrition 5, pp. 2 - 9.

Swaminathan, M., Pardia, H.A.B., Daniel, V.A. Narayanaswami, D. and Somakurien (1971). Supplementary value of a Low Cost Protein Food Based onWheat and Kaffer Corn". Indian Journal of Nutrition and Dietetics, 8, p. 309.

Talwalkar, R.T. and Patel, S.M. (1970). "Biological Evaluation of Proteins of Probadi (Hibiscus Cannabinus) and Methi (Trigonella Doemungroecum) and their Supplementary Effect on Jowar". Indian Journal of Nutrition and Dietetics, 7, p. 13.

Tandon, B.N., Das, S.C., Suraya, A.K. and Deo, M.G. (1966). "Functional and Structural Studies of Small Bowel Ankylostomasis". British Journal of Medicine 1, p. 714.

Tandon, B.N., Saraya, A.K., Ramachandran, K., and Sama, S.K. (1969). "Relationship of Anaemia and Structural Changes in the small Bowel in Hook Worm Disease". Gut, 10, p. 360.

Teply, S. (1970). "Strategy and Tactices of Improvement of Nutrition of Children and Mothers". Malnutrition a Problem of Ecology Nutrition and Dietetics. New York, p. 181.

Trivedi, B.A., Srivatava, B.C. and Maheswari, B.B. (1971). "A Study of Height and Weight of Primary School Children". Indian Journal of Pediatrics, 38, p. 30.

Trowell, H.C., and Simpkiss, M.I. (1957). "Intramuscular Iron in the Treatment of the Anaemia Associated with Kwashiorkor". Lancet, 2, pp. 266 - 267.

UNICEF. (1970). "UNICEF News". United Nations Children's Fund, United Nations, New York Issue, 67, p. 11.

Varley (1968). "Practical Clinical Biochemistry". The English Language Book Society. London.

Venkatachalam, P.S. (1968). "Iron Metabolism and Iron Deficiency in India". American Journal of Clinical Nutrition, 2, pp. 1156 - 1161.

Venkatachalam, P.S. (1971). "Vitamin and Mineral Deficiencies among Children". Social Welfare, XVIII, pp. 24 - 30

Vijayaraghavan, K., Darshan Singh and Swaminathan, M.C. (1971). "Growth Standards for Indian Children". First Asian Congress of Nutrition - Abstracts, p. 54.

Vinodini Reddy, and Srikantia, S.G. (1970). "Anemia in Kwashiorkor". Indian Journal of Medical Research, 58, pp. 645 - 650.

Vinodini Reddy, (1969). "Common Nutritional Disorders in India". Nutrition, National Institute of Nutrition, 3, pp. 3 - 6.

Vinodini Reddy (1968). "Nutritional Problems in Children". The Children's Annual, p. 43 - 46.

Visweswara Rao, K. (1969). "Nutrition and Family Size". Nutrition, 3, p. 3.

Wadsworth, G.R. (1963). "Nutritional Factors in Anaemia" World Review of Nutrition and Dietetics. 1, p. 149

Wallersteri, R.O. Hoag, M.S., and Pollycove, M. (1961). "Occult Blood Loss in Iron Deficiency Anaemia in Infancy". Journal of Pediatrics, 27, p. 199.

Wallace, M.R. (1971). "The Effect on Oral Iron on the Anaemia of Patients on Maintenance Haemodialysis" Newzealand Medical Journal, 74, pp. 167 - 170.

WHO. (1963). "Expert Committee on Medical Assessment of Nutritional Status," Tech: Rep: Ser: 258, World Health Organisation, Geneva.

WHO. (1963). "Malnutrition and Disease" Freedom from Hunger Campaign, Basic No. 12, p. 32.

WHO. (1966). "Malnutrition Increasing". Journal of Pediatrics, 33, pp. 203 - 208.

WHO. (1966). "Assessment of Nutritional Status of the Community". Monograph Series, World Health Organisation, Geneva.

WHO. (1968). "Nutrition in Maternal and Child Health". Monograph No. 5, p. 150.

WHO. (1968). "Criteria for the Diagonosis of Anaemia". World Health Organisation, Technical Series No. 405, pp. 3, 5, 9.

WHO. (1969). "The Health Aspect of Food and Nutrition." Westorn Pecific Regional Office Manila. pp. 31, 75.

WHO. (1970). "Nutrition". WHO Chronicle, World Health Organisation, 24, p. 552.

Wilson, E.D., Fischer, F.H., and Faque, M.E. (1966). "Principles of Nutrition". Second Edition, Wiley Eastern Private Limited, pp. 156 - 159.

Wilson, J.E., Heiner, D.C. and Lahey, M.E. (1962). "Studies on Iron Metabolsim Evidence of Gastrointestinal Dysfunction in Infants with Iron deficiency Anaemia". Priliminary Report Journal of Pediatrics 60, p.787.

Woodruff, A.W. (1961). "Nutritional Anaemia Recent Advances in Human Nutrition". Brock J.F. J.A. Churchil London.

Woodruff, A.W. (1966). "Nutritional Aspect of Metabolism Growth Development". Journal of American Medical Associetion, 196, p. 214.

Woodruff, A.W. (1969). "Nutritional Anaemia in Early Childhood". American Journal of Clinical Nutrition, 22, p. 504.

A P P E N D I C E S

APPENDIX-A

EFFECT OF DIFFERENT COOKING UTENSILS ON THE IRON, CALCIUM AND ASCORBIC ACID CONTENT OF AMARANTHUS.

