Anaemia, Work Output and Impact of Iron Fortified Salt Supplementation On Adult Women

BY

Rema N.

A DISSERTATION SUBMITTED TO THE BHARATHIAR UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE THROUGH SRI AVINASHILINGAM HOME SCIENCE COLLEGE FOR WOMEN (AUTONOMOUS) COIMBATORE.

MAY - 1988

Acknowledgement

ACKNOLWEDGEMENT

The author expresses her deep sense of gratitude to Dr (Mrs) Vijayalakshmi Purushothaman M.Sc Ph.D (Madras) Professor, Department of Foods and Nutrition, Sri Avinashilingam Home Science College for Women, Coimbatore for her dynamic guidance and valuable suggestion offered through out the course of the study.

The author is grateful to Mrs. Vasanthamani, M.Sc, M.Phil, Assistant Professor of Foods and Nutrition for her continuous encouragement and help extended through out this study.

The author extends her thanks to Dr (Mrs) Lakshmi Shantha Rajagopal M.Sc (Tennesse) Ph.D (Madras) Principal, Sri Avinashilingam Home Science College for Women, Coimbatore for all the help extended in this study.

The author owes her sincere gratitude to Dr (Mrs) Usha Chandrasekar M.Sc Ph.D (Purdue University) Head of the Department of Foods and Nutrition for the encouragement given in this attempt.

She records her deep sense of gratitude to Dr (Tmt) Rajammal P.Devadas, M.A., M.S; Ph.D (Ohiostate) D.Sc. (Madras), Director, Honorary Professor and Dean of Post Gradute Studies of Sri Avinashilingam Home Science College for Women, Coimbatore - 43 for granting permission, opportunity and for providing amenities to carry out the study.

The author records her thanks to Mr. Sundar, Director, Sundar Chemicals, Madras for supplying the iron fortified salt. Author also extends her thanks to Mr. Chinnasamy, Professor of Maruti College, Sri. Ramakrishna Mission Vidyalaya for their help in conducting the study.

The author renders her special word of thanks to all their subjects for their co-operation in carrying out this research.

CHAPTER	TABLE OF CONTENTS	PAGE NO:

LIST OF TABLES

LIST OF APPENDICES

LIST OF FIGURES

Introduction

I. INTRODUCTION

Malnutrition in a society results in a degradation of the human being which itself is a social problem that cries for a solution (Aree, 1984). Malnutrition which exists in all countries is a challenge to man's conscience and an opportunity to eradicate a social evil by methods which increase economic productivity.

Dallman, Simes and Stretkel (1980) Syolin (1981) and Nutrition News (1988) report that in developing countries the incidence of anaemia is high compared with that in industrialised parts of the world.

Finch etal (1983) point out that anaemia is more prevalent among the low income groups than among the moderate and high income groups. Several extensive surveys conducted all over the world reveal that the prevalence of anaemia varies from 10 - 50 percent or even more and most of the cases have been ascribed to iron and other nutritional deficiencies (Bengoa 1974).

Among the population groups those affected by anaemia are mainly children below school age, adult women of child bearing age and nursing women. It has been recently estimated by Maeyer (1984) that 200 - 250 million women in the world suffer from iron deficiency anaemia, the number of children affected is probably about the same, which means that at any time there are about 500 million people with anaemia due to iron deficiency.

Studies indicate that about 29 percent of school going children suffer from anaemia. (Nutrition News 1984). Rao (1987) reports prevalence of anaemia ranges from 60-70 percent both among women and children and 30-40 percent among adult males and older children in most parts of India, (Thiagarzi) warns that in India at least 50 percent of pre school children and 60 percent of the women suffer from anaemia. Iron deficency anaemia is so wide-spread that it is not restricted to vulnerable groups but affect a large cross section of the population including males without significant loss of blood. Studies conducted by National Institute of Nutrition (1980) show that a prevalence rate of 28-30 percent exists among men in rural India.

Anaemia is a major complication of pregnancy in developing countries and is believed to be a contributing factor in the increased incidence of genitourinary infections, still births, premature infants and in reduction of birth weight of infants (Easwaran etal 1982).

Anaemia reduces the work capacity due to early on set of fatigue and the productivity of non-anemic labourers was about 20 percent higher than that of their anaemic counter-parts (IBRD 1974).

The prevalence of iron deficiency anaemia and the resulting lowered work capacity of population groups brings home the pressing need for improving the condition of anaemic groups, especially women.

High prevalence of anaemia with special reference to iron deficiency in India leads to poor nutritional status greater incidence of morbidity and affects both physical and mental behaviour of the individual.

Haymes (1972) stresses that there is a real need for insuring an adequate iron intake in the diet of people who participate regularly in strenous physical activities, with special reference to women.

Rao (1985) opines that the only proven way through which anaemia can be alleviated is to increase iron intake, either by providing medicinal iron (supplementation) or by adding iron to the diet through fortification,or by increasing the intake of iron rich foods.

Benefits of anaemia alleviation include reduction in maternal and infant morbidity and mortality, lowered incidence of stunted growth and development, enhanced levels of productivity of industrial and agricultural workers and improvement in the over-all health status of the population (1985).

World Bank (1982) reports that iron supplementation increased the productivity of employees by 20 percent and has a high social cost benefit. Reduction of the percentage of people living below the poverty limit to an extent of about 10 percent amounting to about 70 million people can be accelerated by implementing measures to prevent anaemia and to treat people afflicted by anaemia, according to Thiagaraj (1984).

The incidence of anaemia in rural and urban communities of India was reduced by the introduction of salt, fortified with iron according to Nutrition Review reports (1983) and Vijayalakshmi etal (1986). These studies have proved that after iron supplementation, energy output decreased and work output increased. Fortification of salt helped to improve hemoglobin levels in the anaemic groups and prevented deterioration of hemoglobin, values in children Nadiger (1980).

Levin (1985) points out that fortification of salt with iron showed an increase of about 3g/dl of hemoglobin over the initial values.

A study conducted by Levin (1985) indicated that a rise in hemoglobin level by 10 percent is associated with a rise in work output by 10-20 percent.

A solution has to be evolved for improving the poor nutritional status of the population with special reference to their iron intake and hence present study has been undertaken, along these lines of thinking.

Salt is a substance which is universally consumed and centrally processed. Iron fortified salt has been commercially developed by some of the salt procuring companies, recently. The effectiveness of the fortified salt in improving the anaemic status and working capacity needs to be evaluated before making it available to the populations.

Hence the present investigation was undertaken with the following objectives.

1) To identify anaemic adult women.

2) To supplement iron fortified salt to these adult women.

3) To study the impact of supplementation of iron fortified salt on these adult women with reference to their biochemical picture and work efficiency.

Review of Literature

II REVIEW OF LITERATURE

The review of literature related to the present study on Anaemia, Work output and Impact of iron fortified salt supplementation on Adult Women is discussed under the following headings

A. Prevalence of Iron Deficiency Disorders

B. Anaemia and Work Output

C. Supplementation with Iron

D. Factors Affecting Iron Absorption

A. Prevalence of Iron Deficiency Disorders

Devadas et al (1981) observed that despite India's marvellous increase in food production, nutrition problems continue to be formidable. Malnutrition is still one of the unwanted obstacles in national development.

Anaemia constitutes a considerable problem of public health throughout the world specially in developing countries (Baker and De Maeyer (1979) and De Maeyer and Adiels-Tegman (1985).

According to Herberg et al (1981) nutritional anaemia is estimated to affect 500 million to 1 billion people world wide and around 10 to 20 percent of the population. Rates are as high as 80 to 90 per cent for pregnant women in certain areas of India, Bangladesh and Pakistan.

Hallberg et al (1984) found out that there is a high prevalence of iron deficiency anaemia in most developing countries. Haemoglobin survey in hospital attending urban slum population in India indicated that the prevalence of anaemia is still as what it was ten to fifteen years ago (Nutrition News, 1983).

The high frequency of anaemia in several parts of the world emphasises the importance of iron as a limiting nutrient. The prevalence of iron deficiency anaemia varies from 9 to 70 percent in different population groups examined (chandra, 1981).

Shukla (1982) reported that anaemia in a rural community of uttar pradesh, India, showed as overall prevalence rate of about 68 percent in pregnant women and 25 percent in non-pregnant women.

A study conducted by Ueno et al (1984) showed that 8 to 10 percent had low hemoglobin levels. Blot et al (1980) and Hecberg etal (1983) opined that the risk was increased during pregnancy and breast feeding with inadequate iron stores at the beginning of pregnancy and it was impossible to meet the increased need. Based on the world health organisation standard, 26.6 percent of the population were anaemic, the highest percentage of anaemic subjects were found at the age group below one year (51-3 %) and among pregnant women (48-60 percent Emilie et al, 1985).

Bothwell etal (1981) pointed out that women of child bearing age because of their increased iron losses due to menstruation constituted a group of 'at risk' due toiron deficiency.

Studies from Health and nutrition surveys by Johnson and Abraham (1979) confirmed that the mean value of blood hemoglobin and serum iron concentration as well as mean percentage transferrin saturation were higher for males than for females and for whites compared to blacks.

From studies conducted by Refino <u>et</u> <u>al</u> (1980) it is evident that some tissue iron compounds such as skeletal muscle, cytochrome C and myoglobin becomes depleted to a similar degree as haemoglobin, not only with servere iron deficiency anaemia but also when iron deficiency is relatively mild.

The major cause of anaemia in our country is iron deficiency due to inadequate intake of dietary iron and / or its poor absorption from cereal based diet consumed by our population (Rao, 1984 and 1987).

The mean nutrient intake of the anaemic subjects was inadequate with regard to energy, iron and retinol and it was lower than the nutrients consumed by non-anaemic groups (Vijayalakshmi and Selvasundari, 1983).

The global reduction of energy intake observed in the last decade has been followed by a decrease in iron intake making it more difficult to cover the requirement of some population groups (Dupin <u>et</u> <u>al</u>, 1983).

Hodges and Cantam et al (1978) established that anaemia is a consequence of inadequate intake of vitamin A.

Relatively high prevalence of iron deficiency existed among the elderly subjects and that iron deficiency contributed to low haemoglobin levels (Johnsonaand Walters, 1986).

Atheletes may be at risk of developing iron deficiency because of sweat losses, intestinal losses, haematuria, increased demand for increased total body haemoglobin and poor di.etary intake (Paulev et al 1983, stewart et al 1984 siegel et al 1979).

The main factor in the anaemia and lower vitamin B-12 was nutritional deficiency and in some cases bacterial infection and liver disorders (Mayer et al 1983)

Severe iron deficiency anaemia can lead to an over worked heart and reduced muscle function, faulty digestion, reduced production of hydrochloric acid in the stomach increased infections,reduction in iron containing enzymes, cellular damage, low iron stores and altered behaviour in children are additional hazards of an iron deficient condition (Wench et al 1983).

B. Anaemia and Work Output

Physical activity can be defined as the potential of an individual to engage in activities involving muscle action (WHO, 1975).

Iron deficiency anaemia affects the physical work capacity by reducing the availability of oxygen to the tissues which in turn affects the cardiac output and the heart eventually leading to death in severe cases (Vijayalakshmi et al, 1983).

Anderson and Barker, (1971) opined that significant changes in physical performance were noted only when the haemoglobin concentration was below 10g/dl. Studies conducted by Viteri and Torun (1974) on the working capacity of a group of agricultural workers with an increased prevalence of anaemia showed that anaemic workers had significantly lower sceres for physical performance test than non-anaemic control subjects.

Anaemic subjects with haemoglobin level below 12g/ 100ml in males and below 11.5g/ 100 ml in females had disturbances in attention and perception (Brown et al 1972 and Webb and Oski, 1973).

Iron deficiency anaemia induced in rats lowered both voluntary activity and ability to withstand forced exercise. The degree of impairment of performance is more closely related to haemoglobin level rather than to levels of other compounds containing iron (Grills, 1983).

Studies conducted by Hutton (1979) revealed that iron deficiency anaemia leads to a significant decrease in whole blood viscosity thus decreasing oxygen availability to the tissues.

Srikantia et al (1976) found out that the cell mediated immunity and bactericidal activity of circulating leuko cytes were below normal when haemoglobin concentration was below 10g/ dl.

Finch, (1979), Dougall *et al*, (1975) Leibel *et al*, (1979) and Brock *et al*, (1987) suggested that iron deficiency anaemia causes a defect in oxygen transport, impaired muscle metabolism, immune defects and cognitive disturbances.

Chandra, (1973) indicate that iron deficiency causes abnorm-alities in brain function in children. There is a good deal of experimental evidence suggesting that there is a decreased resistance to infection in iron deficiency.

Davies *et al* (1984) and Malhotra *et al*, (1985) showed hyperactivity of platelets in iron deficiency anaemia and reactivity returned to normal after correction of anaemia. When anaemia is corrected, performance in tolerance test is improved and oxygen consumption (VO_2) returns to almost normal.

Griesen (1980) and Nutrition News (1986) found that the haemoglobin level was high in those who received iron and after the running test, it was found that those who had lower haemoglobin values ran significantly shorter distance.

During very strenous strainful physical workthe red blood cells become fragile and there is transcient anaemia that is corrected after two weeks of training (Yoshimura, 1980).

A study conducted among cross country runners revealed that when they were not given iron tablets, they had a likelihood of having reduced iron stores developing iron deficiency (Pierce *et al*, 1985).

Basta (1977) and FAO (1977) had identified iron deficiency anaemia among the possible factors, limiting work output and physical capacity of male agricultural and road constructing workers in tropical conditions.

Apart from a reduced circulatory mass of haemoglobin, iron depletion also leads to reduced muscular performance due to a reduced concentration of iron containing enzyme in it (Finch et al, 1976).

Work output and productivity have also been shown to be low among anaemic rubber tappers and tea garden workers (Basta, (1979), Edgerton, (1979), and this condition could be corrected with iron administration.

According to Lakhanpal (1976) iron deficiency is a nutritional disorder where the mean corpuscular haemoglobin concentration falls below the accepted normal level which is described as hypochromic anaemia. The iron deficiency anaemia is characterised by decreased size of red cells, reduced serum iron and decreased haemoglobin concentration. Scot et al, (1982) proposed that in individuals engaging in moderate fitness type exercise, physiological adaptations occur so that anaemia is prevented and that iron stores are maintained at a some what compromised level. It is thus proposed that adaptation occurs and results in the maintenance of normal iron and haematological status.

Studies carried out in Indonesia have (Lancet, 1980) shown a relation between haemoglobin concentration and productivity in agricultural workers.

A study conducted among women receiving iron brought about an improvement in appetite, a sense of well being and decrease in tiredness and palpitation (Rahmattulah, 1983).

Iron requirement of children are closely related to growth. The requirements increase during periods of rapid growth both in preschool and school age children (INAOG 1977). Hall berg et al (1984) opined that anaemia had negative effects on health and well being.

Both well et al (1981) suggested that severe anaemia during pregnancy can be prevented by either iron supplementation or by food fortification.

Anaemic patients suffer from fatigueness, irritability dizziness, palpitation, head ache and breathlessness (Basta 1974). Joseph (1977) reported that chronic and severe anaemia results in cardiac failure second to the increased need of the mus cular man of oxygen.

Hammonds (1987) discusses the effects of iron deficiency anaemia to be growth retardation, faulty digestion loss of energy, increase in infection and failure to gain weight. It is important to find effective and realistic methods to counter act iron deficency. A study was conducted among women with iron deficency anaemia and it was pointed out that after supplementation of iron there was an increase in their haemoglobin level and body weight as well as the number of days worked Rahamathullah (1983).

