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Study of the Effects of the Nutritional and Socio-economic Factors on the Prevelance of Iron Deficiency Anaemia among Pregnant Women

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Abstract

This study was conducted with the following objectives :

1. Determine the prevalence of iron deficiency anaemia among pregnant women .
2. Determine the factors that affect the iron status of pregnant women (nutritional, social etc.)

For the assessment of iron status during pregnancy , 30 healthy pregnant women were included in a longitudinal study from the first to the third trimester. One blood sample was taken in the first trimester and a second blood sample was taken in the third trimester. All subjects were given ten iron supplement tablets at the begining of the study by the researcher. However, they did not recieve any other iron supplements throughout their pregnancy. Ten healthy non-pregnant women were included in the study to serve as controls.

The iron status was assessed using the following parameters : Haemoglobin and serum ferritin levels.The nutritional status was assessed from a nutritional/socio-economic questionnaire that was answered by the study and control groups. (Nutritional status assessed by Body Mass Index).

Both the study and control groups had haemoglobin level below the WHO cut-off points (<12g/dl for non-pregnant women and <11g/dl for pregnant women). However, there was no significant difference (p>0.05) between the level of haemoglobin of the control and the study groups in the first and third trimesters. There was significant difference (p<0.01) in the level of serum ferritin between the study and control group. The study group had a higher level of serum ferritin than the control. There was also high significant difference (p<0.01) in the level of serum ferritin between the first and third trimester in which a large decrease in the level of serum ferritin was apparent.

The results of this study also showed that 16.5% of the study group had IDA* in the first trimester whereas 27.6% had depleted iron stores without frank deficiency. The prevelance of IDA increased to 26.4% in the third trimester while those who had depleted ion stores increased to 46.6%.

*IDA: Iron Deficiency Anaemia

Almost 50% of pregnant women started their pregnancy with adequate iron stores however the level of serum ferritin decreased with the progress of pregnancy. The level of serum ferritin was found to have decreased more in those women who consumed less than 2 meals per day, consumed tea after meals, members of a large family and were of low socio-economic status.

CHAPTER ONE

INTRODUCTION

Anaemia is one of the most observed nutritional deficiency diseases in the world today. It is especially prevalent in women of reproductive age, particularly during pregnancy when it is often a contributory cause of maternal death. Anaemia is a disorder characterized by a blood haemoglobin concentration lower than the defined normal level and is usually associated with a decrease in circulating mass of red blood cells which may be due to a number of reasons (WHO, 1992).

Nutritional anaemia is a condition in which the haemoglobin content of blood is lower than normal as a result of one or more essential nutrients , regardless of the cause of such a deficiency (WHO, 1992).

Davidson et al (1972) stated that iron deficiency anaemia is a problem of serious public health significance, given its impact on psychological , physical development, behavior and work performance. Iron deficiency occurs when there is insufficient amount of iron intake, reduced bioavailibity of dietary iron, increased need for iron or chronic blood loss.When prolonged, iron deficiency leads to iron deficiency anaemia.

It is estimated that about 2,150 million people are deficient . About 90% of all anaemias have an iron deficient component. In the developing world, nearly half the population is iron deficient (Fernando, 1994).

Fernando (1994) stated that roughly 47% of non-pregnant women have anaemia world-wide and including iron deficiency without anaemia the figures may approach 60% and 90% respectively.

Iron deficiency anaemia is much common in women than in men. The main cause is the increased need for iron which is a direct consequence of menstruation and pregnancy.

The loss of iron involved in a normal pregnancy(iron content of fetus, 400mg), delivery (iron content in placenta, uterus and blood loss, 325mg) and lactation (iron content of milk during 6 months of lactation , 175mg) may total to approximately 900mg.

This requires an extra demand of approximately 2mgFe/day for a period of 460 days. It is obvious that pregnancy greatly increases a woman's requirement for iron, it is not surprising that diet alone is often unable to meet the deficit. Iron needs exhibit a marked increase during the second and especially the third trimester when median daily needs increase up to an average of 5.6mg per day (that is , 4.1mg above the median pre-pregnancy needs) (Davidson et al , 1972).