REPLICATE VALUES FOR NUTRIENTS

No.	Particulars	Nutrients	REPLICATIONS IN Mg.		
			1	2	3
	Amaranthus				
1.	Uncooked	Iron	25.0	24.8	25.3
		Calcium	389.5	389.0	390.0
		Ascorbic acid	96.0	97.0	95.2
2.	Cooked in aluminium vessel	Iron	22.7	22.7	22.8
		Calcium	383.7	381.9	383.5
		Ascorbic acid	38.5	38.7	38.3
3.	Cooked in iron vessel	Iron	118.0	117.2	118.8
		Calcium	385.0	385	385.0
		Ascorbic acid	53.7	54.0	53.5

APPENDIX - B

MONTHLY HEIGHT RECORD OF INDIVIDUAL CHILDREN IN THE FOUR GROUPS

GROUP I HEIGHT IN CENTIMETERS

No.	Age Year-Months	Class	August	September	October	November	December	January	February
1.	11-10	V	122.2	123.2	123.9	125.0	125.0	125.3	125.5
2.	10-1	V	118.3	120.0	120.9	121.1	122.2	122.4	122.6
3.	9-0	V	123.6	124.9	125.6	126.2	127.8	128.1	128.4
4.	9-1	V	121.4	121.7	122.2	123.3	124.5	124.8	125.2
5.	9-1	V	122.2	123.1	123.3	124.0	124.9	125.2	125.5
6.	9-5	V	124.5	125.8	126.4	127.3	127.8	128.2	128.5
7.	8-2	IV	119.0	119.9	120.0	120.5	120.5	120.9	121.4
8.	8-2	IV	123.7	124.1	125.4	125.7	126.0	126.5	127.0
9.	8-4	IV	113.3	114.1	114.5	114.8	115.2	115.5	115.9
10.	8-2	IV	115.0	116.5	118.0	118.4	118.9	119.2	119.5
11.	8-4	IV	112.8	113.9	114.6	114.9	115.2	115.7	116.5
12.	10-3	IV	137.0	139.6	140.1	141.0	142.0	142.6	143.4
13.	8-2	IV	113.4	114.1	114.5	114.9	115.3	115.7	116.0
14.	7-2	III	107.8	107.9	108.5	109.0	109.4	109.7	110.0
15.	7-5	III	110.4	112.8	112.9	113.1	113.5	113.8	114.1
16.	7-5	III	116.6	117.1	118.1	118.9	119.5	119.7	120.0
17.	6-8	III	116.3	117.0	117.8	118.1	118.5	118.9	119.3

No.	Age year	Month	Class	August	September	October	November	December	January	February
18.	6-2		II	110.4	111.5	111.9	112.1	112.5	112.8	113.1
19.	6-1		II	113.1	114.2	114.8	115.2	115.5	115.8	116.0
20.	6-1		II	116.0	116.9	117.3	117.7	118.1	118.4	118.8
21.	6-2		II	109.0	111.4	112.5	112.9	113.3	113.6	113.8
22.	6-11		II	109.8	110.3	110.6	110.3	111.1	111.4	111.7
23.	6-5		II	115.0	116.1	116.8	117.4	118.0	118.3	118.6
24.	5-3		I	110.8	111.4	112.8	113.1	113.4	114.0	115.0
25.	5-3		I	106.7	107.1	109.0	109.5	110.0	110.4	110.7
26.	5-2		I	99.0	99.9	100.1	100.7	101.1	102.0	102.5
27.	9-1		I	125.7	126.0	126.2	126.5	126.9	127.2	127.5
28.	9-2		V	124.1	124.5	125.0	126.3	126.7	127.1	127.4
29.	8-2		IV	116.0	116.4	116.8	117.2	117.5	118.1	118.6
30.	8-7		IV	112.3	112.6	112.9	113.4	113.8	114.2	114.5
31.	8-9		IV	118.2	118.6	119.1	119.5	119.9	120.6	121.0
32.	6-3		II	103.5	103.8	104.2	104.5	104.8	105.0	105.3
33.	5-4		I	103.6	109.0	109.3	109.5	109.8	110.2	110.6
34.	8-0		IV	122.8	123.1	123.6	123.9	124.4	124.9	125.3
35.	6-1		II	110.7	111.1	111.6	112.1	112.6	112.9	113.2

GROUP II HEIGHT IN CENTIMETRES

No.	Age years-months	Class	August	September	October	November	December	January	February
1.	10-0	V	127.2	128.0	130.0	131.0	132.0	132.8	133.1
2.	9-7	V	127.3	127.5	127.9	128.1	128.8	129.2	130.1
3.	9-9	V	124.7	124.9	126.1	125.9	127.6	128.0	128.3
4.	9-2	V	127.6	127.9	128.2	129.0	130.5	130.9	131.2
5.	9-4	V	116.4	117.0	117.5	118.7	120.0	120.3	120.7
6.	10-0	IV	130.1	131.0	131.7	132.0	132.5	132.9	133.4
7.	8-1	IV	118.3	118.6	120.6	121.4	122.5	122.8	123.2
8.	8-5	IV	117.2	118.5	119.2	119.9	121.5	121.9	122.4
9.	8-1	IV	108.3	108.9	109.8	110.4	111.0	111.3	111.7
10.	10-3	IV	137.3	138.1	138.2	138.6	139.0	139.4	139.9
11.	8-1	IV	118.5	120.2	120.6	120.9	121.5	122.0	122.5
12.	8-3	III	121.5	124.0	124.2	125.0	125.5	125.8	126.2
13.	8-2	III	119.9	120.3	120.5	121.1	122.0	122.3	122.6
14.	7-8	III	113.5	115.2	115.4	115.9	117.5	117.8	118.0
15.	7-6	III	119.9	122.0	122.7	123.1	123.4	123.4	123.6
16.	7-1	II	113.3	114.6	114.9	115.8	116.5	116.8	117.2
17.	6-0	II	112.7	113.3	114.2	115.1	116.0	116.5	117.0
18.	6-1	II	111.1	111.9	112.1	112.[illegible]	112.8	113.1	113.4
19.	6-3	II	112.1	114.3	114.6	115.1	115.6	116.0	116.3