World Bank reports, that iron supplementation increase the productivity of employees by 20 percent and has a high social cost benefit.

The incidence of anaemia in rural and urban communities of India was reduced by the introduction of salt fortified with iron according to Nutrition Review reports (1983) and Vijayalakshmi et al (1986).

A study conducted by Levin (1985) indicated that fortification of salt with iron showed an increase of about 3g / dl of blood in haemoglobin over initial values and a rise in haemoglobin by 10 percent is associated with arise in work output by 10-20 percent.

Rahamathullah (1983) pointed out that among women receiving iron brought about an improvement in appetite, a sense of well being and decrease in tiredness and palpiation.

In some studies, work output increased significantly following correction of the anaemia by administration of iron. Prolonged iron deficiency in rats impair work capacity even in the absence of anaemia. This is possibly due to a decrease in glycero phosphate deby drogenase activity in the skeletal muscle. The abnormality is rapidly reversed by iron therapy (Anderson 1970).

C. Supplementation with Iron

Iron deficiency is a world wide problem. Its prevalence varies among different groups and is relatively high among children and women. The main cause of iron deficiency in many population groups is inadequate intake and poor absorption of dietary iron which have a negative effect on health and well being. It is important to find effective and realistic methods to counter act the iron deficiency.

Fortified iron is designed as a long term strategy for maintaining iron status while requiring no special behaviour on the part of the recipients (Levin, 1985).

Both well _et al_ (1981) pointed out that severe anaemia during pregnancy could be prevented by either iron supplementation or by food fortification.

Rovand _et al_ (1981) found out that even though iron rich sources such as green leafy vegetables are cheaply available in large quantities in India, they are not widely included in the daily diet due to the ignorance of the nutritive value of the locally available food.

The findings coupled with the fact that the diets are purely vegetarian in nature and provided only non haem iron would indicate that the availability of iron from these diets was low (Shah and Sheshadri, 1984).

A study was conducted among women with iron deficiency anaemia and it was pointed out that after supplementation of iron there was an increase in their haemoglobin level and body weights. They also showed a marked improvement in work performance as well as in the number of days worked (Rahamathullah, 1983).

In a study conducted among adult women it was found out that haemoglobin level of anaemic subjects rose significantly after iron supplementation. The energy expenditure had been reduced after iron supplementation for performing the same [illegible] (Vijayalakshmi and Selvasundari, 1983).

A study conducted by Gardner et al, (1979) indicated that after one month of iron supplementation more tea was picked when the haemoglobin concentration was increased through iron supplementation than when it was not.

Malhotra et al (1978) concluded that inspite of possible interaction with other trace elements additional iron became available for haemoglobin synthesis.

Government of India has begun a programme in which every pregnant women is regularly given a tablet of iron and folic acid during the last trimester of pregnancy. This programme is administered through the maternal child health centre and is meant specially for prevention of anaemia among pregnant women (Mannual of Nutrition, 1982).

An alternative approach to combat iron deficiency in the population is through fortification of a suitable food item with iron. In Industrial countries these deficiencies may be caused by an increased use of refined food such as wheat flour of low extraction or a lower intake of energy due to lower energy expenditure of recent generation which in turn is often accompanied by a critically low intake of certain essential nutrients such as iron (Nutrition Review, 1980).

This is an approach which can be applied to large population groups at low cost and it has the advantage that the fortification, identification and co-operation of actually or potentially deficient individual is not a prerequiste according to Baker et al, (1977).

Since the usual channel of food distribution are used fortification does not require any special delivery system (Rao, 1982).

To set up an iron fortification programme a suitable vehicle to carry iron must be identified and the source and amount of iron to be added should also be determined (WHO, 1975).

Iron supplementation can be an effective way of combating anaemia and help in increasing the work output of population groups. It was studied that supplementation conserves energy and the work output is increased after supplementaion suggesting that anaemia decrease productivity and supplementation with iron improves work output (Vijayalakshmi and Selvasundari, 1983).

Studies conducted by Wenlock et al (1980) assumed that 10 percent of the domestic food intake was wasted on pets and such a deduction may be too high for large families.

Low intake of dietary intake of irondue to lowered food intake often seen among the poor further aggravates iron deficiency among our populations (Rao, 1984).

The type of iron used fof fortification must be something that is readily assimilated, does not cause undesirable conditions or change in the vehicle and is stable under locally prevailing storage conditions (WHO, 1975).

Ferric Ortho Phosphate has proved to be a more satisfactory form of iron for fortifying salt and has been reported to have reasonable absorbability provided, ascorbic acid or sodium hydogen phoshphate is added according to Narasinga Rao, (1977), Vijayasarathy (1975).

Absorption of ferrous sulphate and ferric ammonium citrate is fairly good and this reduced iron is absorbed about half as much as most stable salts.

Success in fortification of common salt has been claimed using a modification of this approach in which a stabilising agent was added to reduce the reactivity of the iron andacidifying agent to enhance the availability of iron at the time of ingestion (Rao, et al, 1980).

Nutrients added to salt should be fully available to the body where salt is eaten with food as to derive full nutritional benefits from fortification. Salt consumption in India varies within the range of 12 to 20 g with a mean of 15g/day for adult males with moderate activity.

Salts have been fortified in the following manner - 3.5 mg/kg of ferrous sulphate, orthophosphoric acid 3.5 mg/g and sodiumacid sulphate 5.0 mg/g. In this formula ferrous sulphate provided 1 mg/of iron/g of Salt, (Rao,1985).

Nadiger et al (1980) found an increase in the mean levels of both haemoglobin and packed cell volume at the end of one year of supplementation with fortified salt.

Studies conducted by Amne and Hegsted (1974) point out that ferrous sulphate is best absorbed.

Nadiger *et al* (1980) emphasised that ferrous sulphate is so highly bio available and cheap and it could be the yardstick against which preparations are tested.

Iron absorption would be higher in women and anaemic subjects who need higher amounts (Narasinga Rao, 1978).

Studies conducted by Romano *et al* (1979) indicated that the mean absorption from ferrous sulphate varies from 2 to 30 percent according to food vehicle mixed with the salt, the absorption from ferric ethylene diamine trichlore acetic acid remains practically the same.

All these data suggest that only a small amount of iron, about 10 mg daily, would be necessary to prevent iron deficiency anaemia even in those populations relying for their subsistence on vegetable food only.

Fortification of salt with iron has been accepted by the Government as a public health approach to reduce prevalence of anaemia. The iron fortified salt is now being introduced on a pilot scale in two districts of Tamil Nadu through public distribution system (Rao, 1987).

The ideal vehicle should be consumed by the vast majority of the target population in adequate amounts. They should be stable in colour and tasteand must be well absorbed when mixed with the vehicle and when the vehicle is added to the diet (Cook and Reusen, 1983).

Of the several dietary factors which influence iron absorption from the pool of non haem iron, tannins markedly decrease it, (Disler *et al*, 1978) while ascorbic acid increase it.

A study conducted by Murthy et al (1985) indicated that the addition of meat extract to rice and red gram dhal or ascorbic acid to bajra or ragi increased the available iron content of food. Tannins, phytic acid or ethylene diamine Tetra acetic acid added to food decreased the available iron content (Cumming, 1978).

Ferric ethylene diamine tri chloro acetic acid (EDTA) is claimed to be an excellent fortification compound partly because factors inhibiting to iron, ferrous salt absorption in cereals are not as inhibitory to ferric ethylene diamine trichloro acetic acid absorption (Both well, 1981).

The final identifiable cost for both supplementation and fortification is related to the higher energy needs for anaemic persons engaged in strenous activities or has been found that 10 percent increase in work output demands an additional daily energy requirement of 160 calories (Levin 1985).

D. Factors Affecting Absorption of Iron

Factors that affect the availability of dietary iron for absorption has been studied extensively. Impaired iron absorption resulting from high intake of various anti-nutrients such as phytates, dietary fibre and tannins and low intake of fleshy foods has been proposed as the cause of this inadequate iron status (Rao and Prabavathy, 1982).

Absorption of iron is inhibited by the presence of phosphate (Mousen and Cooke, Peter et al 1976, Levin, 1985).

Bowering, Masch and Lewis (1977) report that increasing the levels of dietary fat and changing to a more saturated fat source increase iron absorption in rats.

Disorders in metabolism of iron have been reported in vitamin A deficiency. It decreases haemoglobin and packed cell volume which have observed in human, rats, and horses (Meija et al 1979) and Hodges & Canham et al, 1978).

It is pointed out that the low absorption of iron observed from cereals and legumes is due to their high content of phytate and polyphenols (Cook et al, 1981, Morris et al, 1976, Hazel et al, 1987).

Fibre has little effect on non-heam iron absorption (Gelloidy et al, 1984). It is studied that there is no relationship between haemoglobin concentration and iron absorption (Fair-Weather et al, 1983, Trinided et al, 1980).

Ethylene diamine tetra acetic acid which is used as a food preservative causes a 50% reduction in the absorption of non-haem iron.

Several papers have presented evidence that transferrin and ferritin are the regulators of intestinal uptake and transfer of iron. The high iron diet appeared to suppress the total iron transported while the low diet enhances it. Anaemia is usually accompanied by hypolipidemia and a low blood viscosity.

Experimentally induced riboflavin deficiency in man and animals is associated with a number of physiological and biochemical lesions notably with an interference in iron metabolism and an impaired production of erythrocytes

1979)

Studies conducted by Galon et al (1986) point out that there is a direct relationship between anaemia, iron and folacin deficiency, haemoglobinopathies and parastic infection.

Coffee inhibits iron absorption (Hallberg and Rossander, 1982, and Morch et al, 1983) probably mainly due to its contents of tannin, but the inbibition is less marked than that of tea (Hallberg and Rosander, 1982 and Ikawa et al 1987).

Soya protein products have been shown to diminish the fraction of non-hame absorbed from a meal (Cook, Morch and Lynch, 1981). This inhibition can be counteracted by the addition of ascorbic acid.

Derman et al (1980)have suggested that the molar ratio of iron and ascorbic acid in a meal has a determing influence on the absorption effect of ascorbic acid. The addition of ascorbic acid and foods rich in ascorbic acid can then be expected to increase iron absorption markedly and may be considered a realistic alternative to iron fortification as proved by Hallberg and Rossander, 1984).

Cox and Peter (1980) indicate that iron deficiency reversibly induces brush border iron carriers and suggest that in man initial entry into the erythrocytes rather than cellular relation of iron is a major regulatory step in control of iron absorption.

A block has been noted in the reversible microcytic hypo chromic anaemia due to aluminiu, intoxication by tri valent aluminium acquired from haemodialysis water, (shoft wenney and Rohsow 1980).

Problems of anaemia caused by a low iron diet can be solved by increasing the dietary iron intake in different affluent societies (Ruby Das 1987).

Sweat losses of iron have been noted among population, living in hot climate and in atheletes engaged in endurance sports with excessive training over a long period of time (Brene _et al_ 1986).

Wheat bran has been shown to inhibit non-haem iron absorption, (Simpson _et al_, 1981). Phosphate salts in the presence of sufficient calcium have been shown to promote non-hame iron absorption (Miller _et al_, 1981, Levin, 1985).

The reason why man can absorb the heme in meat products so well and the iron in grain products so poorly is not known, but may relate in part atleast to the fact that it is only comparitively recently in evolutionary terms that he has abandoned his hunting gathered life style in favour of a more settled agricultural existence. (Thomas, Bothwell, Robert 1984).

Study conducted by Skinner _et al_ (1985) showed that iron in snacks was mostly non-hame iron and amount of enhancing factors were low. Adolescents consume one-third of their calories as snacks jusfiying their poor nutritional status of iron.

Experimental Procedure

III EXPERIMENTAL PROCEDURE

The experimental procedure pertaining to the present investigation on anaemia, work output and Impact of Iron Fortified Salt Supplementation on adult women is presented under the following headings

A. Selection of Area

B. Selection of Subjects

C. Assessment of Nutritional Status of Subjects

D. Determination of Work Efficiency of Subjects

E. Supplementation With Iron Fortified Salt

F. Evaluation of the Effectiveness of the Supplementation.

A. Selection of Area

Ramanathapuram, a village near Thudiyalur in Coimbatore Direct was selected for conducting the research work. This village was chosen as there were adequate number of anaemic and non-anaemic women available and a good rapport had already been established through constant contact with the village people. The subjects also were very co-operative.

B. Selection of the Subjects

There were 78 families living in Ramanathapuram village and the adult female population of the village was 429. Based on their haemoglobin values and body weight 54 adult women were chosen for the study in the age group of 20-39 years and all of them were doing moderate work. They were divided into three groups of eighteen women each having approximately equal body weight. The details of the groups thus selected were as follows

GROUP I

Group I constituted the experimental group with eighteen adult women. All the eighteen women were anaemic with haemoglobin levels below 9g/100ml of blood. This group of women were selected for supplementing the iron fortified salt. This group will be referred as anaemic beneficiary group.

GROUP II

A second group of eighteen adult women who were anaemic with haemoglobin levels below 9g/100ml of blood served as the anaemic non-beneficary group. They did not receive any supplement.

GROUP III

Group III constituted the non-anaemic control group with eighteen adult women who were normal and healthy with haemoglobin levels above 11g/100 ml of blood.

C. Assessment of Nutritional Status of the Subject

The overall nutritional status of all the fifty four adult women were assessed through anthropometric measurements, clinical examination, biochemical changes and diet survey.

1. Anthropometric measurements

The two reliable measurements namely weight and height were used for evaluation.

The weight of all the selected adult women were taken in the morning after bowel movement and before breakfast, using a spring balance.

The accuracy of the balance was periodically checked with standard weights. Weight was recorded nearest to 0.5 Kg.

The heights were measured using a fibre glass tape fixed to the wall, and read to the nearest 0.5 cm.

2. Clinical examination

All the subjects were clinically examined for the presence of any symptoms of iron deficiency or any other deficiency symptoms. A proforma was prepared and used for the examination. Clinical examination was conducted before and after the supplementation period of one hundred any twenty days. The details of the proforma are given in Appendix VII.

3. Biochemical examination

The biochemical examination was done through the analysis of blood. The blood was analysed for haemoglobin, serum iron, total iron binding capacity and packed cell volume. Haemoglobin was analysed using cyanmethaemoglobin method of Varley (1981).

The serum iron and the total iron binding capacity were analysed using $\alpha\alpha$ Dipyridyl method of Ramsay (1958).

Packed Cell volume was estimated using wintrobe macro method of Henry (1986). The details of the procedures followed are given in Appendix III.

4. Diet Survey

The food habits of the population groups are the key causative factors of deficiency diseases. Hence, to evaluate the dietary practices of the subjects a one day food weighment survey was conducted at the beginning of the study.

The diet survey was conducted on a sub-sample of ten subjects from each group.

The raw food items were weighed individually before cooking. After the food was cooked the total cooked food was weighed and weight recorded. Then the subjects were requested to consume the food. After consumption the quantity of food that is left unconsumed was also weighed and subtracted from the total cooked weight of the food to know the exact amount consumed by the subjects.

From this method, the quantity of food consumed by the individual was calculated. The raw ingredients consumed were then computed from the quantities of cooked food. The nutrients consumed by the individual in dailydiet calculated using the Nutritive value of Indian Foods (ICMR, 1984). Individual food consumption pattern of both male and female anaemic and non-anaemic groups are given in Appendix IV.