Nutritional Importance of Iron

Iron is an essential nutrient for the human body. It accounts for 0.1% of the mineral elements in the body and the total amount of iron in the body of a healthy person is about 4g (Davidson et al , 1972). Of this, 2.5g are found in haemoglobin, 0.5g in the tissue myoglobin and enzymes and 0.1g stored in the liver, spleen and bone marrow (Taifour, 1991).

Taifour (1991) stated that iron is required for the building of haemoglobin of which it is an essential component and stimulates red blood cells production. Haemoglobin is the pigment which transports oxygen from the lungs to the tissues. If the iron contained in the red blood cells is passed out of the body, it would be difficult to replace it from food.

Fortunately, most of the iron released is conserved and is used to form the new red corpuscles which are produced in the bone marrow in adults and in the liver and spleen in fetal life.In this way, the iron present in haemoglobin is used repeatedly (WHO, 1992).

In the expectant mother, there is an increased demand for nutrients especially in iron and folic acid required for the growth of fetus , the placenta and the larger amount of circulating blood . Most women in third world countries start their pregnancy with depleted iron stores . This means that there is a larger requirement for nutrients during this period (WHO, 1992).

For the first trimester, the requirement is 0.8mg per day increasing to 6.3mg during the second and third trimesters. (WHO, 1992).

During the whole period of pregnancy the total iron required in about 1000mg. For a pregnant woman the requirement is six times greater than for a non-pregnant one. As this cannot be met by diet alone, it is partly derived from maternal stores. Malnutrition and repeated pregnancies causes these reserves to below and therefore anaemia occurs. Even when food intake is adequate , it may take up to two years to replenish body iron stores. (WHO, 1992).

General Causes of Iron Deficiency

The level of body iron is a mirror to the balance between the physiological demand for iron and the amount and type of ingested dietary iron. When iron demands exceeds the absorptive capacity of gastrointestinal tract, iron deficiency occurs. It should be distinguished that there is a difference between iron deficiency anaemia occurring from physiological form from pathological form (Cook ,1984).

Consequences of iron deficiency anemia

The consequences of iron deficiency anaemia are very great. It reduces the working and learning capacity of the human being and severe anaemia increases death associated pregnancy and child birth .
(Galloway et al . 1994).

Evidence indicates that 20% of maternal mortality is due to anaemia, either directly by heart failure or the inability to tolerate haemorrhage indirectly (McGuire, 1988). An anaemic mother gives birth to an anaemic child or premature birth or a low birth weight child (WHO, 1992).

Anaemia in its early stages is often symptomless. As a consequence to low levels of haemoglobin, oxygen supply to the vital organs declines and the mother begins to feel general weakness, tiredness, dizziness and headaches. Impaired resistance to diseases, which is the maximal result of iron deficiency anaemia , leads to heart failure.Iron deficiency anaemia leads to 20% of maternal mortality. In two refugee camps in Somalia (1987), anaemia was the main cause for maternal deaths among women

(42 out of 44 death were associated to iron deficiency) (WHO, 1992). It is well known that anaemic women do not tolerate blood loss as healthy women do and while less severe anaemia may not be the direct cause of maternal death, it can contribute to death from other causes, particularly haemorrhage. Anaemic mothers are also poor anesthetic and operative risks because iron deficiency anaemia lowers the in resistance to infection , in many cases wounds fail to heal promptly after surgery(WHO, 1992). Khattab (1989) reported that in one of the hospitals of Khartoum, 37% of pregnant mothers suffered from iron or folic acid deficiency .

McGuire et al (1988) stated that women in Africa over their reproductive life conceive and nourish 7 children. As reproduction demands heavy work load and proper diet, and this is not available to women of third world countries, we find that this exhausts women. This is known as " Maternal Depletion Syndrome " which due to high physical burden with less food.

Infants with anaemia will never catch up with other healthy children .premature and low birth weight children have a dysfunction in the immune system and growth failure and this in turn increases morbidity and mortality (McGuire et al , 1988). Murphy et al (1986) found that the frequency of low birth weight deliveries was greater in women with very low or very high haemoglobin levels during their second and third trimester. Scholl and Hidiger (1994) found that iron deficiency anaemia in early pregnancy was linked to low birth weight in both pre and full term deliveries.

Iron Deficiency Anaemia in the Sudan

There is not much information regarding the prevalence of iron deficiency anaemia in the country. The contribution of anaemia with high prevalence of maternal morbidity and mortality of children is not very clear. Hospital records showed that iron deficiency anaemia was found to be one of the 10 major causes of hospital admission and deaths (Mohamed , 1991).