No.	Age ye-ar Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nov-em-ber	Dec-em-ber	Janua-ry	Febru-ary
20.	6-4	II	103.0	105.4	105.4	106.1	107.0	107.4	107.8
21.	5-9	II	103.9	105.2	105.5	106.0	106.5	106.9	107.3
22.	6-2	II	110.4	111.2	112.0	112.2	112.9	113.3	113.7
23.	5-3	I	101.8	102.0	102.8	103.1	103.5	104.0	104.5
24.	5-1	I	108.8	109.1	109.4	110.4	111.5	111.9	112.5
25.	5-4	I	101.1	102.4	102.7	103.1	103.5	104.8	104.5
26.	5-1	I	102.5	103.0	103.5	103.9	104.2	104.6	105.0
27.	9-11	V	137.0	138.9	140.3	140.5	140.5	140.8	141.1
28.	9-5	V	120.1	121.4	121.9	122.4	123.0	123.3	123.6
29.	8-6	IV	125.1	127.0	127.3	127.9	128.5	128.8	129.5
30.	6-11	II	104.8	105.6	107.0	107.7	108.5	108.9	109.3
31.	6-9	III	111.7	113.5	114.1	114.8	115.5	115.9	116.3
32.	7-8	III	105.9	108.0	108.5	109.0	109.5	110.2	111.0
33.	6-5	II	110.7	111.4	112.4	113.0	113.5	114.0	114.4
34.	7-3	III	115.9	118.0	118.6	119.2	119.9	120.5	121.0
35.	7-5	III	114.0	114.4	114.6	114.9	115.2	115.5	115.8

GROUP III HEIGHT IN CENTIMETRES

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nov-em-ber	Dec-em-ber	January	Febru-ary
1.	10-1		V	134.0	134.6	135.3	135.9	136.5	137.0	137.4
2.	9-2		V	117.1	118.7	119.2	119.7	120.2	120.5	121.0
3.	9-6		V	120.1	121.9	123.2	123.9	124.5	124.9	125.4
4.	10-0		V	139.4	140.0	140.4	140.4	141.7	142.1	142.5
5.	10-1		V	119.6	120.1	123.6	125.1	127.0	127.5	128.0
6.	10.3		IV	126.0	126.8	126.9	127.4	127.9	128.7	129.2
7.	8-9		IV	118.1	119.5	120.0	121.0	121.9	122.4	122.9
8.	8-2		IV	123.2	124.2	125.0	126.0	126.9	127.3	127.7
9.	8-2		IV	122.2	123.1	123.4	124.8	126.0	126.5	126.9
10.	8-3		IV	119.5	120.6	121.7	122.0	122.4	122.9	123.5
11.	9-11		IV	113.2	114.0	114.5	115.0	115.5	116.0	116.5
12.	10-8		IV	124.9	126.7	126.9	127.4	127.9	128.6	129.3
13.	8-0		III	119.0	120.5	120.8	121.0	121.2	121.6	122.5
14.	7-3		III	115.7	117.6	118.2	118.5	118.9	119.4	119.9
15.	7-1		III	109.5	110.3	110.7	110.9	111.0	111.7	112.5
16.	8-4		III	114.2	115.5	115.8	116.1	116.5	116.9	117.4
17.	7-2		III	106.7	107.7	108.5	109.3	110.4	110.9	111.6
18.	6-2		II	103.5	103.9	104.0	104.5	105.2	105.7	106.4
19.	6-2		II	109.0	109.5	111.1	111.6	112.1	112.7	113.5

No.	Age years	Months	Class	August	September	October	November	December	January	February
20.	6-1		II	111.6	112.9	113.8	114.3	115.0	115.5	116.4
21.	6-3		II	112.5	113.6	114.3	114.8	115.4	115.8	116.1
22.	7-3		II	101.6	102.1	102.3	102.7	103.0	103.5	104.3
23.	6-5		II	112.2	113.3	113.6	114.0	114.3	114.7	115.1
24.	5-2		I	100.4	101.5	103.3	103.7	104.2	104.8	105.5
25.	5-7		II	110.0	112.1	113.0	113.8	114.2	114.8	115.5
26.	5-5		I	108.5	109.1	110.0	110.6	111.0	111.4	111.9
27.	10-2		V	126.5	127.3	129.0	129.5	130.1	130.5	131.0
28.	9-3		V	130.8	132.0	132.5	133.0	133.5	134.0	134.3
29.	8-11		IV	124.6	124.9	125.5	126.2	127.5	127.9	128.4
30.	8-2		IV	109.0	110.4	111.1	111.7	112.5	112.9	113.5
31.	7-1		III	112.4	114.1	114.6	115.1	115.9	116.4	116.8
32.	8-3		III	111.3	112.0	113.0	113.5	114.0	114.5	114.8
33.	6-6		II	111.8	112.4	113.4	114.0	115.5	115.9	116.3
34.	5-1		I	103.5	104.1	105.2	106.0	106.5	106.9	107.5
35.	7-0		II	111.0	111.6	111.9	112.4	113.0	113.4	114.2

GROUPS IV HEIGHT IN CENTIMETRES

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nov-ember	Dec-em-ber	Janu-ary	February
1.	10-7		V	132.5	133.2	133.4	133.9	134.0	134.6	135.5
2.	9-4		V	123.2	123.7	123.9	125.5	125.5	126.0	126.8
3.	9-2		V	127.4	128.8	131.4	131.9	132.4	132.9	133.4
4.	9-5		V	119.3	120.1	120.5	120.8	121.1	121.6	122.4
5.	9-0		V	114.8	116.4	116.7	117.3	118.0	118.8	119.5
6.	9-1		V	119.3	121.0	121.2	122.3	123.5	124.0	124.9
7.	9-7		V	135.0	135.7	135.9	136.8	138.0	138.5	139.3
8.	10-1		V	117.4	118.0	118.2	118.7	119.3	119.7	120.4
9.	10-11		IV	132.2	132.7	133.0	133.4	133.9	134.8	135.9
10.	8-3		IV	121.4	122.8	123.4	124.4	125.5	126.6	127.3
11.	8-9		IV	118.0	118.3	118.6	119.0	119.5	120.5	121.3
12.	9-3		IV	127.0	127.7	129.4	129.7	130.0	130.4	131.2
13.	7-2		III	114.2	116.5	117.0	117.6	118.0	118.9	119.9
14.	7-7		III	120.8	121.6	122.7	123.0	123.5	123.9	124.4
15.	8-2		III	121.8	122.3	122.8	123.2	123.9	124.4	125.8
16.	7-0		III	118.0	118.9	119.3	119.7	120.2	120.7	121.3
17.	7-1		III	99.9	101.5	101.7	102.4	103.3	103.7	104.6
18.	6-4		II	104.7	105.5	106.5	107.0	107.5	108.0	108.6
19.	6-4		II	112.4	112.9	113.9	114.6	115.1	115.6	116.5