D. Determination of work efficiency of the subjects

Determination of work efficiency of the subjects was done through two activities namely washing clothes and cutting wood. All the subjects in the group I (anaemic beneficiary) group II (anaemic non-beneficiary) and group III (non anaemic control) were requested to perform the activities continously for a period of 10 minutes. The blood pressure and pulse rate were recorded before and after performing the activities. Two tests namely Harvard step test and Cooper's test were also used for evaluating the work efficiency of the subjects.

1. <u>Recording pulse rate and blood pressure of the subjects during the two activities (Auscultatory methods)</u>

The instrument is kept at the level of the heart and the cuff is tied around the upper arm. Pressure is raised to 200 mm Hg and then gradually released. Variations of sounds are heard with a stethoscope placing its chest piece on the brachial artery, a little below the cuff. The sounds are heard due to occurence of turbulance in the flow of blood through the narrowed blood vessels, when the manometric pressure just coincides with the systolic blood pressure.

Due to gaining air pressure in the cuff, the vessel is pressed and blood flow obliterated. But while releasing the air pressure gradually, blood just begins to flow through the narrowed blood vessels and the pattern of flow is changed from stream line flow (silent) to turbulent flow (noisy). When the pressure is further released normal stream line flow sets in and the sound is no longer heard. At this point manometric pressure coincides with the diastolic pressure so as the pressure is released, the following variations of sounds are heard. First phase-sudden appearance of a clear tapping sound. This indicates systolic pressure. It persists while the pressure falls through 15mm Hg. Second phase - the tap sound is replaced by a murmur persisting after another 15mm Hg. Third phase the murmur is replaced by a clear loud gong sound lasting for the next 20 mm Hg. Fourth phase - the loud sound suddenly becomes muffled and rapidly begins to fade. This point indicates diastolic pressure. Fifth phase - absense of all sounds.

2. Harvard step test

Harvard step test was conducted on all, the three groups of subjects Harvard step test is done to find out the heart recovery rate using the procedure suggested by Barry and Nelson (1968). The subject stands before the bench and on command begins to step up the bench with one foot first and then the next. Now both her feet are on the bench and then she steps down with one foot followed by the next foot.

Two steps down and two steps up denotes one count. Counting is continued till 90 counts are reached. This under normal conditions consumed a period of three minutes. The body should be erect when she steps on to the bench. There is no regulation regarding which foot the subject should put forth first.

The subject continues to exercise for three minutes unless the feels that she must stop before the specified time because of exhaustion. As soon as she stops exercising she sits down and remains seated and quiet throughout the pulse counts.

The pulse rate is felt at the carotid artery and is counted from half to one minute after exercise. The same procedure the Harvard step test. The time is noted and pulse is counted for thirty seconds.

SCORING

$$\frac{\text{Number of seconds completed} \times 100}{\text{Recovery pulse} \times 5.6}$$

5.6 is a constant value.

3. Cooper's Test

Cooper's test was conducted on all the subject in three groups.

The procedure adopted is presented in the following paragraphs:-

Cooper suggested that a specific course be measured in distance so that the number of laps completed can be counted and multiplied by the course into quarters or eights by placing markers.

This enables the tester to quickly determine the exact distance covered in nine minutes. A stop watch, whistle and distance marker are needed for group testing.

It is usually most efficient to assign each runner to a spotter. The runners start behind a line and upon the starting signal run and/or walk as many laps as possible around the course within nine minutes. The spotters maintain a count of each lap and when the signal to stop is given, they immediately run to she spot at which their runners were at the instant, the whistle on command to stop was given.

The score in yards is determined by myltiplying the number of complete laps times, the distance of each lap plus the number of segments of an incomplete lap, plus the number of yards stepped off between a particular segment.

E. Supplementation with Iron fortified salt

As cooking salt is used by all the families and as iron fortified salt was available iron supplementation was done by distributing the iron fortified salt to all the families of the anaemic subjects belonging to group I. Iron fortified salt was obtained free from Sundar Chemicals, Madras. According to Indian Consumption pattern, 12-15 g of table salt is consumed by each individual (Franh, 1962). Accordingly the subjects in the present study consumed 15-17g of iron fortified salt per day. One gram of fortified salt provided 1 mg of iron and the fortified salt did not have any change in taste and colour and was similar to the unfortified salt.

About 6 kg of salt was provided to each family and the families were instructed to use only the iron fortified salt for all cooking and as table salt. Six kilo gram of salt was distributed as per the studies made by Vijayalakshmi et al, (1987), who have indicated that 6kg would last for a period of approximately three months. So through iron fortified salt alone, the individual aconsumed 15 to 17 milligrams of iron per day.

Evaluation adds the ingredient of a value of judgement of a programme and it includes a recommendation for some course of action (Best, 1978).

At the end of 120 days of iron supplementation for the anaemic beneficiary group the improvements with reference to any changes in the work efficiency of all the subjects in the three groups were evaluated, by subjecting them to the activities namely washing the clothes and cutting wood for the specified time. They were also made to undertake the Harvard step test and Cooper's test again.

The blood pressure and pulse rate were recorded after supllmentation. The haemoglobin, serum iron, total iron binding capacity and packed cell volume were also estimated at the end of the 120 days of supplementation. The improvement shown in the blood pressure, pulse rate and the blood picture were analysed and discussed.

Results and Discussion

IV RESULTS AND DISCUSSION

The results and discussions pertaining to the study on, "Anaemia work output and impact of iron fortified salt supplementation among adult women", are presented under the following headings.

A. Mean food and nutrient intake of the selected subjects.

B. Mean height and weight of the selected subjects.

C. Clinical examination.

D. Biochemical picture of the selected subjects.

1. Mean haemoglobin levels
2. Mean serum iron levels
3. Total iron binding capacity and packed cell volume.

E. Blood pressure and pulse rate after selected activities

F. Work output as judged by Harvard step test.

G. Work output as judged by Cooper's test.

A. MEAN FOOD AND NUTRIENT INTAKE OF THE SELECTED SUBJECTS

Table I shows the mean food intake and the percentage deficits of foods of the selected subjects. The individual values are presented in Appendix V.

TABLE I

MEAN FOOD INTAKE AND PERCENTAGE DEFICIT OF SUBJECTS IN THE THREE GROUPS

Subjects		Cereals g	Pulses g	Green Leafy vegetables g	Other Vegetables g	Roots and Tubers g	Fruits g	Milk	Fats and Oils g	Sugar and Jaggery g	Meat and Fish g	Egg g
ANAEMIC	A.I	236	39	39	53	25	0	85	18	13	0	0
BENEFICIARY	P.D	33	29	69	23	67		15	55	57	0	0
ANAEMIC	A.I	248	34	22	47	38	0	85	9	13	0	0
NON BENEFICIARY	P.D	29	38	81	37	49		15	78	57	0	0
NON ANAEMIC	A.I	360	40	52	68	53	0	148	22	17	6	10
	P.D		27	58	9	29	0	-	45	43	80	67
FOOD ALLOWANCES 1985		350	55	125	75	75	30	100	40	30	30	30

A.I - Actual Intake

P.D - Percentage Deficit

From Table I it is evident that except for cereal consumption by the non-anaemic subjects in Group III the intake of all the other foods were inadequate for the subjects in the three different groups. The intake of fruits was nil for all the three groups. The percentage deficit ranged from 15 to 69 percent among the anaemic beneficiary group; 15 to 78 percent for the anaemic non-beneficiary group and 9 to 80 percent for the non-anaemic group.

Mean Nutrient Intake of The Selected Subjects

Table II shows the mean nutrient intake and the percentage deficit of nutrients of the selected subjects. The individual values are presented in Appendix VI

TABLE II

MEAN NUTRIENT INTAKE OF SUBJECTS

Details of Subjects		Energy k.cal	Protein g	Calcium mg	Iron mg	Retinol ug	Thiamine mg	Fibo Flavin mg	Niacin mg	Vitamin C mg
Anaemic	A.I	2060	27	411	24	694	1.21	1.0	10	35
Bene-ficiary	P.D	6	40	Nil	20	7.5	Nil	1.6	13	30
Anaemic	A.I	2040	32	440	25	694	1.00	1.0	11	35
Non Bene-ficiary	P.D	7	29	Nil	17	7.5	9.09	1.3	27	30
Non-	A.I	2100	43	474	31	723	1.21	1.1	12	39
Anaemic	P.D	5	4	Nil	Nil	.5	Nil	1.0	20	22
RDA (1985)		2200	45	400 to 500	30	750	1.10	1.2	15	50

A.I - Actual Intake

P.D - Percentage Deficit

Table II indicates that the intake of protein, iron, riboflavin, niacin and ascorbic acid were very much deficient in the case of anaemic (beneficiary) and anaemic (non-beneficiary) when compared with the Recommended Dietary Allowances of nutrients by ICMR (1985). The deficiency was not much in the case of non-anaemic subjects. When the percentage deficits were calculated it indicated a greater deficit in the case of protein, iron, niacin and vitamin C, which probably aggregated the anaemic condition in the subjects.

The percentage deficit of protein was 40, 32 and 4 percent in the case of anaemic beneficiary, anaemic non-beneficiary and non-anaemic subjects. The percentage deficit of iron was 20, vitamin C 30 percent and niacin 33 percent for the anaemic beneficiary group. The percentage deficits of these nutrients were low for the anaemic non-beneficary group also. But the deficit was not much in the case of non-anaemic subjects.

Such low intakes of essential nutrients are responsible for the incidence of anaemia in the anaemic subjects. Such poor intakes have been observed by Rao (1987) and Vijayalakshmi et al (1987) also.

B. Mean heights and weights of the selected subjects:

Table III presents the mean body heights and weights of anaemic beneficiary, anaemic non-beneficiary and non-anaemic subjects. The individual values are given in Appendix VI.

TABLE III

MEAN HEIGHTS AND WEIGHTS OF THE SUBJECTS

SUBJECTS	HEIGHT in cm	WEIGHT in kg.
ANAEMIC BENEFICIARY	157 ± 2.12	44 ± 2.69
ANAEMIC NON-BENEFICIARY	159 ± 2.89	47 ± 3.41
NON-ANAEMIC	160 ± 2.68	48 ± 2.30
ICMR (1984)	-	45

The anaemic beneficiary subjects had recorded a height of 157 cms while the anaemic non-beneficiary subjects recorded a height of 159 cms and the non-anaemic subjects had recorded 160 cms.

The mean weight of the anaemic beneficiary subjects was 44 Kg, that of anaemic non-beneficiaries 47 Kg, and that of non-anaemic subjects 48 Kg. ICMR (1984) suggests a value of 45 Kg for a reference Woman and all the subjects in the present study have registered values slightly higher or lower than the suggested values.

C. RESULTS OF CLINICAL EXAMINATION

Table IV gives the clinical assessment data of the subjects in the three different groups at the start of the study. The individual values are presented in Appendix VII.

TABLE IV

CLINICAL ASSESSMENT OF SELECTED SUBJECTS

Signs and Symptoms	Anaemic (beneficiary)		Anaemic (Non-Beneficiary)		Non-Anaemic	
	No	percent	No	Percent	No	Percent
Poor musculature	7	35	7	35	Nil	Nil
Deficient Sub-cutaneous fat	9	45	2	10	Nil	Nil
Anaemic Mild	8	40	12	60	Nil	Nil
Anaemic Severe	12	60	8	40	Nil	Nil
Red/Raw/Glazed tongue	Nil	Nil	1	5	Nil	Nil
Bleeding of gums	Nil	Nil	3	15	2	10
Angular Stomatitis	Nil	Nil	2	10	1	5
Dry/Rough skin	7	35	2	10	3	15

The results of the clinical examination showed that a majority of the cases (35 percent in anaemic beneficiary and anaemic non-beneficiary group) had poor musculature while only five percent of the non-anaemic group had poot musculature. Forty five percent of the anaemic beneficiary subjects, 10 percent from the anaemic non-beneficiary subjects and no one from non-anaemic group had deficient subcutaneous fat deposition.

All the subjects in the anaemic beneficiary and anaemic non-beneficiary group suffered from anaemia and out of this 60 percent of the beneficiary group was suffering from severe anaemia and 40 percent from the anaemic non-beneficiary group was suffering from severe anaemia. Clinical examination also revealed evidence of B-complex and vitamin C deficiency in the form of red raw tongue and bleeding gums among the anaemic non-beneficiary and non-anaemic subjects, ten to thirty five, percent of the subjects in the three different groups had dry and rough skin.

D. Biochemical Picture Of The Selected Subjects

1. Mean Haemoglobin Levels

Table V depicts the mean haemoglobin levels and serum iron levels of the anaemic beneficiary, anaemic non-beneficiary and non-anaemic subjects. The individual values are given in Appendix - VIII. The mean levels of haemoglobin are diagramatically represented in figure 2.

gure 2. Initial and final hemoglobin values of anaemic, naemic non-beneficiary and non-anaemic subjects.

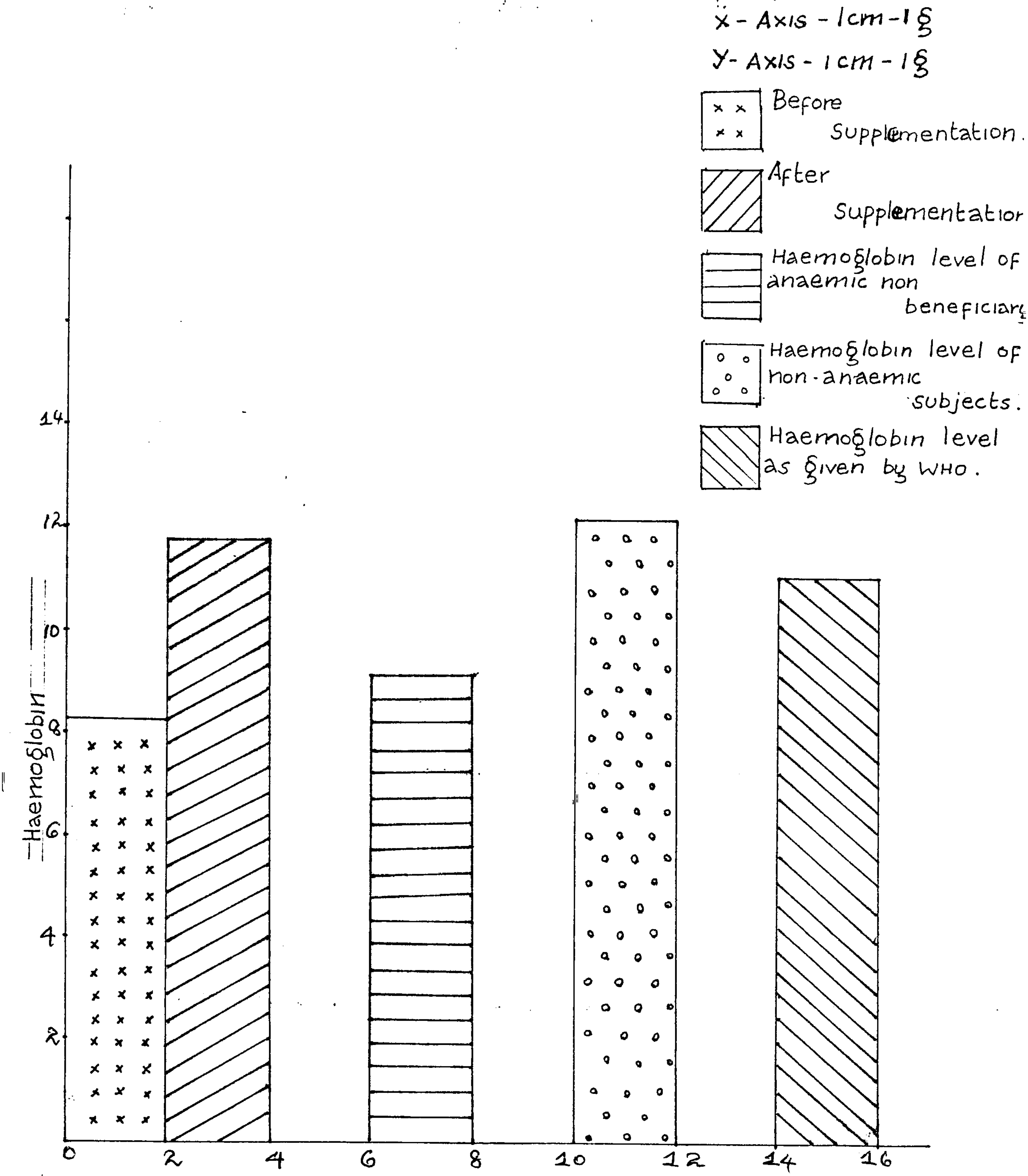

TABLE V

MEAN HAEMOGLOBIN AND SERUM IRON LEVELS OF SUBJECTS IN THE THREE GROUPS

Subjects		Haemoglobin g/100 ml	Serum Iron ng/100ml
ANAEMIC BENEFICIARY	B.S	8.23 ± 28	58.9 ± 7.27
	A.S	11.68 ± 0.42	90.5 ± 8.43
ANAEMIC (NON-BENEFICIARY)		9.10 ± 0.83	70.2 ± 8.38
NON-ANAEMIC		12.14 ± 0.72	105.8 ± 6.74
WHO		11.00	60

B.S. Before Supplementation

A.S. After supplementation.