Justification

In the Sudan , there has not been much work on the prevalence of iron deficiency. Economic stress and low standards of living among other factors are the main causes leading to iron deficiency anaemia. The result of the study will help us fill the gap in our knowledge about the prevalence of iron deficiency among pregnant women in Khartoum State, determine the causes of the deficiency, nutritional behavior and taboos and will help us implement the already known means of prevention and control.

Objectives of the Study

1. Determine the prevalence of iron deficiency anaemia among pregnant women.
2. Determine the factors that affect the iron status of pregnant women (nutritional, social, economic)

Chapter TWO

LITERATURE REVIEW

2.1 Iron in the Body

In the average adult body , the total content of iron is 3 - 4 grams. Of this , 60% is found in circulating haemoglobin , 30% as storage iron (ferritin or haemosiderin) of which 65% is ferritin and 35% haemosiderin. Storage iron is found in parenchymal cells , which derive it from the plasma and reticuloendothelial systems , which derive it from the breaking down of red cells. Myoglobin contains 4 - 5 % of body iron and a small amount of iron is present in haem-containing enzymes such as cytochromes, catalase, peroxidase and a minute quantity approximately 4mg or 1% circulates in the blood stream bound to transferrin (Wilson et al . 1965).

2.1.1 In Red Blood Corpuscles

The highest portion of iron in the blood is found in red blood cells (erythrocytes) and they amount up to 20,000 billion in the human body. Iron is found in haemoglobin (protein, globin + iron containing pigment, haem). In iron deficiency, there is a limitation on the formation of haemoglobin even though the content of iron required for the formation does not exceed 1%. However, it is the basis for haemoglobin production. After absorption, iron is transported to the bone marrow where new red blood cells are formed. Absorbed iron takes 24 hours to be transported to the bone marrow and after another 15 days it is used in the formation of red blood cells.

Erythrocytes have a lifespan of 120 days. After that red blood cells are broken down in the liver and spleen and the iron is transported to the bone marrow to be used again. Haemoglobin transports oxygen from lungs to the tissues.Haemoglobin lightly bounds to oxygen forming oxyhaemoglobin which is later released to the tissues where there is a need for it (Wilson et al , 1965).

2.1.2 In Blood Plasma

The amount of iron in plasma is approximately 0.2% of the total iron in blood. This iron is in transport and may be :

i) iron absorbed from the gastrointestinal tract

ii) iron from hemolysis of red blood cells

iii) iron released from storage sites or iron transported for excretion. (Gubler , 1956)

All these different irons are transported bound to a protein, globulin known as transferrin. Approximately 27 to 28mg of iron comes from iron obtained through hemolysis whereas 1mg comes directly from food (Gubler, 1956). The level of iron in plasma may vary from 50 to 180mcg/100ml plasma. In iron deficiency, this level is reduced (Wilson et al , 1965).

2.1.3 In Blood Serum

Serum ferritin is the main storage compound in the body. It is found in the reticuloenotheilial cells of the liver, spleen and bone marrow. 10 - 200ug ferritin is found in the circulating blood (Walters et al , 1973). 1ug/L of ferritin is equivalent to 8mg of storage iron. The mean ferritin concentration in men is 94ug/l and in women is 25ug/l (Cook et al , 1976).

2.1.4 In Muscle tissue

Iron is found in muscle cells in 2 forms :

i) **Myoglobin** : Myglobin is formed from the combination of an ion-containing pigment and a protein. Myoglobin stores oxygen.

ii) **Constituent of certain enzymes** i.e. cytochromes, catalses and peroxidases. These enzymes contain iron oxidase, carbohydrates, fat and protein within the cell. They have the same oxidative changes within the cell and provide the oxygen necessary for oxidation (Wilson et al, 1965).

2.2 Absorption of Iron

Iron balance is physiologically controlled by the regulation of iron absorption rather then excretion (Passamore and Eastwood, 1986).Iron absorption is from the gastrointestinal tract to the blood stream and no re-excretion occurs from the blood stream back to the tract i.e. unidirectional movement (Brown , 1963). It is absorbed evenly all through the gastrointestinal tract , with different rates, except the colon. The highest rate of absorption is in the duodenum then decreases progressively from jejunum to ileum (Moore et al , 1962).