No.	Age year-Month	Class	August	September	October	November	December	January	February
20.	6-2	II	110.5	111.6	111.9	112.1	112.5	113.3	114.2
21.	6-6	II	108.0	108.6	110.0	111.0	112.0	112.4	113.0
22.	6-1	II	114.6	115.0	117.3	117.8	118.4	119.0	119.9
23.	5-0	I	96.4	98.3	98.5	98.7	99.0	99.8	100.5
24.	5-4	I	105.5	105.9	106.6	107.0	107.4	107.9	108.6
25.	6-4	I	105.0	106.0	107.3	107.5	107.9	108.4	109.2
26.	5-6	I	95.9	96.5	98.2	99.1	99.5	99.9	100.8
27.	10-5	V	118.3	119.7	121.0	121.5	121.9	122.3	123.2
28	9-4	V	130.4	130.9	131.3	131.7	132.5	133.3	134.2
29.	9-1	IV	120.5	121.5	122.1	122.6	123.0	123.4	124.3
30.	9-2	IV	105.1	105.5	105.9	106.4	106.9	107.8	108.7
31.	9-4	III	127.1	127.8	128.0	128.4	128.9	129.4	130.3
32.	6-6	II	120.5	121.1	122.0	122.6	123.5	124.0	124.9
33.	9-3	III	112.3	113.0	114.5	115.4	116.0	116.4	117.3
34.	6-2	II	107.1	107.6	108.7	109.1	109.5	110.0	110.9
35.	6-5	II	95.0	96.7	98.0	99.0	100.2	100.7	101.5

APPENDIX-C

MONTHLY WEIGHT RECORD OF INDIVIDUAL CHILDREN IN THE FOUR GROUPS

GROUP I WEIGHT IN KILOGRAMS

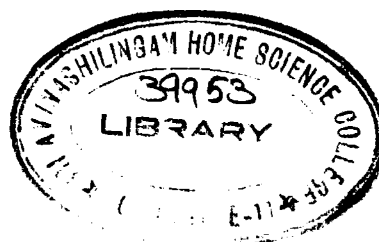
No.	Age ye-ar Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nove-mber	Dec-mber	Janu-ary	Febru-ary
1.	11-2	V	25-0	24.5	25.0	25.0	25.5	26.0	26.0
2.	10-1	V	16.0	17.0	17.5	17.0	17.5	18.0	18.0
3.	9-0	V	20.0	20.5	20.5	21.0	22.0	22.5	22.5
4.	9-1	V	21.0	22.0	22.0	23.0	23.5	23.0	23.5
5.	9-1	V	19.0	19.5	20.5	20.0	21.5	21.0	21.0
6.	9-5	V	20.0	20.0	21.5	22.5	22.0	22.6	22.5
7.	8-2	IV	17.0	17.5	18.0	17.5	18.5	18.0	18.5
8.	8-2	IV	20.0	20.5	21.0	21.0	21.5	21.5	21.0
9.	8-5	IV	17.0	17.5	17.0	17.5	18.0	18.0	18.5
10.	8-2	IV	18.0	18.0	18.5	19.0	19.0	18.5	19.0
11.	8-4	IV	15.0	16.0	16.0	15.5	16.5	17.0	17.0
12.	10-3	IV	25.0	26.0	26.0	27.0	28.0	28.0	28.0
13.	8-2	IV	17.0	17.5	18.0	18.0	19.0	19.0	19.5
14.	7-2	III	16.0	16.0	16.5	16.5	16.5	17.0	17.5
15.	7-5	III	17.5	18.0	18.0	18.5	19.0	19.5	19.5
16.	7-5	III	18.0	17.5	18.0	18.5	18.5	18.5	19.0
17.	6-8	III	20.0	20.0	20.5	20.0	21.0	21.0	21.5
18.	6-2	II	17.0	17.0	17.0	16.5	17.5	17.0	17.0
19.	6-1	II	18.0	18.5	19.0	18.5	20.0	20.0	20.5

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nov-em-ber	Dec-em-ber	Janu-ary	Febru-ary
20.	6-1		II	18.5	19.0	19.0	19.0	20.0	20.0	20.0
21.	6-2		II	16.5	17.0	16.5	16.0	17.0	17.5	18.0
22.	6-11		II	18.0	18.5	18.5	18.5	20.0	19.5	19.0
23.	6-5		II	14.5	15.0	15.0	14.5	15.5	15.5	16.0
24.	5-3		I	19.5	20.0	19.5	20.0	20.0	20.0	20.0
25.	5-3		I	17.0	17.5	17.0	17.0	18.0	17.5	18.0
26.	5-2		I	13.0	13.5	13.0	13.0	13.5	13.0	12.5
27.	9-1		V	25.0	25.5	25.5	25.5	25.5	26.0	26.5
28.	9-2		V	20.0	20.0	20.6	20.5	20.5	20.5	21.0
29.	8-2		IV	16.0	16.0	16.5	17.0	17.0	17.0	17.0
30.	8-7		IV	17.0	17.5	18.0	18.5	19.0	18.5	18.5
31.	8-9		IV	18.0	18.0	18.0	18.5	19.0	19.5	20.0
32.	6-3		II	13.0	13.0	13.0	13.5	13.0	13.0	13.5
33.	5-4		I	16.0	16.0	16.0	16.0	16.5	16.5	16.5
34.	8-0		IV	19.0	19.5	19.5	20.0	20.0	19.0	19,0
35.	6-7		II	18.0	18.0	18.5	19.0	18.5	18.5	19.0