Table V shows that the anaemic beneficiaries had recorded a mean haemoglobin level of 8.23 g/100 ml before the start of the iron fortified salt supplementation. For the same subjects the haemoglobin levels were estimated again after the supplementation period was over and at that time the mean value was 11.68g/100 ml. The anaemic non-beneficiaries had recorded 9.1g/100 ml and the non-anaemic subjects had recorded a value of 12.14g/100 ml. WHO suggests a value of 11g as the demarking point between anaemic ana non-anaemic subjects. As judged by this value the anaemic subjects who were supplemented with iron fortified salt had actually become non-anaemic at the endof the study by registereing a value of 11.68g/100 ml.

There was an increase of 3.46g/100 ml in the haemoglobin levels of anaemic beneficiary group. These results indicate the beneficiary effects of supplementation of iron in the long run. These results are in line with the results of Rahamatullah (1983) and Rao (1985) who are of the view that salt supplementation is beneficial.

The mean serum iron level of anaemic beneficiary before supplementation was 58.9μg/ml. However at the end of the supplementation period they had recorded a mean value of 90.5mg/100 ml. Varley (1980) reports that a value of 60mg/100ml may be considered as acceptable levels of serum iron for adult females. In the present study initially the anaemic beneficiaries had recorded values lower than 60 and due to the beneficial effects of the supplementation the values had increased to 90.5mg/100 ml at the end of the study.

Anaemic non-beneficiaries had recorded a serum iron of 70.2mg/100 ml and the non anaemic subjects had recorded 105.8 mg/100ml and both the values were above the acceptable levels suggested by Varley (1980).

The poor iron status of the anaemic subjects is probably due to the inadequate intake of nutrients and low or no intake of fleshy foods as stated by Rao and Prabhavathy (1982).

On supplementation with iron fortified salt there was a significant increase in the serum iron from a level of 58.9 μg/100 ml to 90.5μg/100ml with an increase amounting to 31.6μg/100ml. This increase in serum iron level in the anaemic beneficiary group points out the effectiveness of supplementation of iron through salt. This view is endorsed by Dahlan (1984).

Table VI presents the packed cell volume and the total non binding capacity of the subjects. The individual values are given in the Appendix IX

TABLE VI

MEAN PACKED CELL VOLUME AND TOTAL IRON BINDING CAPACITY OF THE SUBJECTS

SUBJECTS		PACKED CELL VOLUME	TOTAL IRON BINDING CAPACITY
Anaemic	B.S.	24.6 ± 1.24	379.3 ± 50.34
	A.S.	33.8 ± 1.84	295.5 ± 28.15
Anaemic non-beneficiary		27.5 ± 2.40	343.5 ± 33.32
Non Anaemic		35.5 ± 1.84	291.7 ± 15
Varley (1980		35	300

B.S. Before Supplementation

A.S. After Supplementation.

The packed cell volume values recorded by the anaemic beneficiaries was 24.6 before supplementation and after supplementation period the value had increased to 33.8. The anaemic non-beneficiaries had recorded a value of 27.5, and the non-anaemic subjects had recorded a packed cell volume of 35.5. The value recorded by the non-anaemic group. can be considered as normal, since Varley (1980) has recommended a value between 35 and 47 as normal. After the supplementation period the anaemic beneficiary group had recorded a value of 33.8, which lies close to the normal value. Supplementation had enhanced the packed cell volume in the anaemic beneficiary subjects. Similar results have been obtained by Nadiger (1980).

Disorders in metabolism of iron have been reported in vitamin A deficiency, when there is a reduction in haemoglobin and packed cell volume in Man (Canham and Hodges, 1979).

The total iron binding capacity of the anaemic beneficiaries before supplementation was 379.2 and the values recorded after supplementation for total iron binding capacity was 292.1. The anaemic non-beneficiaries had recorded a value of 343.5 and the non-anaemic subjects had recorded 291.7. Low intake of dietary iron due to the lowered food intake often seen among the poor population groups further aggravates iron deficiency (Rao, 1984).

In anaemic there in an increase in the total iron binding capacity as seen among the anaemic groups with a value of 379.1 ng. But after iron supplementation the value recorded was 293.5 which is close to the value stated by varley (1980) as 300 ng/100 ml.

E. BLOOD PRESSURE AND PULSE RATE AFTER SELECTED ACTIVITIES

The anaemic beneficiary group, the anaemic non beneficiary group and the non anaemic group were subjected to a study of their work efficiency is cutting wood and washing clothes.

Table VII represents the mean blood pressure and pulse rate of the three groups before and after the specific activity namely washing clothes. Individual values for all the subjects in the three groups are given in Appendix X. The differences in pulse rate are shown in figure 3.

Figure 3. Initial and final pulse rate before and after supplementation anaemic, anaemic non-beneficiary and non anaemic subjects.

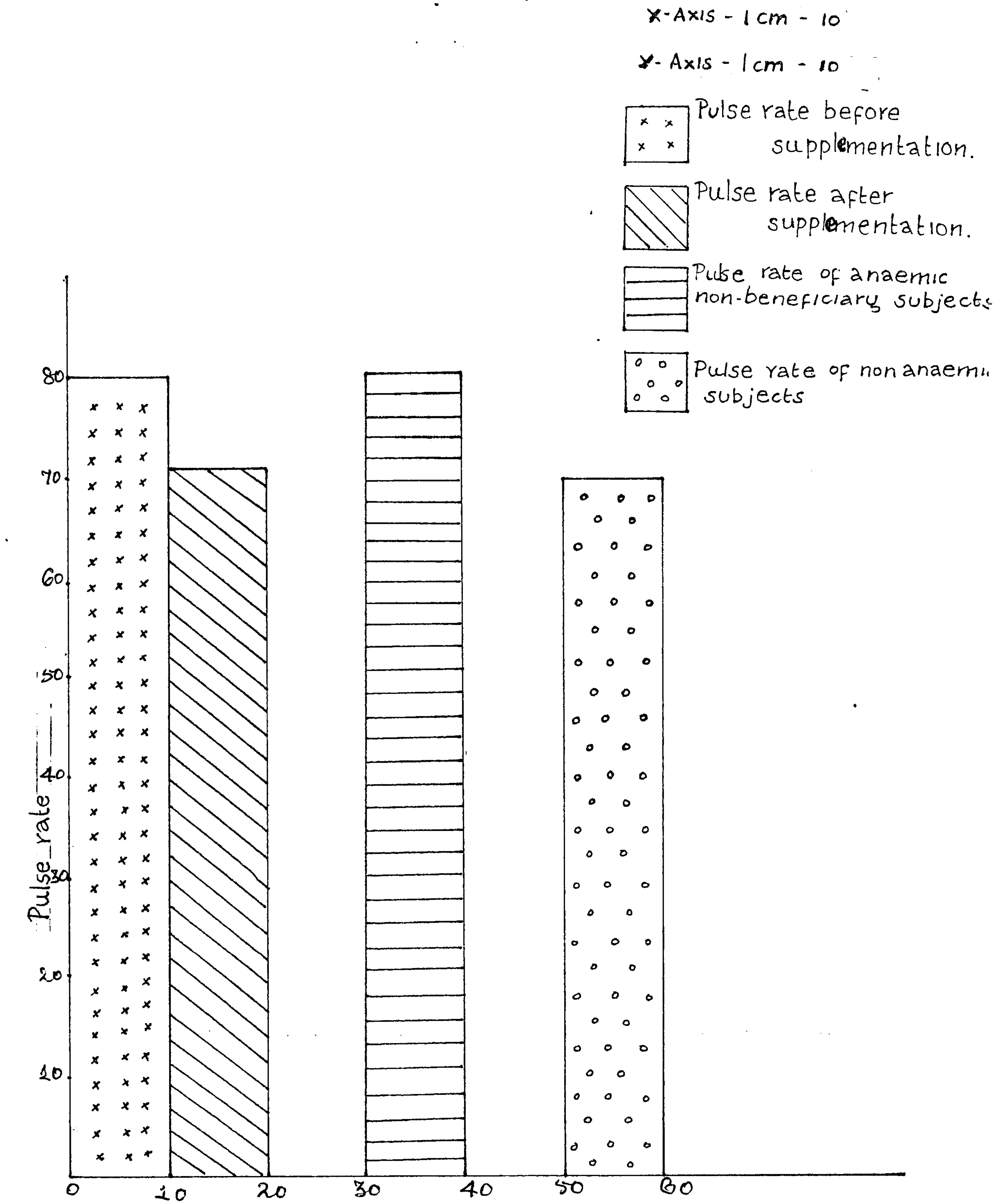

TABLE VII

MEAN BLOOD PRESSURE AND PULSE RATE OF THE THREE GROUPS WHILE WASHING CLOTHES

Details of Subjects		Pulse rate		Blood Pressure	
		Before Activity	After Activity	Before Activity	After Activity
Anaemic (Beneficiary)	B.S	80 ± 2.07	104 ± 2.40	117/78 ± 2.14 ± 2.10	121/81 ± 1.09 ± 1.80
	A.S	72 ± 1.88	81 ± 2.70	118/79 ± 1.84 ± 1.70	120/81 ± 1.17 ± 1.34
Anaemic-Non-Beneficiary		81 ± 2.23	102 ± 1.99	118/80 ± 2.05 ± 2.07	121/81 ± 1.70 ± 1.71
Non-Anaemic		70 ± 0.98	81 ± 1.46	177/79 ± 1.95 ± 3.80	120/81 ± 0.99 ± 2.89

B.S - Before Supplementation

A.S - After Supplementation

From Table VII it is obvious that for all the subjects in the three different groups, the pulse rate had increased after the activity namely washing clothes, irrespective of whether they were anaemic or non-anaemic. However the rate of increase was much less in the non-anaemic group. The anaemic non-beneficiary group and the anaemic beneficiary group before supplementation had marked increase in pulse rate after washing the clothes indicating that they had to exert more to carry out the same activity than their counterparts in the non-anaemic group. The anaemic group after supplementation, however recorded values which were similar to the non-anaemic group indirectly showing the beneficial effects of supplementation.

Wang et al (1986), endorses this finding through his statement that, "in anaemic condition there is a decrease in work efficiency which is reversed by supplementation of iron". work output and productivity have also been shown to be low among anaemic rubber tappers and tea garden workers (Basta 1979), and Edgerton (1979) and this conditon could be corrected with iron administration.

The blood pressure levels of the subjects in the three different groups did not show any significant variation before and after supplementation and before and after activity.

Table VIII presents the mean blood pressure and pulse rate of the subjects while cutting wood.

TABLE VIII

MEAN PULSE RATE AND BLOOD PRESSURE OF THE THREE GROUPS WHILE CUTTING WOOD

Details of Subjects		Pulse rate		Blood Pressure	
		Before Activity	After Activity	Before Activity	After Activity
ANAEMIC					
Beneficiary	B.S	81 ± 2.80	103 ± 2.34	117/78 ± 2.44 ± 2.83	120/80 ± 1.37 ± 1.37
	A.S	72 ± 1.69	81 ± 1.95	118/79 ± 1.63 ± 1.99	120/80 ± 1.37 ± 1.37
Anaemic non-beneficiary		82 ± 2.13	104 ± 2.29	118/80 ± 2.07 ± 2.07	121/80 ± 1.37 ± 1.75
Non Anaemic		71 ± 1.42	81 ± 1.78	118/79 ± 2.05 ± 2.70	120/80 ± 0.73 ± 0.87

B.S - Before supplementation

A.S - After supplementation

Table VIII indicates that for the second activity of cutting wood, the pulse rate had increased at the end of the activity for all the three groups. But, the rate of increase was less in the case of non-anaemic group and after supplementation for the anaemic beneficiary group. For the anaemic non-beneficiary group and anaemic beneficiary group before supplementation the rate of increase in pulse rate was more after doing the activity indicating the same fact that they had to exert more to carryout the same activity than their counterparts in the non anaemic group and anaemic beneficiary group after supplementation.

The blood pressure levels of the subjects in the three different groups did not show any significant variation after the activity.

F. WORK OUTPUT AS JUDGED BY HARVARD STEP TEST

Table IX presents the mean recovery pulse rate and cardiovascular efficiency as judged by Harvard step test. The individual values are given in Appendix XI.

TABLE IX

PULSE RATE AND CARDIOVASCULAR EFFICIENCY AS JUDGED BY HARVARD STEP TEST

Details of Subjects	Pulse rate at 30 sec recovery	Cardiovascular efficiency scores
Anaemic Beneficiary	49 ± 5.21	64 ± 6.04
Anaemic Non-beneficiary	50 ± 4.63	62 ± 6.38
Non-Anaemic	48 ± 2.99	59 ± 4.79

The mean cardiovascular efficiency scores of the anaemic subjects was 64 after activity ; that of anaemic non-beneficiaries was 62 and the non-anaemic subjects recorded a score of 59. Johnson and Nelson (1968) have reported on cardiovascular efficiency scores. They have indicated that a score between 49-59 can be considered as good; 60-70 very good and 71-80 excellent. In the present study according to this criteria non-anaemic subjects will fall in the category of good and the anaemic beneficiary group and anaemic non-beneficiary group will be considered as very good.

In the Harvard step test when the pulse rate at 30 seconds recovery was conducted the pulse rate was in the range of 49, 50 and 48 for the anaemic beneficiary, anaemic non-beneficiary and non-anaemic subjects. According to Johnson and Nelson values below 60 is considered good. All the three groups show a level below 60, irrespective of supplementation.

Table X highlights the mean distance covered in cooper's test. Individual values are given in Appendix XII.