Iron absorbed is bound to apoferritin for transport across the inner membrane of the mucosal cell where it is given up to plasma transferrin. Absorption is regulated by the level of transferrin saturation (ACC/SCN, 1991).

Food iron is released into the gastric juice either in ferric or ferrous form or as a haem complex. Haem iron absorption is less dependent on lumial environment than inorganic iron i.e. gastric acid, phytates , ascorbic acid etc donot effect it, however calcium and aminoacids decrease its absorption(Passamore and Eastwood, 1986). Amino acids, simple sugars and other substances of low molecular weight facilitate the attachment of iron to the intestinal mucosa , therefore making it unavailable to the body (Jacobs, 1983). Iron in animal products is in inorganic form and bound to haemoglobin or myoglobin whereas in vegetables it exists in iron-containing enzymes such as peroxidases. The intestinal cells are extremely sensitive to iron requirements in the body and can reject unwanted iron or absorb increased amounts when stores are low. The amount of iron absorbed varies from one individual to another and from one condition to the next. Absorption depends on the bioavailbility of a meal. In some foods, absorption may be as high as 20 - 30% e.g. liver, meat and can be less than 5% in others e.g. spinach , soyabean. In the diet about 5 to 10% of iron may be absorbed in a normal adult (Jacobs, 1983) . Inorganic iron is more effectively absorbed in the reduced form , ferrous form, than in the oxidized form , ferric form . As iron in food is usually in the ferric form, it has to first be reduced before it can be absorbed and this reduction could be through the reducing substances that can be found in food e.g ascorbic acid.(Brown,1963).Absorption of inorganic iron is decreased by inhibiting factors such as phytates,high pH,etc (Jacobs, 1983).

2.3 Transport of Iron

Iron is transported bound to ferritin which is a glycoprotein synthesized in the liver. It transports iron from the lumen to the bone marrow and other organs. About 3-4mg of iron (1% of body iron) is in the form of tranferrin. Developing red blood cells have receptor sites for transferrin but mature red blood cells lack it. Transferrin binds to these receptor sites and deliver iron into the cell. It is then released for reuse in iron transport. During pregnancy, most of the transferrin is directed towards the fetus where the placenta has receptor sites similar to red blood cells (Passmore and Eastwood -1986).

2.4 Storage of Iron

Iron is stored in the liver , spleen and bone marrow approximately 1 to 2gms. Iron stored in these sites is in two compounds : Ferritin and Haemosiderin.

i - Ferritin : A water soluble complex of iron and protein. Iron is first stored as ferritin, which is the first withdrawn when needed for production of red blood cells in the bone marrow. It is more easily mobilized than haemosiderin for the formation of haemoglobin (Wilson et al , 1965). It is found in the reticuloendothelial cells of the liver, spleen and bone marrow. A small amount is found in circulating plasma (10-200ug/l) (Waters et al , 1973).

ii - Haemosiderin : An insoluble iron-protein complex found in macrophages of the bone marrow and spleen. It is the more stable form of iron storage (Wilson et al, 1965).

2.5 Excretion of Iron

Iron once absorbed into the body is tightly held there. Very small amounts are excreted and this is usually unabsorbed iron from food. This is because iron from hemolysis of red blood cells is used for new synthesis of haemoglobin. Very minute amounts are excreted in urine, in feaces from bile and intestinal lining about 0.3 - 0.5mg/day whereas 0.5mg is lost from sweat .

Iron in significant amounts can leave the body through loss of blood e.g. hemorrhage , menstruation. Menstruation can make a female loose from 0.5 to 1mg iron / day. (Wilson et al , 1965).

2.6 Factors Determining iron balance in man

It includes the amount of iron utilized from the diet , iron used to cover physiological iron losses and iron required for growth and pregnancy. Determinant factors for iron requirement is as follows:

i) Basal obligatory losses from skin, urine, feaces etc and may reach up to 14ug/Kg bodyweight/day.

ii) Menstrual iron losses

iii) Iron needed to cover requirements of growth and pregnancy (Hallberg , 1988).