GROUP II WEIGHT IN KILOGRAMS

No.	Age Year-Month	Class	August	September	October	November	December	January	February
1.	10-0	V	21.5	23.0	25.0	25.5	25.5	25.5	25.0
2.	9-7	V	22.0	22.5	23.0	22.5	23.0	24.0	24.5
3.	9-9	V	18.0	18.0	19.0	19.0	19.0	19.0	19.5
4.	9-2	V	23.5	23.0	24.0	24.5	25.0	25.0	25.5
5.	9-4	V	17.5	16.5	17.0	17.5	17.5	18.0	18.5
6.	10-0	IV	23.0	23.5	23.5	23.5	24.0	24.0	24.5
7.	8-1	IV	18.0	19.0	19.5	19.5	20.0	20.0	19.5
8.	8-5	IV	19.0	20.0	20.0	20.5	20.5	20.5	21.0
9.	8-1	IV	16.0	16.5	16.0	16.5	17.0	17.0	17.5
10.	10-3	IV	28.0	29.0	29.0	29.5	30.0	30.5	31.5
11.	8-1	IV	18.0	18.5	18.0	18.5	19.0	19.0	19.5
12.	8-8	III	22.0	22.5	23.0	23.0	23.5	23.5	24.0
13.	8-2	III	19.0	20.0	19.5	19.5	19.0	19.5	20.0
14.	7-6	III	15.0	15.0	15.5	15.5	16.0	16,0	16.5
15.	7-6	III	22.0	23.0	23.0	23.0	23.6	24.0	25.0
16.	7-1	II	17.0	17.5	18.0	18.0	18.5	18.0	18.5
17.	6-0	II	15.0	16.0	16.5	17.0	17.0	17.0	17.5
18.	6-1	II	16.5	16.5	16.0	16.0	16.6	17.0	17.5
19.	6-3	II	17.0	17.5	17.0	17.5	18.0	18.0	18.5

No.	Age year-Month	Class	August	September	October	November	December	January	February
20.	6-4	II	13.0	14.0	14.5	15.0	15.0	15.5	15.5
21.	5-9	II	16.0	16.5	17.5	17.5	18.0	18.0	18.5
22.	6-2	II	17.0	17.0	17.5	17.5	18.0	18.0	18.5
23.	5-1	I	13.0	13.0	14.0	14.0	14.5	14.5	15.5
24.	5-1	I	16.0	16.0	16.0	16.0	16.5	16.0	16.5
25.	5-4	I	14.0	14.5	14.0	14.0	14.0	14.0	14.5
26.	5-1	I	14.0	15.0	15.0	14.5	16.0	15.5	15.5
27.	9-11	V	25.0	27.0	28.5	28.5	29.0	29.5	30.0
28.	9-5	V	18.0	19.0	20.0	20.0	20.5	20.5	21.0
29.	8-6	IV	21.0	22.0	22.0	22.5	22.5	22.5	22.5
30.	6-11	II	16.0	15.5	16.0	16.0	16.5	16.5	17.5
31.	6-9	III	16.0	17.0	17.5	17.5	18.0	18.0	18.5
32.	7-8	III	17.5	18.00	19.0	19.5	19.5	19.0	19.5
33.	6-5	II	15.0	15.5	16.0	16.5	16.5	17.5	17.5
34.	7-3	III	18.5	18.5	19.0	19.5	19.5	19.0	19.5
35.	7-5	III	16.0	16.0	16.5	16.0	16.5	17.0	17.5



GROUP III WEIGHT IN KILOGRAMS

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nove-mber	Dec-em-ber	Janu-ary	Febru-ary
1.	10-1		V	25.0	26.0	26.0	27.0	28.0	28.5	28.5
2.	9-2		V	17.5	18.0	19.0	19.5	20.0	20.5	21.0
3.	9-6		V	18.0	18.0	19,5	19.5	20.0	20.0	20.5
4.	10-0		V	26.5	26.5	27.0	27.0	27.5	28.0	28.5
5.	10-1		V	22.0	21.5	22.5	22.0	23.0	24.0	24.5
6.	10-3		IV	21.0	22.0	22.0	22.0	22.0	22.5	22.5
7.	8-9		IV	20.0	20.5	21.0	21.0	21.0	21.5	21.5
8.	8-2		IV	20.0	21.0	21.5	22.0	22.0	22.5	23.5
9.	8-2		IV	19.0	20.0	21.0	21.5	21.5	21.0	21.5
10.	8-3		IV	23.0	23.0	23.5	24.0	24.5	24.5	25.0
11.	9-11		IV	15.0	15.5	15.5	15.0	15.5	16.0	16.5
12.	10-8		IV	22.0	23.0	23.0	23.0	23.5	23.5	24.0
13.	8-0		III	20.0	20.5	21.0	21.0	21.0	21.5	21.5
14.	7-3		III	17.0	19.0	19.0	19.0	19.0	19.5	20.0
15.	7-1		III	16.0	17.0	17.5	18.0	18.5	18.0	18.5
16.	8-4		III	17.0	18.0	18.0	18.5	19.0	19.0	19.5
17.	7-2		III	14.0	14.5	15.0	15.5	16.0	15.5	16.5
18.	6-2		II	13.5	13.5	14.0	14.0	14.5	15.0	15.5
19.	6-2		II	16.0	17.0	17.0	17.0	17.5	17.5	18.5

No.	Age year-Month	Class	August	September	October	November	December	January	February
20.	6-1	II	17.5	17.5	18.0	18.5	18.5	18.5	19.0
21.	6-3	II	13.5	14.0	14.0	13.5	15.0	15.0	15.5
22.	7-3	II	16.5	16.0	16.0	16.0	16.5	17.5	18.5
23.	6-5	II	16.0	16.6	16.0	16.0	16.5	17.0	17.5
24.	5-2	I	15.0	15.5	15.0	15.0	16.0	16.0	16.5
25.	5-7	I	17.0	17.5	18.0	18.0	18.5	19.0	20.0
26.	5-5	I	15.0	16.0	16.0	16.0	17.5	17.5	18.5
27.	10-2	V	21.0	21,5	21.5	22.0	22.0	22.5	23.0
28.	9-3	V	21.0	21.0	21.0	21.5	21.0	22.5	23.5
29.	8-11	IV	20.5	21.0	20.0	21.0	22.0	22.5	23.5
30.	8-1	IV	18.0	18.5	19.0	19.5	19.5	19.0	19.5
31.	7-7	III	17.0	18.0	18.0	18.5	18.5	18.5	19.5
32.	8-3	III	15.0	17.0	17.0	17.5	17.5	18.0	19.5
33.	6-6	II	17.5	17.5	17.0	17.5	18.0	18.0	18.5
34.	7-0	II	17.0	17.0	17.5	18.0	18.0	18.5	19.5
35.	6-1	I	14.5	15.0	15.0	15.5	16.0	16.0	16.5