MEAN DISTANCE COVERED IN COOPER'S TEST

Details of Subjects	Mean distance covered in metres
Anaemic (beneficiary)	160 ± 7.94
Anaemic (non-beneficiary)	159 ± 5.06
Non-Anaemic	168 ± 7.98

In the present study the anaemic beneficiaries had coveres 160 metres in 9 minutes while the anaemic non-beneficiary subjects had covered 159 metres and non anaemic subjects had covered 168 metres in the specified time. In the cooper's test the non-anaemic subjects had performed much better than the anaemic subjects. The anaemic beneficiary subjects had performed slightly better than the anaemic non beneficiary subjects indicating probably the beneficial effects of supplementation.

When the coopers test was conducted on the three groups the distance covered by the three groups were in the range of 160, 159 and 168 indicating the significant increase in the work performance and physical capacity of the anaemic beneficiary group. These findings are supported by Levin (1985) and Gardner et al (1979) that work capacity increases after supplementation of iron.

Gresen (1980) and Nutrition News (1986) found that the haemoglobin level was high in those who received iron and after the running test, it was found that those who had lower haemoglobin values ran significantly shorter distances.

Summary and Conclusion

V. SUMMARY AND CONCLUSION

The present investigation on "Anaemia, Work output and Impact of Iron Fortified salt supplementation on Adult Women" was conducted to identify anaemic adult women and to study the impact of supplementation of iron fortified salt on these adult women with reference to their biochemical picture and work output.

A village namely Ramanathapuram near Thudiyalur in Coimbatore was selected for the study. Based on the haemoglobin values and body weight fifty four adult women were chosen for the study in the age group of 20 to 39 years, doing moderate work. They were divided into three groups of eighteen women each. Group I constituted the experimental group with eighteen adult women, who were anaemic and this group was supplemented with iron fortified salt. The second group of eighteen anaemic subjects constituted the anaemic non-beneficiary group. A third group of eighteen adult women who were non-anaemic served as the control group.

The overall nutritional status of all the fifty four adult women were assessed through height weight measurements clinical examination, biochemical changes and dietary survey. The work efficiency of the subjects were evaluated through two activities namely washing clothes and cutting wood. The pulse rate andb blood pressure were studied before and after the activity, before and after supplementation. Two other tests namely Harvard step test and cooper's test were also conducted on all the three groups of subjects and the work efficiency was evaluated.

The results revealed that:

1. Except for cereal consumption by the non-anaemic subjects in Group III, the intake of all the other foods were inadequate for the subjects in all the three groups. The percentage deficit ranged from 15 to 69 percent among anaemic beneficiary; 15 to 78 percent for the anaemic non-beneficiary and 9 to 80 percent for the non-anaemic group.

2. The intake of protein, iron, riboflavin, niacin and ascorbic acid were very much deficient in the case of anaemic beneficiary and anaemic non-beneficiary when compared with the Recommended Dietary Allowances of nutrients by ICMR (1985). The deficiency was not much in the case of non-anaemic subjects. The percentage deficit of protein was 40, 32 and 4 percent for the anaemic beneficiary, anaemic non-beneficiary andn non-anaemic subjects. The percentage deficit of iron was 20, vitamin C 30, and niacin 33 percent for the anaemic beneficiary group. The percentage deficit of these nutrients were low for the anaemic non-beneficiary and very much low in the case of non-anaemic subjects.

3. The anaemic beneficiary subjects had recorded a height of 157 cms while the anaemic non-beneficiary subjects had recorded a height of 159 cms and non-anaemic subjects recorded 160 cms.

4. The mean weight of the anemic beneficiary subjects was 44 kg that of anaemic non-beneficiaries 47 kg and that of non-anaemic subjects 48 kg.

5. Thirty five percent of the anaemic beneficiary and anaemic non-beneficiary had poor musculature while only five percent of the non-anaemic group had poor musculature. All the subjects in the anaemic beneficiary and anaemic non-beneficiary group suffered from anaemia. Out of this 60 percent of the anaemic beneficiary group 40 percent of the anaemic non-beneficiary group had severe anaemia. Clinical examination also revealed the evidence of B-Complex vitamin C deficiency, and dry rough skin among the different groups.

6. Anaemic beneficiaries had recorded a mean haemoglobin level of 8.23 g/100ml before supplementation and 11.68g/100ml at the end of the supplementation period. The anaemic non-beneficiaries had recorded 9.1g/100ml and the non-anaemic subjects had recorded a value of 12.14g/100ml. The anaemic subjects who were supplemented with iron fortified salt had become non-anaemic at the end of the study by registering a value of 11.68g/100ml.

7. The mean serum iron levels of anaemic beneficiaries before supplementation was 58.94 ug/100ml, and at the end of supplementation period was 90.58 ug/100ml. This result indicates the beneficial effect of iron fortified salt supplementation. The anaemic non-beneficiary subjects and non-anaemic subjects had recorded 70.2 ug and 105.8 ug/100 ml.

8. The packed cell volume values recorded by the anaemic beneficiaries was 24.6 before supplementation and 33.8 after supplementation.

The anaemic non-beneficiaries had recorded a value of 27.5 and non-anaemic subjects had recorded a packed cell volume of 35.5. Supplementation had enhanced the packed cell volume in the anaemic beneficiary subjects.

9. The total ironbinding capacity of the anaemic beneficiaries was 379.2 and 292.1 before and after supplementation. The anaemic non-beneficiaries had recorded a value of 343.5 and the non-anaemic subjects had recorded a value of 291.7.

10. For all the subjects in the three groups the pulse rate had increase after the activity namely washing clothes and cutting wood irrespective of whether they were anaemic or non-anaemic. However the rate of increase was much less in the non-anaemic group. The anaemic beneficiary group and anaemic non-beneficiary group before supplementation had marked increase in pulse rate after washing clothes indicating that they had to exert more to carry out the same activity than their counterparts in the non-anaemic group.

11. The blood pressure levels of the subjects in the three groups did not show any significant variation before and after supplementation and before and after the activities namely washing clothes and cutting wood.

12. The mean cardiovascular efficiency scores of the anaemic beneficiaries was 64 after activity; that of anaemic non-beneficiaries was 62 and the non-anaemic subjects recorded a score of 59.

13. In the Harvard step test when the pulse rate at 30 seconds recovery was conducted the pulse rate was in the range of 49, 50 and 48 for the anaemic beneficiary, anaemic non-beneficiary and non-anaemic subjects. All the three groups show a level below 60, which is considered as good.

14. In cooper's test the anaemic beneficiaries had covered 160 meters while the anaemic non-beneficiary subjects had covered 159 meters and non-anaemic subjects had covered 168 meters in nine minutes. The non-anaemic subjects had performed much better than the anaemic subjects. There was a significant increase in the work performance and physical capacity of the anaemic beneficiary group, after supplementation.

The foregoing results indicate the beneficial effect of supplementation with iron fortified salt. The salt also had the additional advantage that it is used by all the sections of the population, all the age groups at all income levels. Hence, when salt is fortified with iron all the members in the family will benefit. In view of this it is recommended that iron-fortified salt may be produced more widely and made available to the public through all the marketing channels.

Bibliography

BIBLIOGRAPHY

Adekile A.D.
Olusi S.O.
Oyebola D.D.o
1985

Oral glucose tolerance test in children with sickel cell anaemia, East African Medical Journal pp2 (3) 213-217, Department of paediatries and child health University Ihadas, Ibadan.

Akenzua. G.I.
Ihongbe J.C.
Imasuen I.W
Nwobi.B.C.
1985

'Anaemia in children'. A survey in obadan a rural community in the rain forest zone of Nigeria; Journal of tropical paediatries 31(1) pp 20-24, 530 Department child health - University Nigeria.

Aghoton.Y.
Bories C.
Devanlay.M.
Dupin H.
Christidus.J.P.
Galan.P.
Soustre.Y.
1986

Relationship between anaemia iron and folacin deficiency haemoglobino pathies and parasitive infection. Human Nutrition clinical Nutrition 40c pp 371-379

Amine E.K.
Hegsted.D.M
(1978)

Biological Assessment of available iron in food products, Journal of Agriculture, food chemistry (1975) 22, 470-476.

Amar.M.
Biachi.R.G.
Coster.A.
Dillman E.
Faril.M.
Grebe.G.
Laryrisse.M.

Iron absorption from typical Latin American Diets, American Journal of clinical nutrition 39 (6) p 953.

Achi.H.E.
Brubacher.G.B.
Turner.M.R.
(1984)

Problems in Nutrition Research today (1981) PP 63-67

Anne garwick.E.
Corrine H.Robinson
Marilyn.R.Lawler
Wanda.L.Chenoweth
(1986)

'Anaemia and Iron Deficiency' Normal and therapentic Nutrition, Seventeenth edition, pp 126-27

Adelekan Delan.A.
Tburham David I
(1986)

The influence of riboflavin deficiency on obsorption and liver storage of iron in growing rat. British Journal of Nutrition vol 56, No.1.P 114.

Aohlquist D.A
M.C.Gill
Owen R.A.

Gastro intestinal blood loss and anaemia in runners. American Inter Medicine 100:843 P. 936

Annapurni S., Murthy N.Q., Premjyothi P., Rajan.H., Shubha Q. 1985 — Bio availability of iron by invitro method from selected foods and effect of fortification promote and inhibitors. Indian Journal of Nutrition and Dieteties 22(3) pp 68-72. Sri Avinashilingam Home Science College.

Brune M., Hallberg L., Rossander L. 1986 — Low bioavailuability of carbonyl iro in man. Studies on iron fortification of wheat flour. Amercian Journal of clinical Nutrition 43 (1) 59-67.

Brune M., Magnusson B., Persson H., Hallberg L. 1986 — Iron losses in sweat. American Journal of clinical Nutrition 43 (3) 438-443 P. 577.

Brooks G.A., Dallman P.R., Henderson S., Jansson L.T., Perkkio M.V., Refino C. 1985. — Work performance in iron deficiency rat, improved endurance with exerci training, American Journal of physiology p 249 (3.1) Department Paediatries School of Medicine-Line Versity California.

Strup D.M.
Schwartz S.
Stewart J.G.
(1984)
Arimatsu Y.

Koha S.
Futatsuka M.
Nagano M.
Nomuna S.
Shihata Y.
Ueda A.
Uedo T.
Yasutaqe R.
(1985)

A multiple regression analysis of haemoglobin values and iron status in Japanese farmers, Journal of Nutritional Science and Vitaminolc 31 (6) pp 573 - 584.

Anand S.
Halsted M.D.
Manucher Nadini
James A.

Prasad M.D.
1983

Synchrome of iron deficiency anaemic, hepatospleno megaly, hypogonadism, Dwarfism and geophagria nutition, Review Vol.41 No.7 pp 220 - 223

Agarwal D.K.
Bhardway J.
Singla P.N.
Tripathi A.M.
1986

Ethology of maternal and early childhood deficiency anaemic. Indian Journal of Paediatries 53(389 - 395. Department of Paediatries Hindu University.

Bhardway P. Gopaldas T. Kale M. 1985	Prophylactic iron supplementation for under privileged school boys. Impact on sub-maximal work capacity. Indian Paediatric 22 (10) pp. 745-752. Department of Foods and Nutrition.
Birgegard Bergstrom S. Lelje strand J. (1986)	Anaemia of pregnancy in Mozambique. Transaction of the Toyal Society of Tropic Medicine and Hygiene 80 (2) 249-255 Department Obstetrics.
Bowman Henry C. Lusake Phyllis E.Johnson (1985)	Effect of level and saturation of fat and iron level and type in the diet on iron absorption and utilisation by Rat. Journal of Nutrition Publication of American Institute of Nutrition No.3, Vol.117, pp.409-630.
Blum S.M. Boileau R.A. Sherman A.R. (1986)	The effect of fitness type exercise on iron status in adult women. American Journal of Clinical Nutritiona 43(3) pp. 456-463
Basker S.J. Mathur V. Ponnaiah J. Ramachandran K. Rani K. Soor S.K. (1979)	World Health Organisation sponsored collaborative studies on nutritional anaemia in India. The effect of Parenteral iron administration in control of anaemia in pregnancy. British Journal of Nutrition 42(3) pp 399-406 All M.S.

Bothwell T.H.
Charlton R.W.
1981
Iron deficiency in women. A report of the International Anaemia consultation group (INACG) p 1-6.

Brock J.H.
Manow - Fowlder T.
1987
Iron and Immunity relationship, proceedings of nutrition Society of U.K. 57(1) 348, 44.

Bengoa J.N.
1974
Problems of Malnutrition WHO Chronicle 28 p.3

Basta
Samir sanad
1977
Iron deficiency anaemia and labour productivity Vol.3, No.4, pp 15-17.

Beaton G.H.
1975
Defining a food and nutrition policy Vol.1, No.3 pp 8-16.

Bourne G.H.
1980
World Review of Nutrition and Dieteties Vo.35, P.14-39.

Bhardway P.
Gopaldas T.
Kale M.
1986
Prophylactic iron supplementation for underprivileged school boys, Nutrition Abstract Vo.56, No.2, P.120.

Bhardway P.
Gopaldas T.
Kale M.
1985
Impact on selected tests of congnitive function. Indian Pediatrics 22(10 pp 737-743. Department of foods and Nutrition, M.S. University.

Bjorm E.
Hallberg L.H.
Romander
Rasmussen
(1977)

Absorption of fortification of iron. Bio availability in man of different samples prediction of effects of iron fortification, British Journal of Nutrition Vol.37, No.3, pp.375-388.

Basta S.S
Karyadi D.
Serineshaw N.S.
Soekirman M.S.

Iron deficiency anaemia and the productivity of adult males in Indonesia. American Journal of Cliniccal Nutrition 32:916 pp. 47-51.

Brooks G.A.
Dallman P.R.
Henderson S.
Janson L.T.
Perkkio M.V.
Refino C (1985).

Work performance in iron deficient rat, improved endurance with exercise training Journal Applied Physiology 249 pp 306-311.

Bezwoods W.R.
Charlton R.W.
Bothwell T.H.
Duman D.D.
Mac Phail A.P.
Mayet F.
1981

Factors affecting absorption of iron from ferric ethylene diamine tetra acetic acid British Journal of Nutrition 45 pp 215 - 227.

Bary L.Johnson
Jack K.Nelson
(1982)

Practical Measurements for evaluation of physical education, third edition suyeet Publication pp 143-146.

Barnard R.
Ohra V.
Edgerton V.
Gardner G.
Senewiratne B.
(1977).

Physical work capacity and metabolic stress in subjects with iron deficiency anaemia. American Journal of Clinical Nutrition 30 pp 910-917

Branch G.
Henry S.E.
Magpuri P.
Smitha A.L.
(1986)

Effectiveness of a Nutrition programme for mothers and their anaemic children under 5 years of age. Journal of American Dieteties Assóciation 86(8) pp 1039 - 1042 Watte. Health Foundation

Choudhary V.P.
Ghai O.P.
Malhotra R.
Saraya A.K.
Kumar R.
1985

Platelet aggregation in Iron deficiency anaemia. Indian Journal of Paediatrics 52 (415) 939-145, A.K.Saraya haematology Unit, Department of Pathology - AllMs.

Cox T.M.
Peter J.J.
1980

Cellular Mechanism in the regulation of iron absorption by human intestine Studies in patients with iron deficiency before and after treatment, British Journal of haematology 44(1) pp 75-86.

Cook J.D.
Morris E.R.
Simpson K.M.
1982

The inhibitory effect of bran on iron absorption in man, American Journal of Clinical Nutrition Vol.34 p. 1469-1478.

Cook J.D.
James D.
Finch C.A.
1980

Assessing iron status of a population. American Journal of clinical Nutrition Vol. 32, 2115-2119.