2.7 Recommended Daily Intake (RDA)

Age/Sex	mg/day
1- 4-12 months	0.96
2-13 - 24 months	0.61
3- 2 - 5 years	0.7
4- 6 - 11 years	1.17
5- 12 - 16 years (girls)	2.02
6- 12 - 16 years (boys)	1.82
7 - Adult males	1.14
8- Menstruating women	2.38
9- Lactating women	1.3
10- Third trimester of pregnancy	6.0

(DeMaeyer , 1989)

2.8 Role of Haem and Non-haem iron

There are two kinds of iron in the diet , haem and non-haem iron, and they are absorbed irrespective of one another and are directly influenced by various factors (Hallberg , 1994). Another form of iron is contamination iron. (Monsen, 1978)

2.8.1 Haem iron

This type is found in haemoglobin and myoglobin and is less influenced by the iron status of subjects. Meat and calcium are the only dietary factors that influence haem iron absorption which is approximately 25% but may range from 10 to 40% (Hallberg , 1994).

2.8.2 Non-haem Iron

It is found in cereals , vegetables, fruits, roots etc. and constitutes about 90% of the total iron intake. The iron status of subjects and the composition of the meals greatly influences non-haem iron absorption. In non-anaemic subjects absorption may range from 10 - 40% (Hallberg , 1994).

2.9 Role of Meat in Iron Availibility

Haem iron makes up 50% of iron in meat. In an average diet, the amount of haem iron intake may be 1 - 2mg/day, therefore 0.2 to 0.5mg of absorbed iron is derived from it. Thus, as the requirement of a normal adult man is 1mg, 50% of the iron required may be derived from meat. However, in a normal average mensturating woman, as her iron requirement is higher (1.4mg/day), haem iron may account for as much as 25-30% when meat intake is high. However, the larger part of iron in diets of most nations is derived from non-haem foods.

Meat has two roles in iron nutrition:

i) provision of haem iron.

ii) Presence of an unknown factor that enhances the absorption of both haem and non-haem iron (present also in poultry and sea foods) (Hallberg , 1994).

Table I

Iron content in some selected foods *(Sudan Food Composition Table)*

(See annex for more details)

Food and description *(100g edible portion)*	**Iron (mg)**
Meat , beef	2.7
Meat , mutton	2.8
Sesame	44.7
Okra	16.8
Dates	6.3
Ground nut	12.0
Garden beans	3.2

2.10 Factors influencing Haem and Non-haem Iron Absorption

Absorption of haem and non-haem iron in iron deficient subjects may reach up to 40%. This absorption will be lower in iron replete subjects especially for non-haem iron. Inhibitors in diet reduce the absorption to 1% in non-haem iron and less than 10% in haem iron (Hallberg et al , 1979).

2.10.1 Factors Enhancing Non-haem iron absorption

2.10.1.1 Meat , poultry, fish and sea foods

These greatly increase iron absorption especially if the diet contains inhibiting factors (Sayers et al, 1973).

2.10.1.2 Role of Ascorbic Acid

It has a physiological role in reducing ferric to ferrous iron before its passage through the intestinal tract. An amount ranging from 25 - 100mg of ascorbic acid greatly influences iron absorption. If inhibitors are present in a meal, then the amount of ascorbic acid required to counter act it has to be increased (Sayers et al , 1973).

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2.10.1.4 Gastric Juice + HCl

Liberation of iron in the ferrous state from its bound complex in food is facilitated by HCl and pepsin. The lowering of the pH of the contents of the small intestine helps in increasing the absorption of iron from food (Hallberg , 1994).

2.10.2 Factors Inhibiting Non-haem iron absorption

2.10.2.1 Phytate (Inositol phosphates)

Phytate content is high in seeds , cereals, nuts, beans, peas (Hallberg 1992). These are the largest inhibitors of iron absorption which the body has no intestinal adaptation to its inhibiting effects. (Bruné et al, 1989). The phytate content in flour and rice is greatly influenced by the milling and polishing techniques (Hallberg , 1992).

Fermentation of bread methods also influences the content of phytates (Hallberg , 1992). Iron absorption is inhibited by very small quantities of phytate. This inhibition is counteracted by ascorbic acid and the greater the phytate content in the meal, the more ascorbic acid is needed to balance the inhibition. However, most meals do not contain adequate ascorbic acid to counteract the effect of phytates (Gleerup et al , 1995).