GROUP IV WEIGHT IN KILOGRAMS

No.	Age year-Month	Class	August	September	October	November	December	January	February
1.	10-7	V	24.5	26.5	26.5	26.5	26.0	26.5	27.0
2.	9-4	V	19.0	19.0	20.0	20.5	21.0	21.5	22.0
3.	9-2	V	24.0	24.5	25.0	25.5	26.0	26.0	26.5
4.	9-5	V	18.0	19.0	19.0	20.0	21.0	21.5	22.0
5.	9-0	V	17.0	17.0	17.5	18.0	18.0	18.5	19.0
6.	9-1	V	17.0	18.0	19.0	19.5	20.0	20.0	20.5
7.	9-7	V	24.0	24.5	25.0	26.0	26.0	26.5	27.0
8.	10-1	V	21.0	21.0	22.0	22.0	22.5	23.0	23.5
9.	10-11	IV	25.0	26.0	27.0	27.5	27.5	28.0	28.0
10.	8-3	IV	19.0	20.0	21.0	21.5	22.0	22.5	22.5
11.	8-9	IV	19.0	19.5	19.5	20.0	20.0	20.5	21.5
12.	9-3	IV	20.0	20.0	21.0	21.0	21.5	22.0	22.5
13.	7-2	III	18.0	19.0	19.5	19.0	19.5	19.5	20.0
14.	7-7	III	19.0	19.5	20.0	20.5	21.0	21.5	21.5
15.	8-2	III	13.0	20.0	20.5	21.0	21.0	21.5	21.5
16.	7-0	III	19.0	19.5	19.5	20.0	20.0	20.0	20.5
17.	7-1	III	13.0	13.5	14.0	14.5	15.0	15.5	15.5
18.	6-4	II	16.0	17.0	17.0	17.0	17.5	17.5	18.0
19.	6-4	II	18.0	18.0	19.0	19.0	19.5	20.0	20.5

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nove-mber	Dec-mber	Janu-ary	Febr-uary
20.	6-2		II	16.5	17.0	18.6	18.0	18.5	19.5	20.0
21.	6-6		II	15.0	15.0	16.0	16.5	16.5	17.0	17.5
22.	6-1		II	17.5	18.0	18.5	19.0	19.5	20.0	20.5
23,	5-0		I	12.0	12.0	12.6	13.0	13.5	14.0	14.5
24.	5-4		I	16.0	16.5	17.0	17.5	17.0	17.5	18.5
25.	6-4		I	15.0	15.0	15.5	15.5	15.5	16.5	17.0
26.	5-6		I	13.0	12.5	14.0	14.5	13.5	14.0	14.5
27.	10-5		V	17.0	18.0	19.0	19.5	19.5	20.0	20.5
28.	9-4		V	25.0	25.0	25.5	26.0	26.5	27.0	27.5
29.	9-1		IV	21.0	22.0	22.0	22.5	22.5	23.0	23.5
30.	9-2		IV	14.0	15.0	15.0	15.5	15.5	16.0	16.5
31.	9-4		III	24.0	25.0	25.0	25.5	25.5	26.0	28.5
32.	6-6		II	17.0	17.5	18.0	18.0	18.5	19.5	20.0
33.	9-3		III	16.0	17.5	20.0	20.5	20.5	20.0	20.5
34.	6-2		II	15.0	15.0	15.0	16.0	16.5	17.0	17.5
35.	6-5		II	13.5	14.0	14.0	15.0	15.5	15.5	16.0

A P P E N D I X-D

MONTHLY HAEMOGLOBIN RECORD OF
INDIVIDUAL CHILDREN IN FOUR GROUPS

GROUP I HAEMOGLOBIN LEVEL
(g/100ml)

No.	Age year-Month	Class	August	September	October	November	December	January	February
1.	11-2	V	13.25	12.25	12.15	12.55	13.00	12.20	12.80
2.	10-1	V	9.25	9.51	9.50	9.56	9.55	9.35	9.50
3.	9-0	V	12.55	11.51	11.51	11.59	11.95	12.41	12.58
4.	9-1	V	11.99	12.59	12.60	12.85	12.00	12.00	12.00
5.	9-1	V	10.50	10.30	11.50	11.75	11.95	11.95	11.00
6.	9-5	V	11.15	11.15	11.02	11.11	11.25	11.30	11.40
7.	8-2	IV	11.54	11.45	11.10	11.55	11.53	11.50	11.55
8.	8-2	IV	11.55	11.55	11.55	11.59	11.60	11.65	11.67
9.	8-4	IV	13.00	13.00	12.95	12.95	12.85	12.90	12.90
10.	8-2	IV	9.26	9.24	9.25	9.30	9.37	9.50	9.59
11.	8-4	IV	10.04	10.05	10.15	10.25	10.15	10.10	10.25
12.	10-3	IV	9.53	9.56	9.50	9.55	9.60	9.50	9.65
13.	8-2	IV	11.82	11.90	11.96	11.95	11.95	11.90	11.85
14.	7-2	III	12.23	12.25	12.20	12.25	12.25	12.22	12.25
15.	7-5	III	12.57	12.50	12.45	12.40	12.40	12.30	12.35
16.	7-5	III	11.27	11.21	11.00	11.25	11.35	11.30	11.40
17.	6-8	III	11.00	11.10	11.20	11.25	11.30	11.20	11.24
18.	6-2	II	11.00	11.00	11.00	11.10	11.15	11.00	11.10
19.	6-1	II	12.00	12.21	12.25	12.11	12.45	12.20	12.20