Anaemia and physical performance

Charles C.Thomas
Melvin H.Willioms
(1976)

Nutrition Aspects of Human Physical and Atheletic performance, pp 160-68.

Carmel R.
Johnson C.S.
Waner J.M.
(1987)

Iron deficiency occurs frequently in patients with pernicious anaemia. Journal of American Medical Associatior 257 (8) 1081-1083, School of Medicine.

Conway S.P.
Dear P.R.F.
Killeher J.
Rawwson I.
Shires S.E.
(1986).

The early anaemia of the premature infant is there a place for vitamin E supplementation. British Journal of Nutrition Vol.56, No.1, p 114.

Costello C.A.
Ezell J.M.
Penfield M.P
Salvetti N.N.
Skinner J.D.
(1985).

Appalachean Adolescents eating pattern and nutrient intake. Journal of Americal Dietetics Association, Vol.8
1093-P 971.

Canham S.E.
Hodger R.E.
Mejia L.A.
Mohanlam M.
Rucker R.B.

Haematopoietic studies in vitamin A deficiency. American Journal of Clinical Nutrition, Vol.31 pp 876-885

Sauberlich H.E.
(1978)

Cummings J.H. (1978) Nutritive implications of dietary fibre, American Journal of Clinical Nutrition, 31, 521-9 Vol.38, No.2 p.200.

Chen X.C., Lice D.S., Wang W.G. (1986) Haematologic response to iron and ascorbic acid administration in preschool children with anaemia Nutrition Resault Vo.6(3) pp 241-248. China.

Chandra R.K., Vyas D. (1984) Functional implications of iron deficiency. Iron deficiency in infancy and childhood: A.Strekel.

Craig G.M., Elliot C., Hughes K.R. (1985) Masked Vitamin B-12 and folate deficiency in elderly. British Journal of Nutrition Vo.54, No.3, pp-618 Department of Geriatrices.

Devanlay M., Dop M.C., Dupin H., Galan P., Hercberg S. 1985 Effect of iron supplementation on serum ferritins and other haemotological indices of iron status on menstruating women, Nutrition Metabolism 232, S.Karger.

Duplin
Hereberg H.
Lagrange S.
1983

Evolution of French diet, Nutritional Aspects. World Review, Nutrition Diet Vol.123, 3710-3717.

Devadas R.P.
Rajakumar
Sarojini K.S .
(1981)

Impact of nutrition andhealth educationn on the growth and development of primary school children in selected areas of Tamil Nadu. Indian Journal of Nutrition and Dieteties, 18(1) 3-5 Sri Avinashilingam Home Science College for women.

David Kritchersky
Derick B.Jelliffe
Partick Jelliffe E.D.
Roslyn-Alfin-Slater B.
1980

Nutrition and growth, Human Nutrition P.23
Nutritionnand Adult Micro nutrients plenum press, Vol.2, p.209-309.

Doris Howes
Gerorge Briggs M.
(1979)

Bogerts Nutrition and Physical Fitness 10th edition W.B.Sunders Company. pp 209-309.

Dorothy A.Wench
Martin Baren
Sat Paul Dara
(1983)

Nutrition Second Edition, Ruston publishing company p.252.

Davies M.
Grant A.K.
Kerlin P.

Iron deficiency anaemia - a prospective study. Australia and Newzealand Journal of Medicine 9(4) pp 402-407.

Runer R.
Sage R.E.
(1979)

David S.
Louis K.Diamond
Nathan
Nasrollah
Shahider T.
Iron deficiency anaemia associated with concentration of iron metabolism in two siblings pp 311-318.

Dallman P.R.
Refino C.
Siemes M.A.
(1980
Manifestation of iron deficiency at various levels of dietary iron intake Americal Journal of colinical Nutrition 33, PP 570 - 574.

Dallman P.R.
Refino C.A.
Yland M.J.
(1982)
Sequence of development of iron deficiency in rat. American Journal of Clinical Nutrition 35 pp 671-677. Annual Review of Nutrition Vol.3.

Emilie G.
Flores
Josefina A.
Magbitang
1985
Anaemia and clinical survey Anthropometry philippine Journal of Nutrition Vol.38 No.2, 51-54 published quarterly by by phillippine Association of Nutrition ist-dieticians association of the Phillippine second Nation wide Nutrition Survey.

Ernst E.
Eisenberg J.
Blood rheology in vegetables British Journal of Nutrition Vol.56, No.3,

Matrai A. Pietsch L. (1986)	P-519-683 Haemorheology Research laboratory.
Edgerton V.R. Gardner G.W. Othira Y. Guna Waredina K.A. Seniwiratne B. 1979	Iron deficiency and its effect on workers productivity and activity pattern. British Medical Journal 2(6204) pp 1546-1549.
Ehrenberg A. Reeihard P. (1983)	Ribonucleotide reductase a radical enzyme science 221, P-514-519.
Fuyita H. Ikida M. Ishihara N. Miyasaka M. Koizumi A. Watanabe T. 1986.	Haemoglobin levels among Japanese farmers with special reference to climate and work intensity. Human biology 58(2) 197-208. Department of Environmental health, Japan.
Futasuka Ueda A. Ueno M. Yasutake Koyama W. (1984)	An improvement of haemoglobin values during the last decade in female farm workers, Kumamoto Medical Journal (3) 95-111, faculty of Medicine.
Finch C.A. (1977)	Iron Nutrition Vol.3 No.4, pp 2-14

Finch C.A.
Inamdar A.R.
Miller L.R.
Person R.
Seiter K.
Mackler B.
(1976).
Iron deficiency in the rat. An investigation 58, 447. Indian Council of Medical Research Bulletin Vol.12, No.5, pp 47-51.

Greisen - G
1986
Mild Anaemic in African School children effect on running performance and an interventiontial (1986) Nutrition Abstract and Review, series A, Humanand Experimental series A Volume 56, No.12, Page No.980 75 (4) 662-667.

Gopalan
1975
Anaemia as a public health problem National Institute of Nutrition, Vol.9, No.2 pp1-11.

Greger
Janet L.
(1987)
Food supplements and fortified foods scientific evaluation in regard to toxi cology and nutrient bio availability Journal of American Dieteties Association Vol. 87, No.10, P.1370.

Gina V.Vigligette
Jean D.Skineer
(1987)
Estimation of iron bioavailability in adolescents meals and snacks. Journal of American Dietetics Association Vol.87 P.971.

Geoffrey H.Bourne (1985) — Minerals in foods and Nutritional Tropics Karger, Vol.46, pp.46-50.

Holubets M. Pierce W.E. Nickerson H.J. Tripp A.D. 1988 — Reduced iron stores in high school female runners. American Journal of Diseases of children 139 (11) 115-1119.

Hilary J.Powers (1985) — Experiment to determine the effect of riboflavin deficiency at weaning on iron economy and haem synthesis. Annals of Nutrition Metabolism p.261.

Hallberg K. Rossand L. 1984 — Improvement of iron nutrition in developing countries, American Journal of Clinical Nutrition, 39, (4) pp 577-583.

Hutton L.I. 1979 — Effect of iron deficiency on whole blood viscosity in polycythaemic patients, 43(2) 191-199.

Harold Varley (1969) — Practical clinical Biochemistry fourth edition, Arnold-Haneman Publishers-pp 472-75.

Hazell T. Johnson I.T. (1987) — Invitro estimation of iron availability from a range of plant food; influence of phytate, ascorbate and citrate. British Journal of Nutrition 57-(2) pp 223-233.

Hurley L.S.
Keen C.L.
Lonnerdal B.
(1981)
Levels of iron, copper, zinc and marganese in milk, Annual Review of Nutrition 1:149.

Hendrickse S.
Oppenhumen
(1983)
Clinical affect of iron deficiency and iron supplementation. Nutrition Abstract and Review A 53 (7) pp 585-598.

Henry Thiagarag
(1984)
Limit Poverty control Anaemia printed with an intake from UNICEF. Audio visual presentation on increasing productivity of people through anaemia control.

Henry M.Levin
(1985)
Putting iron bace into the blood. Economic and social ebenefits and costs. Fultere 15-16 Summer-Autimn .

Haymes E.M.
(1980)
Iron supplementation. In encyclopedia of physical education fitness and sports training, Environments, nutrition and fitness pp 335-344.

Indian Councel of Medical Research Bulletin (1982)
Control of anaemia through iron fortified salt. A critical appraisal of its application. Vol.12, No.5, pp 47-51.

Ikawa G.
Kojima K.
Mikami R.
Nishikawa K.
Iron deficiency anaemia associated with tea leaf ingestion. Journal of Nara Medical Association 37(2) p 169-173, Second Department International Medicine.

Narita N.
Yoshikawa M.
(1986).

Indian Council of Medical Research (1986) — Towards the inplementation of the National Seminar held in Sri Nagar P-81.

Harry P.Broquest, Robert E.Olson, William J.Barby (1981) — Iron and sports Anaemia, Annual Review of sports nutrition Vol.1 pp 340- 343. pp

Inoue T., Shirak K., Yamada T., Yoshimura H. (1980) — Anaemia during hard physical training and its casual mechanism with special reference to protein nutrition world review nutrition Diet 35 PP 1-86.

Jayanthi N., Vijayalakshmi P. 1986 — Anaemia and work output. Indian Journal of Nutrition and Dietetics Sri Avinashilingam Home Science College 23(10).

Jenkins N.G., Taylor T.G. 1985 — Inhibitors and enhancers of iron absorption. Proceedngs of the XIII. International Congress Nutrition pp 520-535.

James Christopher (1976) — Want a life of good cheer say good bye to anaemia, Home Science Vol.14, No.11 PP 26-27.

Jordal R. Pauvlev P.E Pederson N. Strandberg (1983()	Dermal excretion of iron in intensely training atheletes clinical chemical Aeta, 127:19, p 936.
Jean-Pierric Habicht Lopez M. Laureen (1987)	Food stamps and iron status of U.S. elderly poor. Journal of American dietetics Association Vol.87, No.5 pp 598-604.
John R.Reinhold Pedro M.Garcia Pedro Garzan 1986	Retention of iron by rat intestine in vivo as affected by dietary fibre Ascorbate and citrate Journal of Nutrition Vol.116, No.6.
Jenkins N.K. Taylor T.J.	Bioavailability of Iron in food, studies on iron fortification.
Both Well Laryisse (1985)	Proceedings of the XIII International Congress of Nutrition pp 519-529.
Karl E.H. Hammonds (1987)	Insight on iron deficiency Herald of health, Vol. 64, No.1, pp 11-13.
Kimuagar M. Yassai M. (1986)	Nutritional Anaemia in pregnant women in iron Recent advances in Clinical Nutrition 2, pp 357-359. Institute of Nutrition Science and Food technology.

Kim I.
Pollitt E.
Soemantri A.G.
(1985)

Iron deficiency anaemia and educational achievement. American Journal of Clinical Nutrition 42(6) pp 1221-1228. Pollitt-E School of Public health University Texas.

Kadan R.S.
Zeigler G.M.
(1986)

Effects of ingrediens on iron solubility and chemical state in experimental bread, (cereal Chemistry 63(1) pp 47-51.

Leibel R.L.
Pollit E.
Saco-Pollitt C.
Vieteri F.E.
1986

Iron deficiency and behavioural development in infants and preschool children, American Journal of Clinical Nutrition 43(4) 555-565. Department Behavioural Science, University California.

Lancet
(1980)

Foods and Nutrition, Vol.37, No.4 P.1117.

Linmann A.V.
Strener F.V.
(1986)

Myocardium in moderately pronounced iron deficiency anaemia, 64(2) pp 80-83, V.SS R. Nutritional Abstract and Review series A, Volume 56, No.9, p. 692.

Lakshmi R.N.
Vijayalakshmi P.
(1983)

Effect of Vitamin A and Iron supplementation on serum level of these nutrients among expectant mothers. Indian Journal of Nurition and Dietetica Vol.20 No.5, pp 149-153.

Laryrisse M.
Martenez - Torres
Renzi M.
Romano E.L.
(1979)

Fe (111) EDTA complex as iron fortification. Further studies American Journal of Clinical Nutrition 32(4) pp 809-816.

Loawe R.T.
Payat L.V.
Ranhotra G.S.
(1978)

Interaction and bioavailability of iron, zinc, and magnesium cereal chemistry 55 p 625.

Mayet F.G.H.
Reinach S.G.
Schuttee C.H.J.
1985

Anaemia among the inhabitat of a rural area in Northern Natal, South African Medical Journal 67(12) 458-462 Department Medicine, S.Africa.

Margaret J.Minski
Susan Fair-Weather Tait
(1985)

Studies on iron availability in man using stable isotope technique. British Journal of Nutrition Vol.55, pp No. 282-284.

Macarthy P.O.
Johnson A.A.
Walters C.S.
(1986)

Iron Nutritional status of selected elderly black persons in washington Vol.6, Winter Journal of American Dieteties Association, Vol.87, No.7, p-971.

Mehta B.C.

Interaction between nutritional anaemia and thalassemia. Indian Journal of Medical science 36 p 180-187. Dr.J.C.Pate Hematology Department.

Mehta B.C. (1982)	Widespread iron deficiency anaemia in India-its causes. Indian Journal of Medical Sciences 36 pp 108-112 Dr. J.C.Patel.
Miller D.D. Rasmussern R.R. Schiken B.R. Van Comper D. (1981)	An invitro method for estimation of iron availability from meals. American Journal of Clinical Nutrition 34, pp 2248-2256.
Maria Vermane Norman. Jean Gills (1983)	Mannual of Nutrition and diet thereapy p.247.
Melvin H.Williams (1976)	Aspect of Human Physical and Atheletic performance charles - C thomad Publisher pp 161-165.
Narasimga Rao B.S. 1985.	Control of Anaemia through fortification of salt with iron, swasth Hind 55-57, volume 31, No.2
Narasimga Rao B.S. Vijaya Sarathy (1978)	Alternate formula for the fortification of common salt with iron. American Journal of clinical nutrition Vol.31 1112 p-6.
Narasimga Rao B.S. Srikantia S.G. (1980)	The use of common salt sodium chloride fortified with iron in control of anaemia, British Journal of Nutrition Vol. 43, p-267.

Narasimga Rao B.S. (1981)	Physiology Iron absorption and supplementation Nutrition of man pp 27-29.
Narasimga Rao B.S. (1984)	Control of Anaemia through fortification of salt with iron nutrition news. National Institute of Nutrition, Hyderabad Vol.5, P. 267.
Narasimga Rao B.S. (1987)	Double fortification of salt with iron and iodine to control anaemia and goitre, Nutrition News Vol.8.
Narasimga Rao B.S. Prabavathi 1982	Tannin content of food consumed in India and its influence on ionisable iron. Journal of food science and Agriculture 33. 89-96.
Narasinga Rao. B.S. Vijayasarathy. 1975	Fortification of common salt with iron effect of chemical additions on stability and biovai - lability American Journal of chemical Nutrition 28:13 p 95 .
National Institute of Nutrition (1980)	Community studies using common salt fortified with iron, Annual report.
Nutrition Review 1980	Use of iron fortified salt to combat anaemia the Indian experience, pp 202-203.