Table III

Phytic Acid Content in Some Foods (Nichollas et al , 1986)

Food *(100g edible portion)*	**Content mg**
Barley	57
Millet	60
Maize	70
Rice	54
Wheat	60
Cow Pea	35
Soya bean	33
Nuts	38

2.10.2.2 Iron-binding Phenolic Compounds

Tea, coffee, cocoa , certain spices and vegetables e.g. spinach contain galloyl groups. Cereals have the same properties. The content of tannins is the main reason behind iron absorption inhibition. It should be realized that the inhibition is very strong and there is a relationship between the inhibition of iron absorption and the content of galloyl groups in different foods. Tea is a strong inhibitor of iron absorption. However, although coffee inhibits iron absorption it is not as high as tea (Hallberg , 1994). Rossander et al (1979) stated that tea reduced the absorption of iron to less than half than in a meal with coffee whereas orange juice increased the absorption to two and a half times.

2.10.2.3 Soy Proteins

The content of phytate is the reason behind its inhibitory effect (Hurnel et al , 1992).

2.10.2.4 Calcium

Calcium strongly influences the absorption of both haem and non-haem iron .The degree of inhibition depends on the dose (up to 300mg) regardless of the source of calcium e.g milk, cheese or CaCl. Iron absorption is reduced by 50-60%. However, if a calcium containing source of food is given at times different from those of main meals (not during the main meals) it was found to increase the total iron absorption by 40% (Hallberg . 1992).

Table IV

Factors Influencing Dietary Iron Absorption (Hallberg, 1988)

Haem iron absorption	**Non-haem iron absorption**
Amount of haem iron Content of calcium in meal Food preparation (time , temp)	Iron status of subject Amount of potentially available non-haem iron
Positive Factors Ascorbic acid Meat/poultry Fermented foods	**Negative Factors** Phytates Polyphenols Calcium Soy proteins

Table V

Upper limit of Absorption of iron form various foods (WHO, 1970)

Food	**Absorption %**
Eggs	10%
Cereals	10%
Vegetables	10%
Pulses (excluding soya bean)	10%
Fish	15%
Soya bean	20%
Meat	30%

2.11 Iron Bioavailability

Iron bioavailability may be characterized as follows :

2.11.1 Low Bioavailability diet

Diet based on cereals , roots and tubers with negligible quantities of meat, fish or ascorbic acids. It contains foods that inhibit iron absorption such as maize, rice, beans , whole wheat flour and sorghum. Such foods are part of a typical diet in many developing countries especially among low income groups. In very low bioavailbility diets which are made up exclusively of cereals, iron absorption may be as low as 3 - 4% (DeMaeyer , 1989) . Contamination iron usually has very low bioavailbility. One exception is iron derived from cooking pots. (Monsen, 1978)

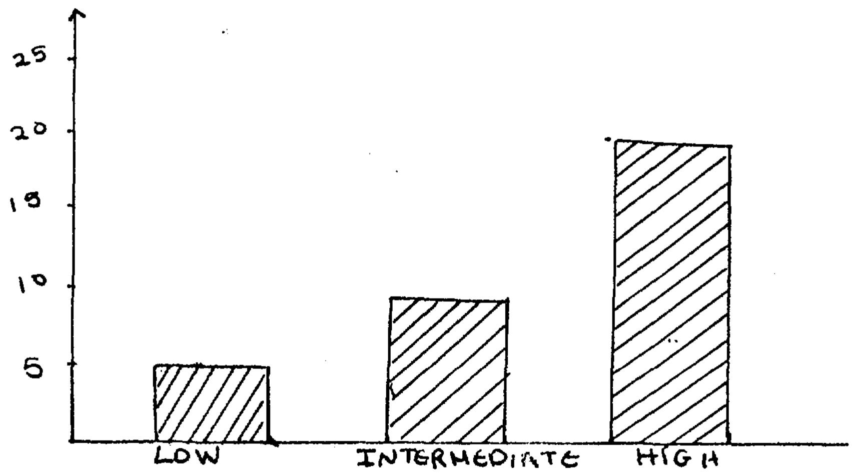
2.11.2 Intermediate Bioavailability Diet

This diet constitutes of cereals, roots (tubers) including some animal product foods and/or ascorbic acid. A low bioavailbility diet can be raised to intermediate bioavalibilty by increase in the uptake of foods that enhance iron absorption i.e. foods of animal origin and foods rich in ascorbic acid. In the same way , a high bioavailibiltiy diet can be reduced to an intermediate availibility diet by intake of absorption inhibitors such as tea, coffee (DeMaeyer , 1989).