No.	Age ye-ar	Mon-ths	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nove-mber	Dece-mber	Janu-ary	Febru-ary
20.	6	1	II	11.00	11.00	11.05	11.05	11.10	11.15	11.20
21.	6	2	II	10.23	10.32	10.50	10.25	10.28	10.25	10.30
22.	6	11	II	11.31	11.35	11.40	11.39	11.45	11.40	11.40
23.	6	5	II	9.51	10.10	10.25	9.75	9.50	9.50	9.59
24.	5	3	II	10.52	10.50	10.50	10.52	10.55	10.55	10.62
25.	5	3	I	10.00	10.22	10.30	10.00	10.00	10.10	10.23
26.	5	2	I	9.50	10.25	10.50	10.25	10.15	9.50	9.63
27.	9	1	V	13.00	12.85	12.90	12.85	12.95	13.00	13.01
28.	9	2	V	12.78	12.75	12.70	12.75	12.75	12.75	12.80
29.	8	2	IV	12.50	12.50	12.60	12.60	12.75	12.80	12.75
30.	8	7	IV	12.78	12.80	12.80	12.75	12.60	12.80	12.85
31.	8	9	IV	13.20	12.75	12.90	13.00	12.90	13.00	13.27
32.	6	3	II	10.54	10.60	10.40	10.55	10.70	10.50	10.66
33.	5	4	I	10.21	10.30	10.45	10.55	10.00	10.25	10.70
34.	8	0	IV	12.78	12.80	12.35	12.80	12.80	12.80	12.99
35.	6	1	II	12.50	12.75	12.80	12.79	12.89	12.80	12.85

GROUP II HAEMOGLOBIN LEVEL
(g/100 ml)

No.	Age year-Month	Class	August	September	October	November	December	January	February
1.	10-0	V	12.70	12.50	12.65	12.75	12.30	13.05	13.10
2.	9-7	V	13.10	13.00	12.90	13.50	13.60	13.85	14.00
3.	9-9	V	11.50	11.70	11.60	11.65	11.65	11.99	12.55
4.	9-2	V	12.95	13.00	13.10	13.20	13.39	13.39	13.50
5.	9-4	V	11.20	11.25	11.35	11.25	11.20	11.40	12.39
6.	10-1	V	10.90	10.90	10.90	10.75	10.90	11.10	11.25
7.	8-1	IV	11.70	11.75	11.80	11.60	11.90	12.12	12.25
8.	8-5	IV	11.50	11.75	11.65	11.80	12.00	12.10	12.12
9.	8-1	IV	12.99	13.00	13.20	13.60	13.65	13.70	13.70
10.	10-3	IV	12.75	12.75	12.70	12.70	12.75	12.80	12.89
11.	8-1	IV	11.25	11.50	11.75	11.80	11.85	11.83	11.95
12.	8-8	III	10.90	10.90	10.90	10.90	11.15	11.85	11.95
13.	8-2	III	10.90	11.00	11.25	11.30	11.40	11.89	12.10
14.	7-6	III	9.95	10.10	10.15	10.20	10.20	10.32	11.01
15.	7-6	III	10.56	10.50	10.00	10.00	10.55	10.59	10.64
16.	7-1	II	12.20	12.25	12.35	12.30	12.30	12.31	12.39
17.	6-0	II	10.66	11.00	11.25	11.50	11.70	11.75	11.85
18.	6-1	II	12.56	12.55	12.50	12.90	13.30	13.60	13.71
19.	6-3	II	11.45	11.50	11.60	11.70	11.75	11.70	11.62

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sep-tem-ber	Oct-ober	Nove-mber	Dece-mber	Janu-ary	Febru-ary
20.	6-4		II	10.75	11.00	11.50	11.50	11.50	11.58	11.89
21.	5-9		II	10.75	10.75	11.50	11.56	11.50	11.60	11.60
22.	6-2		II	9.55	9.60	9.60	10.10	10.20	10.45	10.60
23.	5-3		I	10.30	10.35	10.50	10.80	10.99	11.40	11.50
24.	5-1		I	10.25	10.35	10.40	10.50	10.50	10.50	10.70
25.	5-4		I	10.45	10.50	10.50	10.60	10.65	10.69	10.75
26.	5-1		I	11.20	11.25	11.30	11.40	11.50	11.60	11.71
27.	9-11		V	12.45	12.50	12.50	12.55	12.60	12.60	12.90
28.	9-5		V	12.45	12.25	12.50	12.40	12.45	12.50	12.50
29.	8-6		IV	11.59	11.60	11.75	11.80	11.75	11.83	11.95
30.	6-11		II	11.67	11.70	11.75	11.80	11.80	11.85	11.85
31.	6-9		III	10.20	10.20	10.20	10.25	10.35	10.25	10.39
32.	7-8		III	11.77	11.70	12.00	11.90	12.00	12.10	12.15
33.	6-5		II	10.90	11.00	11.00	11.75	12.00	12.30	12.55
34.	7-3		III	10.59	10.60	10.75	10.80	11.00	11.50	12.02
35.	7-5		III	11.65	11.70	11.75	11.75	11.75	11.80	11.80

GROUP III HAEMOGLOBIN LEVEL
(g/100 ml)

No.	Age year-Month	Class	August	September	October	November	December	January	February
1.	10-1	V	12.70	12.70	13.00	13.20	13.20	13.52	13.60
2.	9-2	V	12.10	12.00	12.25	12.50	12.55	12.51	12.95
3.	9-6	V	12.50	12.60	12.75	12.99	12.20	13.30	13.50
4.	10-0	V	13.52	13.50	13.25	13.45	13.50	13.60	13.89
5.	10-1	V	10.21	10.25	10.25	11.10	11.20	11.92	12.55
6.	10-3	IV	10.10	10.15	10.50	10.90	11.59	12.00	12.95
7.	8-9	IV	11.10	11.30	11.75	11.90	12.10	12.47	12.67
8.	8-2	IV	12.57	12.60	12.75	12.70	12.70	12.89	12.99
9.	8-2	IV	11.10	11.15	11.30	11.30	11.75	11.87	11.50
10.	8-3	IV	11.59	11.60	12.00	12.50	12.90	13.10	13.75
11.	9-11	IV	9.26	9.50	10.00	10.45	10.50	10.50	10.75
12.	10-8	IV	10.70	10.90	11.05	11.45	11.60	11.70	11.90
13.	8-0	III	11.72	11.75	12.00	12.20	12.45	12.70	12.89
14.	7-3	III	11.99	12.00	12.10	12.20	12.40	12.50	12.65
15.	7-1	III	10.55	11.00	11.15	11.20	11.40	11.60	11.75
16.	8-4	III	12.32	12.50	12.55	12.70	12.90	13.25	13.51
17.	7-2	III	12.20	12.30	12.52	12.60	12.70	12.75	12.78
18.	6-2	II	10.54	11.00	11.11	11.50	11.75	12.00	12.50
19.	6-2	II	10.55	11.00	11.20	11.20	11.45	11.50	11.95