Nutrition Review (1983)	Iron deficiency and mental development Vol.41, p.235.
Nutrition Review (1975)	Hyperlipemia and iron deficiency problem in iron enrichment and fortification of foods. Vol.33 No.2, p.46
Nutrition Review	Mucocutaneous fungal lesions and iron deficiency vol.34, No.7, P-203.
Nutrition Review (1979)	Vitamin A deficiency and anaemia, No-2, Vol.37, P-38.
Nutrition Review (1982)	Iron deficiency secondary to copper depletion, No:1, Vol 40, P 28-29.
Nutrition Review (1982)	Iron deficiency and intestinal absorption of sugars. Vol.40, No.7, PP 205-207.
Nutrition News (1986)	Iron status in blood donors 7(5) P3-4 Nutrition Abstract and Review, Series A Vol 57, No:3, P-207.
Nutrition News (1988)	Riboflavin and haemoglobin status of urban school boys. Relationship with income and anthropometry. National Institute of Nutrition Hyderabad. Vol 9, No:1.
Nutrition News (1984)	Anaemia in school children, Vol 5 m No: 3 National Institute of Nutrition

Olyvia Mga za 1980 — Nutritional problems and policy in Tanzania, Cornell International nutrition monograph series Vol: 7, pp 16-18.

Nutrition News (1983) — Iron supplementation and anaemic in pregnancy. National Institute of Nutrition vol 4, No:5.

Nutrition News (1986) — Iron status of donors, Vol. 17, No:5 National Institute of Nutrition, Hyderabad.

Pawar.R.G. Sudha Yadav Yadav B.S. (1986). — Indian Medical Gazetta for the development of modern medicine and surgery Vol CXX, No:1, p- 30.

Robinson J.S. shoft A.I.K. Winney R.J. 1982 — Revisible micro cytro hypochomic anaemic in clialysis patients due to aluminium intoxication. Proceedings of European dialysis Transplant society, 17, 226-233.

Report on working group on fortification of salt with iron (1982) — Use of common salt fortified with iron in the control and prevention of anaemia American Journal of clinical Nutrition 35(6) pp 1442-1451, National Institute of Nutrition.

Rebert W-Charlton
Thomas.H.Both Well
(1984)
Iron deficiency in women. International Nutritional Anaemic conscultative group.

Ruby Das
(1987)
Malnutrition among the rich. Social welfare Vol XXXIV, No:2, P-7.

Selva Sundari.S.
Vijayalakshmi P.
(1983)
Relationship between Iron deficiency anaemia and energy expenditure of young women. India's Journal of Nutrition and Dietetics 20 113-117 Sri Avinashilingam Home Science College for women.

Shobhana.R.
Vijayalakshmi.P.
(1982)
Impact of iron and folic acid supplementation on expeetant mothers and their offspring Indian Journal of Nutrition and Dietetics 19, 363-69, Sri Avinashilingam Home Science College for women.

Sjolins.S.
(1991)
Anaemia in adolescence Nutrition Review 39, pp 96-99.

Sadasivam.P.R.
(1979)
Relationship between Nutrition health and work efficiency Regional workshop on planning diet for health. P-90 workshop manual.

USHA.V.
VIJAYALAKSHMI.P.
(1981)

Impact of iron and folic acid supplementation on expected methers participating in modified special Nutrition programme. Indian Journal of Nutrition and Dieteties. Vol 18, No:2, pp . 2 45-53

WADDELL.J.

The bioavailability of iron stores and their utilisation in food enrichment, federation proceedings 33, 1778-1783.

Appendices

APPENDIX I

ESTIMATION OF HAEMOGLOBIN BY CYANMETHAEMOGLOBIN METHOD

(VARLEY 1969-1980)

PRINCIPLE

The haemoglobin is treated with a reagent containing potassium ferricyanide, potassium dihydrogen phosphate. The ferric cyanide forms methaemoglobin which is converted to cyanomethemoglobin by the cyanide.

REAGENTS:-

Drabkin's diluent solution

Sodium bicarbonate - 1 g.

Potassium cyanide - 0.05g

Potassium ferricyanide - 0.2g

Distilled water - 1 Litre.

This solution is preserved in a dark bottle and preferably under cold storage. Its preparation and handling should be done with great care. This solution should not be used after it forms a precipitate at the bottom of the storage bottle.

PROCEDURE:

1. Exactly 5ml of the Drabkin's diluent solution is measured into a dry test tube from a burette or a pipette with section bulb.
2. Exactly 0.02ml of blood is transferred from a standard haemoglobin pipette into a diluent solution. Usual care in filling and cleaning of loaded haemoglobin pipette must be observed.

3. The pipette is rinsed three times with the diluent solution without allowing the formation of air bubbles in the solution.

4. The blood and the diluent are thoroughly mixed by rotating the tube.

5. Ten minutes time is allowed for the formation of cyanmethaemoglobin.

6. Five ml of diluent solution is used as blank.

7. The readings are taken in photoelectric calorimeter at 540 milli micron.

CALIBERATION PROCEDURE

1. Total blood iron is determined by Wong's method which would give absolute amount of haemoglobin.

2. Exactly 0.02 ml of this known blood sample is measured into 5.0, 7.5, 10.0, 12.5 and 15.0 ml of diluent solution. These are now equivalent to blood samples containing respectively 100, 67, 50, 40, and 30 percent of the original haemoglobin concentration.

3. The intensity of the colour is read using a green filter at 540 milli micron against a blank set at Zero optical density.

APPENDIX II

ESTIMATION OF SERUM IRON BY DIPYRIDYL METHOD

PRINCIPLE:

Ferrous iron gives a pink colour with 2.2 dipyridyl. A solution of dipyridyl in acetic acid is added to serum followed by a reducing agent. Proteins are removed by heating in boiling water and then centrifuging.

REAGENTS:

1. 2.2 Dipyridyl - 0.1%
2. acetic acid 12% v/v
3. Sodium sulphate - 0.1m
4. Chloroform
5. Standard solution containing 200 Ng.
6. WORKING STANDARD

Dilute 3ml of the solution to 100 ml with water to obtain a solution containing 3mg/ml.

PROCEDURE

Mix equal volumes of serum and 0.1m sodium sulphate and dipyridyl reagent in a glass stoppered tube which can be centrifuges. Heat in boiling water for five minutes at 300 ppm. If the supernatent is not completely clear, repeat the shaking and centrifuging. Read at 520m/ standard in the same way.

$$\text{Ng Iron/100ml} = \frac{\text{Reading of Unknown}}{\text{Reading of standard}} \times 300$$

These reading are linear with concentration to atleast 500/ 100ml. To obtain a calibrated curve, dilute 5 ml of the stock standard to 100 ml with water and set up tubes containing 0.4, 0.8, 1.2, 1.6 and 2.0 ml. This makes each to 2 ml with water and develop the colour as described above and read against the blank. These correspond to 100, 200, 300, 400 and 500 mg/100 ml.

APPENDIX III

ESTIMATION OF PACKED CELL VOLUME BY WINTROBE MACRO METHOD

PRINCIPLE:

The packed cell volume or haematocrit of blood is determined using heparinised capillary tube (7521) and micro haematocrit centrifuge.

PROCEDURE

Blood from finger t p is collected in EDTA and is allowed to run about half to three-fourth length of the tube. The tube is sealed on the opposite using sealing wax plasticine. The tubes are then transferred to the high speed micro-haematocrit centrifuge and placed in grooves of the centrifuge head. They are centrifuged for five minutes at 11,000 pm and read on the reader which gives the direct haematocrit volume in volume percentage.

APPENDIX IV

ESTIMATION OF TOTAL IRON BINDING CAPACITY BY DIPY RIDYL METHOD.

PRINCIPLE:

Transferrin is saturated 100% by adding iron from outside in ferric form. After chelating the iron not bound to transferrin, the transferrin iron is estimated as in the case of serum iron. Transferrin normally is saturated to only 33% by iron.

Determination of transferrin solution provides a good index of iron in nutritional status.

REAGENTS:

1. Ferric chloride solution containing 5 mg/ml in 0.005 N hydrochloric acid. Prepare a stock solution containing 145 mg of ferric chloride/100ml of 0.5N acid, dilite one hundred millilitre with distilled water.
2. Magnesium carbonate for light absorption.
3. Sodium sulphite 0.2 / 2.52g of the anhydrous salt/100 ml
4. 2.2 dipyridy 1:0.2% in acetic acid, 3% chloroform and standard solution as for the method.

PROCEDURE:

To 1ml of serum is added 2ml of ferric chloride solution, shaken well and the mixture allowed to stand for five minutes. After allowing for five minutes add 400 mg of magnesium carbonate (100mg for each ml of ferric chloride). Shake vigorously for 30-60 seconds. centrifuge and pipette off 4ml of the super natent fluid for iron determination. If the dipyvidyl method is used add 1ml of each of the 0.2/ng sulphite and 0.2% dipyridyl and proceed as described previously for determination of serum iron. This result gives total iron binding capacity. If the serum iron is determined at the same time the percent saturation is calculated.

CALCULATION:

x-ug amount iron present in 0.25 ml of serum. This value when multiplied by 400 would give total iron binding capacity value in ug/100ml of serum. Unsaturated Iron binding capacity (UIBC) = Total iron binding capacity - Serum iron (in ug / 100ml serum).

$$\frac{\text{Reading of unknown} \times 100 \times f}{\text{Reading of standard} \times 1.33}$$

$$= \frac{\text{Reading of unknown} \times 450}{\text{Reading of standard}}$$

APPENDIX V

Individual Food Intake of Anaemic groups

FOOD STUFF	I	II	III	IV	V	VI	VII	VIII	IX	X
CEREALS	250	200	250	175	135	270	235	240	240	250
PULSES	40	30	25	40	65	60	25	40	30	30
GREEN LEAFY VEGETABLES	25	-	50	-	-	100	60	50	-	100
OTHER VEGETABLES	15	5	40	30	10	50	65	65	130	60
ROOTS AND TUBERS	15	35	-	10	30	20	25	65	25	25
FRUITS	-	-	-	-	-	-	-	-	-	-
MILK	100	-	50	-	-	100	100	200	150	150
FATS AND OILS	15	10	-	-	10	25	25	30	25	30
MEAT AND FISH	-	-	-	-	-	-	-	-	-	-
EGG	-	-	-	-	-	-	-	-	-	-
SUGAR AND JAGGERY	25	30	20	30	15	10	15	-	10	15

Individual Food Intake of Non-Anaemic Groups

FOOD STUFF	I	II	III	IV	V	VI	VII	VIII	IX	X
CEREALS	400	300	350	350	400	400	350	350	400	300
PULSES	55	50	45	45	30	25	50	45	35	60
GREEN LEAFY VEGETABLES	50	-	90	75	50	50	50	40	-	50
OTHER VEGETABLES	50	50	65	50	80	45	65	70	55	70
ROOTS AND TUBERS	20	90	75	70	50	55	50	--	50	40
FRUITS	-	-	-	-	-	-	-	-	-	-
MILK	200	200	150	100	125	150	200	100	140	200
FATS AND OILS	20	25	25	30	15	15	15	20	10	25
MEAT AND FISH	-	60	-	-	-	-	-	-	-	-
EGG	-	-	50	-	50	-	-	-	-	-
SUGAR AND JAGGERY	-	20	20	10	20	20	15	15	10	20

Individual Food Intake of Anaemic Non-Beneficiary Group

FOOD STUFF	I	II	III	IV	V	VI	VII	VIII	IX	X
CEREALS	200	330	160	200	140	275	300	300	270	300
PULSES	55	20	45	30	30	15	20	50	30	45
GREEN LEAFY VEGETABLES	-	40	60	30	-	35	-	50	-	-
OTHER VEGETABLES	15	40	60	40	30	40	60	50	45	55
ROOF AND TUBERS	25	50	75	20	60	-	60	30	15	40
FRUITS	-	-	-	-	-	-	-	-	-	-
MILK	200	100	150	15	50	50	-	100	150	-
FATS AMD OILS	-	20	-	-	-	-	-	-	45	10
MEAT AND FISH	-	-	-	-	-	-	-	-	-	-
EGG	-	-	-	-	-	-	-	-	-	-
SUGAR AND JAGGERY	-	-	10	10	10	20	25	45	30	20

APPENDIX VI

Individual values of Nutrient Intake of Anaemic groups

FOOD NUTRIENTS	I	II	III	IV	V	VI	VII	VIII	IX	X
PROTEIN	23	22	28	29	17	27	39	24	24	30
ENERGY	2017	1253	2064	1954	1987	1958	2010	1998	1938	2000
CALCIUM	101	372	122	508	813	213	425	365	405	255
IRON	7	19	55	59	9	35	14	23	15	15
RETINOL	2720	1987	2650	2498	2560	2770	2682	2884	2690	2590
THIAMINE	0.45	0.96	0.76	1.08	0.76	1.58	0.93	0.85	0.92	1.92
RIBOFLAVIN	0.29	0.41	1.27	0.76	0.46	0.43	0.85	0.39	1.41	0.40
NIAGIN	4	14	5	18	6	12	13	14	16	12
VITAMINC	21	89	58	18	12	9	32	78	22	13

Individual value of Nutrient intake of Anaemic Non-Beneficiary group

NUTRIENTS	I	II	III	IV	V	VI	VII	VIII	IX	X
PROTEIN	21	31	32	29	38	36	25	37	36	31
ENERGY	2100	1963	2000	1950	1850	1980	1989	2010	2190	1990
CALCIUM	375	116	578	47	321	49	262	498	217	640
RETINOL	1980	2153	2038	2060	1960	1770	1969	2011	1990	1954
IRON	11	28	11	9	13	31	26	30	58	32
THIAMINE	0.81	2.70	0.63	6.14	0.63	0.46	0.86	0.93	0.57	13.10
RIBOFLAVIN	0.87	0.89	0.30	0.39	0.85	0.35	0.86	0.88	0.63	0.43
NIACIN	11	10	13	11	9	11	10	11	13	9
VITAMINC	37	43	40	12	22	10	18	38	53	126

Individual value of Nutrient intake of Non-Anaemic subjects

NUTRIENTS	I	II	III	IV	V	VI	VII	VIII	IX	X
PROTEIN	44	41	59	40	53	41	43	41	35	33
ENERGY	1975	1566	1872	1756	2850	2085	1987	1897	2095	1994
CALCIUM	413	378	467	748	939	496	517	437	475	390
RETINOL	2672	2756	2986	2950	2451	2010	1998	2752	2590	2495
IRON	35	43	34	25	37	97	45	46	26	24
THIAMINE	1.20	0.97	1.77	1.11	1.40	1.15	1.16	1.14	1.12	1.13
RIBOFLAVIN	0.84	0.73	1.83	0.73	1.33	0.52	0.62	0.63	0.62	0.76
NIACIN	14	13	18	11	18	13	16	16	17	13
VITAMIN-C	89	53	152	30	177	12	27	58	23	122

APPENDIX VII

INDIVIDUAL HEIGHTS AND WEIGHTS OF THE ANAEMIC, ANAEMIC NON BENEFICIARY AND NON-ANAEMIC GROUPS

Anaemic Group			Anaemic Non-Beneficiary		Non-Anaemic	
	Heights	Weight	Height	Weight	Height	Weight
1.	159	42	160	44	160	45
2.	162	39	155	43	165	52
3.	159	41	160	41	160	50
4.	163	39	152	44	159	49
5.	160	41	159	45	162	50
6.	163	39	159	49	155	47
7.	155	42	162	47	162	53
8.	159	41	162	50	159	51
9.	150	37	156	42	159	52
10.	159	42	159	41	159	52
11.	159	42	163	50	163	52
12.	154	38	160	43	155	51
13.	155	41	163	50	162	47
14.	155	38	162	49	159	50
15.	152	42	158	52	160	49
16.	156	41	163	46	162	51
17.	140	39	162	47	155	52
18.	154	43	161	52	158	49