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sept-ember	Oct-ober	Nove-mber	Dec-em-ber	Janu-ary	Febr-uary
20.	6-1		II	12.50	12.50	12.44	12.45	12.60	12.78	13.99
21.	6-3		II	11.25	11.30	11.47	11.50	11.77	11.80	11.95
22.	7-3		II	10.90	11.00	11.20	11.33	11.40	11.42	11.48
23.	6-5		II	9.50	9.65	9.70	9.75	10.10	10.99	11.99
24.	5-2		I	11.79	12.00	12.20	12.20	12.20	12.22	12.28
25.	5-7		I	9.47	9.50	9.75	9.76	9.76	9.85	9.98
26.	5-5		I	11.95	12.00	12.12	12.20	12.40	12.80	12.99
27.	10-2		V	13.00	13.00	13.13	13.20	13.32	13.41	13.59
28.	9-3		V	12.56	12.60	12.75	12.90	13.00	13.54	13.99
29.	8-11		IV	12.62	12.65	12.80	12.85	12.90	13.00	13.10
30.	8-1		IV	11.20	11.25	11.32	11.35	11.70	11.90	12.90
31.	7-7		III	11.09	11.10	11.25	11.50	11.80	11.99	12.29
32.	8-3		III	11.21	11.29	11.39	11.50	11.99	12.25	12.50
33.	6-6		II	11.70	11.75	12.01	12.15	12.25	12.35	12.60
34.	7-0		II	9.70	9.70	9.75	9.75	9.80	10.50	11.30
35.	5-1		I	10.50	10.56	10.60	10.60	10.65	11.50	11.72

GROUP IV HAEMOGLOBIN LEVEL
(g/100 ml)

No.	Age ye-ar	Mon-th	Cla-ss	Augu-st	Sept-ember	Oct-Ober	Nov-amber	Dec-emaber	Janu-ary	Febru-ary
1.	10-7		V	12.52	12.59	12.67	12.99	13.20	13.48	13.72
2.	9-4		V	11.21	11.25	11.35	11.54	11.85	12.50	13.03
3.	9-2		V	12.30	12.40	12.50	12.80	13.59	13.79	13.95
4.	9-5		V	11.50	11.58	11.70	11.90	12.75	13.25	13.80
5.	9-0		V	11.21	11.35	11.45	11.55	11.80	12.00	12.55
6.	9-1		V	11.52	12.30	12.51	12.67	12.75	12.80	13.05
7.	9-7		V	12.50	12.65	12.80	12.95	13.11	13.30	13.51
8.	10-1		V	10.90	11.10	11.50	11.90	12.40	13.00	14.01
9.	10-11		IV	10.90	11.20	11.41	11.70	11.99	12.80	13.89
10.	8-3		IV	12.21	12.39	12.45	12.59	12.60	12.79	12.95
11.	8-9		IV	12.51	12.70	12.90	13.10	13.30	13.59	13.85
12.	9-3		IV	12.72	12.82	13.00	13.22	13.49	13.70	13.96
13.	7-2		III	11.25	11.50	11.75	12.10	12.40	12.95	13.20
14.	7-7		III	11.23	11.70	12.00	12.25	12.48	12.67	12.95
15.	8-2		III	10.90	11.21	11.40	11.60	11.85	12.10	12.75
16.	7-0		III	10.90	11.08	11.21	11.40	11.50	11.75	11.99
17.	7-1		III	11.15	11.80	12.00	12.20	12.50	12.80	12.99
18.	6-4		II	11.30	11.37	11.92	12.0	12.05	12.25	12.50
19.	6-4		II	10.90	11.10	11.27	11.51	11.91	12.57	13.07

No.	Age year-Month	Class	August	September	October	November	December	January	February
20.	6-2	II	12.22	12.25	12.50	12.80	13.10	13.49	13.94
21.	6-6	II	9.91	10.40	10.75	11.00	11.35	11.80	12.35
22.	6-1	II	12.30	12.35	12.50	12.50	12.80	13.20	13.91
23.	5-0	I	9.74	9.92	10.10	10.10	11.20	11.40	12.90
24.	5-4	I	10.23	10.32	11.02	11.20	11.40	11.75	12.99
25.	6-4	I	11.62	12.22	12.45	12.56	12.67	12.80	12.96
26.	5-6	I	11.31	12.12	12.68	12.80	13.20	13.40	13.90
27.	10-5	V	12.60	11.78	11.89	12.65	12.70	12.80	13.45
28.	9-4	V	13.20	13.38	13.50	13.75	13.90	14.05	14.27
29.	9-1	IV	12.10	12.35	12.85	13.00	13.25	13.45	14.09
30.	9-2	IV	11.50	12.10	12.50	12.61	12.70	12.80	13.20
31.	9-4	III	11.20	11.35	11.45	11.90	12.50	13.00	13.35
32.	6-6	II	11.57	12.10	12.25	12.60	12.90	13.10	13.50
33.	9-3	III	10.10	10.25	10.45	10.90	11.11	11.50	12.80
34.	6-2	II	10.21	10.99	11.01	11.22	11.80	12.01	12.55
35.	6-5	II	10.94	11.00	11.35	11.60	12.0	12.88	13.57