APPENDIX VIII

CLINICAL ASSESSMENT OF ANAEMIC, ANAEMIC NON BENEFICIARY

AND NON ANAEMIC

SIGNS AND SYMPTOMS	Anaemic Group		Anaemic (Non-Beneficiary GP		Non-Anaemic Group	
	Number	Percentage	Number	Percentage	Number	Percentage
Poor Musculature	7	35	7	35	-	-
Deficient Subcutaneous fat	9	45	-	-	-	-
Anaemic						
Mild	8	40	12	60	-	-
Moderate	12	60	8	40	-	-
Raw/Red/glazed tongue	-	-	1	5	-	-
Bleeding gums	-	-	3	15	2	10
Angular Stomatites	-	-	2	10	1	5
Dry Skin	2	10	2	10	3	15

APPEXDIX IX

HAEMOGLOBIN VALUE AND SERUM IRON ANAEMIC SUBJECT BEFORE AND AFTER SUPPLEMENTATION

	Haemoglobin of Anaemic subjects		Serum Iron of Anaemic Subjects		
	Before supplementation	After supplementation	Before supplementation	After supplementation	
1.	8.29	11.52	60	257	90
2.	8.08	12.10	68	283	105
3.	8.19	11.52	75	321	95
4.	8.60	10.95	60	270	90
5.	8.29	11.52	64	296	90
6.	7.99	11.52	68	309	95
7.	7.89	12.10	68	244	90
8.	8.19	11.52	75	321	113
9.	8.60	12.68	53	257	83
10.	7.87	12.10	56	270	106
11.	8.80	11.52	75	309	90
12.	8.40	12.10	60	321	113
13.	8.29	11.52	68	270	95
14.	8.19	11.52	53	309	90
15.	8.39	11.52	71	334	95
16.	7.99	10.95	75	308	83
17.	8.09	12.10	60	334	95
18.	7.87	11.52	68	309	105

APPENDIX X

PACKED CELL VOLUME AND TOTAL IRON BINDING CAPACITY OF ANAEMIC SUBJECTS

	Packed Cell Volume of Subjects		Serum Iron Level of Anaemic Subjects	
	Before Supple-mentation	After Supple-mentation	Before Supple-mentation	After supple-mentation
1.	25	35	338	257
2.	24	30	326	283
3.	25	36	371	321
4.	26	33	349	270
5.	25	34	338	296
6.	24	32	315	309
7.	24	36	394	244
8.	25	33	338	321
9.	26	31	327	257
10.	26	33	360	270
11.	22	32	394	309
12.	22	34	371	321
13.	26	35	405	270
14.	26	36	349	309
15.	25	36	452	334
16.	25	34	450	308
17.	24	36	405	334
18.	24	34	492	309

Haemoglobin and Serum Iron level of Anamic Non-Beneficiary

and Non-Anaemic Group

	Haemoglobin Serum Iron Level of Anaemic Non-Beneficiary Groups		Haemoglobin and Serum Iron Level of Non-Anaemic Groups	
1.	9	60	11	103
2.	10	80	12	111
3.	9	60	12	94
4.	8	50	12	103
5.	10	70	12	94
6.	9	60	11	103
7.	8	70	12	94
8.	8	55	12	103
9.	8	60	12	103
10.	8	70	12	103
11.	9	70	13	94
12.	9	70	12	103
13.	10	80	12	86
14.	9	60	13	103
15.	10	55	12	103
16.	10	60	13	111
17.	8	70	11	103
18.	8	80	13	111

Total Iron Binding Capacity and Packed Cell Volume of Anaemic Non-Beneficiary and Non-Anaemic Groups

Total Iron Binding Capacity			Total Iron Binding Capacity	Packed Cell
	Of Anaemic Non-Beneficiary Groups	Packed Cell Volume of Anaemic Non-Beneficiary Group	Of Non-Anaemic Groups	Volume of Non-anaemic Subjects
1.	315	28	289	34
2.	300	30	289	34
3.	315	28	321	36
4.	330	25	289	36
5.	390	30	257	37
6.	375	30	305	36
7.	330	27	289	35
8.	375	25	305	36
9.	315	24	273	37
10.	345	24	305	33
11.	315	27	305	39
12.	330	29	273	36
13.	300	26	289	33
14.	330	27	305	36
15.	315	30	289	33
16.	405	23	273	39
17.	390	25	289	36
18.	390	30	289	33

APPENDIX XI

INDIVIDUAL BLOOD PRESSURE OF THE SUBJECTS IN CUTTING WOODS AT THE START OF THE STUDY (ANAEMIC)

	Before Supplementation		After Supplementation	
	Before Activity	After Activity	Before Activity	After Activity
1.	120/80	122/80	115/75	120/80
2.	110/75	115/80	117/78	120/80
3.	115/80	117/82	120/80	122/82
4.	117/80	120/82	118/78	120/80
5.	120/80	122/82	120/80	122/84
6.	120/80	120/81	118/80	120/80
7.	117/75	120/78	120/80	122/80
8.	115/80	120/81	117/78	120/80
9.	115/80	120/82	120/80	121/81
10.	120/80	124/82	122/80	124/82
11.	115/75	120/80	117/78	120/80
12.	115/75	120/80	117/78	120/80
13.	117/80	120/81	120/80	122/82
14.	120/80	122/82	120/80	122/81
15.	120/80	121/81	120/80	124/84
16.	117/75	120/79	117/78	120/80
17.	120/78	122/80	117/78	120/80
18.	115/75	120/80	115/75	120/80

INDIVIDUAL PULSE RATE OF THE ANAEMIC SUBJECTS IN CUTTING WOOD AT THE START OF THE STUDY AND AFTER SUPPLEMENTATION

	Before Supplementation		After Supplementation	
	Before Activity	After Activity	Before Activity	After Activity
1.	80	103	74	82
2.	76	101	72	80
3.	82	104	72	80
4.	81	99	71	81
5.	79	100	70	82
6.	83	105	73	86
7.	77	101	71	82
8.	80	102	70	81
9.	79	104	70	81
10.	81	100	73	80
11.	79	107	71	80
12.	81	105	76	86
13.	83	104	74	82
14.	79	104	73	81
15.	76	107	71	80
16.	80	104	70	83
17.	80	102	72	85
18.	82	101	71	81

INDIVIDUAL PULSE RATE AND BLOOD PRESSURE OF THE ANAEMIC NON - BENEFICIARY AT THE START OF THE STUDY WHILE CUTTING WOOD.

	Pulse rate of Anaemic non beneficiary		Blood pressure of Anaemic Non-Beneficiary	
	Before Activity	After Activity	Before Activity	After Activity
1.	80	103	115/75	120/80
2.	82	101	117/78	120/80
3.	85	105	115/75	120/80
4.	81	99	120/80	122/82
5.	82	100	121/80	123/82
6.	83	105	117/78	120/80
7.	79	104	118/78	120/80
8.	79	105	115/75	120/78
9.	83	100	120/80	122/82
10.	76	104	120/80	124/84
11.	80	102	117/78	120/80
12.	82	101	118/78	120/80
13.	79	104	120/80	122/82
14.	82	101	120/80	122/82
15.	80	99	117/75	120/80
16.	81	98	120/80	124/84
17.	79	100	115/75	117/78
18.	77	101	118/78	120/80

INDIVIDUAL PULSE RATE OF THE NON-ANAEMIC SUBJECTS WHILE WASHING CLOTHES & CUTTING WOOD

	Washing Clothes		Cutting Wood	
	Before Activity	After Activity	Before Activity	After Activity
1.	72	81	73	82
2.	73	82	72	80
3.	70	80	73	82
4.	71	81	75	87
5.	70	80	72	84
6.	70	80	70	80
7.	70	80	71	82
8.	70	81	70	81
9.	70	81	72	84
10.	72	82	70	80
11.	70	81	71	82
12.	70	80	72	81
13.	71	82	73	82
14.	70	83	71	81
15.	71	84	71	81
16.	72	81	70	81
17.	70	80	70	81
18.	71	85	70	80

INDIVIDUAL BLOOD PRESSURE OF NON-ANAEMIC SUBJECTS WHILE WASHING CLOTHES AND CUTTING WOOD

	Washing Clothes		Cutting Wood	
	Before Activity	After Activity	Before Activity	After Activity
1.	120/81	122/81	120/80	121/81
2.	115/80	117/81	120/80	121/82
3.	120/80	122/81	117/80	120/81
4.	118/79	120/80	115/75	120/80
5.	120/80	122/80	110/75	118/80
6.	110/80	110/82	118/78	121/81
7.	120/80	122/81	120/80	121/81
8.	115/75	120/80	120/80	121/81
9.	115/80	120/81	120/80	122/82
10.	110/75	118/78	120/80	122/82
11.	120/78	122/80	120/80	121/81
12.	120/80	121/82	117/75	120/80
13.	110/80	120/81	115/75	120/80
14.	115/75	120/80	118/78	121/81
15.	120/80	121/82	120/80	121/81
16.	120/80	122/82	120/80	121/82
17.	120/80	121/81	120/80	121/82
18.	117/80	120/80	120/80	121/81

INDIVIDUAL BLOOD PRESSURE OF THE ANAEMIC SUBJECTS IN WASHING CLOTHES AT THE START OF THE STUDY

	Before Supplementation		After Supplementation	
	Before Activity	After Activity	Before Activity	After Activity
1.	120/80	124/80	118/80	120/80
2.	118/80	120/82	120/80	121/81
3.	117/78	120/82	118/80	120/80
4.	120/78	124/80	120/80	122/82
5.	118/78	120/80	120/80	122/80
6.	120/75	124/82	120/80	122/80
7.	115/80	118/82	115/80	118/81
8.	120/80	122/82	118/80	120/84
9.	120/80	122/82	118/80	120/84
10.	115/75	120/80	118/78	120/80
11.	118/78	122/82	120/80	122/82
12.	120/80	124/82	118/80	120/81
13.	120/80	122/82	120/80	124/82
14.	117/75	120/80	118/80	120/82
15.	115/75	120/80	115/75	120/80
16.	117/78	120/80	118/75	120/80
17.	115/80	120/83	115/75	120/80
18.	116/75	121/80	120/80	122/82

INDIVIDUAL PULSE RATE IN SUBJECTS (ANAEMIC) IN WASHING CLOTHES

	Before Supplementation		After Supplementation	
	Before Activity	After Activity	Before Activity	After Activity
1.	80	104	76	86
2.	76	107	74	82
3.	84	103	72	80
4.	79	104	73	81
5.	81	101	71	80
6.	80	104	72	80
7.	79	103	72	82
8.	82	109	70	80
9.	81	105	71	81
10.	82	107	70	80
11.	81	105	76	86
12.	76	107	73	85
13.	79	104	73	80
14.	81	100	70	84
15.	82	102	71	80
16.	81	101	71	81
17.	80	102	70	82
18.	79	104	71	81

INDIVIDUAL PULSE RATE AND BLOOD PRESSURE OF ANAEMIC NON BENEFICIARY WHILE WASHING CLOTHS

	Pulse rate of Anaemic		Blood pressure of anaemic (NB)	
	Before Activity	After Activity	Before Activity	After Activity
1.	80	103	120/80	122/82
2.	77	89	118/78	120/80
3.	79	100	120/80	122/82
4.	81	101	115/75	117/78
5.	83	105	117/78	120/80
6.	81	101	115/75	120/80
7.	80	99	120/80	122/82
8.	80	100	121/80	123/82
9.	81	102	120/80	122/82
10.	80	103	115/80	120/80
11.	81	101	120/80	124/84
12.	82	104	120/80	122/82
13.	81	103	115/75	120/80
14.	80	101	117/78	120/80
15.	80	103	115/75	120/80
16.	77	99	117/78	120/80
17.	78	97	117/78	120/80
18.	80	99	117/78	120/80

INDIVIDUAL BLOOD PRESSURE AND PULSE RATE OF ANAEMIC NON-BENEFICIARY IN HARVARD STEP TEST:

	Blood pressure of anaemic non beneficiary subjects	Pulse rate of anaemic non beneficiary subjects
	After Activity	After Activity
1.	145/90	45
2.	135/90	60.4
3.	140/80	60.6
4.	135/80	47.9
5.	140/75	45.9
6.	140/80	48
7.	135/80	44
8.	140/80	55
9.	145/90	48
10.	145/80	48
11.	135/90	49
12.	140/75	50
13.	135/90	48
14.	145/90	50
15.	140/90	49
16.	140/90	48
17.	140/80	51
18.	135/90	46

APPENDIX XI

INDIVIDUAL WORK OUTPUT OF ANAEMIC & NON ANAEMIC SUBJECTS IN HARARD'S STEP TEST

	Blood Pressure of Anaemic		Blood Pressure of Non-Anaemic	
	Before Activity	After Activity	Before Activity	After Activity
1.	140/90	140/80	135/75	135/70
2.	140/80	135/75	135/75	130/70
3.	145/90	140/85	140/80	135/75
4.	140/80	135/75	145/80	140/75
5.	135/90	130/85	135/80	130/75
6.	140/80	135/75	135/75	130/70
7.	135/75	130/70	135/75	130/70
8.	140/80	135/77	140/80	135/75
9.	135/80	130/75	140/80	135/70
10.	140/75	135/73	145/80	135/70
11.	135/80	130/80	145/75	140/70
12.	145/85	135/80	135/75	130/70
13.	140/80	135/75	135/75	130/75
14.	140/80	135/75	135/75	130/70
15.	135/75	130/75	140/80	135/75
16.	135/90	130/85	145/80	140/75
17.	145/90	135/85	135/80	130/75
18.	140/80	135/75	135/75	130/70

INDIVIDUAL WORK OUTPUT OF ANAEMIC AND NON-ANAEMIC SUBJECTS IN HARVARD STEP TEST

	Pulse rate 30 sec recovery in anaemic subjects	30 second Recovery pulse rate in non-anaemic subjects
	After Activity	After Activity
1.	45	49
2.	44	49
3.	40.8	52
4.	45	56
5.	60.6	47
6.	50.3	49
7.	47.9	58
8.	45.9	53
9.	48	54
10.	40.8	52
11.	54.5	56
12.	53.5	54.5
13.	48	55
14.	48	53
15.	45	54.5
16.	53.5	52
17.	55	56
18.	48	55

INDIVIDUAL WORK OUTPUT OF ANAEMIC AND NON-ANAEMIC SUBJECTS

IN HARVARD STEP TEST

	Cardiovascular scores for Anaemic subjects	Cardiovascular efficiency scores for non-anaemic subjects
	After Activity	After Activity
1.	68	67
2.	70	61
3.	67	62
4.	64	56
5.	60	66
6.	53	56
7.	59	55
8.	56	59
9.	71	59.5
10.	73	61
11.	71	61
12.	59	59
13.	60	53
14.	66	51
15.	67	52
16.	73	51
17.	58.5	54
18.	60.5	55

APPENDIX XII

AREA COVERED BY THE THRE GROUPS IN COOPER'S TEST

	ANAEMIC	ANAEMIC (NON-BENEFICIARY	NON ANAEMIC
1.	166.50	150	170.50
2.	160	151	175
3.	164.50	154.50	175.50
4.	169	149.40	165.50
5.	159	140.50	165
6.	155	160	182.50
7.	142	155.50	185.30
8.	162	150.50	190.50
9.	162	149	189
10.	159	145	187.25
11.	155.40	146	189.60
12.	165	147.5	176
13.	156	146	190
14.	141	150	195.50
15.	162	150	187.75
16.	159.75	160	190
17.	163	156	182.75
18.	172.	150	195.30