2.11.3 High Bioavailability Diet

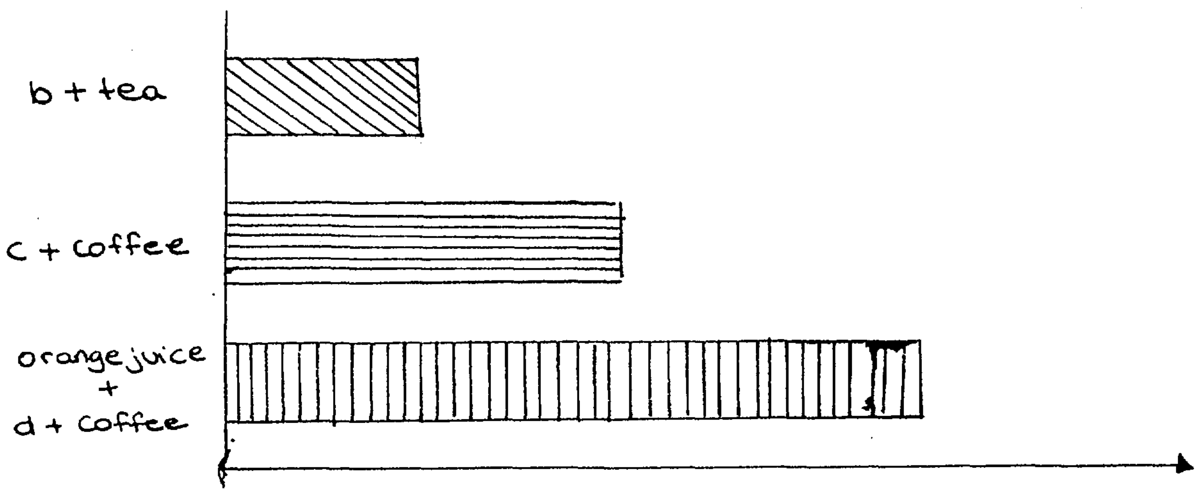
A diversified diet containing generous amounts of meat, poultry, fish and foods rich in ascorbic acid (DeMaeyer , 1989).

Figure II
Effect of iron absorption enhancers on the absorption of non-haem iron



Low availability diet : One that contains less than 30g of meat, poultry or fish or less than 25mg of ascorbic acid daily.
Intermediate availability diet : Diet containing 30-90g of meat, poultry, fish or 25-75mg of ascorbic acid
High availability diet : More than 90g meat or 75mg ascorbic acid or 30-90g meat + 25-75mg of ascorbic acid.
(Monsen et al, 1978)

Figure III
Influence of different beverages on the iron absorption from a Continental Breakfast (a)



a. 2 rolls, margarine, orange marmalade, cheese
b. One cup[of tea (2.5g of tea leaves + 1 50ml of boiling water)
c. Once cup (150ml) of coffee
d. One glass (150ml) of orange juice
(Rosander et al, 1978)

Table VI

Recommended iron intakes (mg/day) designed to cover requirements of individuals in each age /sex group for diets with different bioavaibilites (Monsen et al, 1978)

Age/sex	v. low bio. (< 5%)	Low bio. (5-10%)	Intere bio. (11 -18%)	High bio. (> 19%)
2½- 5 yrs	17	9	5	3
6 -11 yrs	29	16	8	5
12-16 (girls)	50	27	13	9
12 -19 (boys)	45	24	12	8
Adult males	28	15	8	5
<u>Women</u>				
Menstruating	59	32	16	11
Pregnant and				
Lactating	33	17	9	6
Menopause	24	13	6	4

2.12 Nutritional Demands During Pregnancy

Pregnancy makes many demands on the mother and this includes her nutritional needs as well as those of her fetus. There is a definitly direct relationship between the diet of the mother and the status of her infant at birth.(Cooper <u>et al</u> . 1968)

2.12.1 Caloric requirement during Pregnancy

Metabolism of the mother rises during the second half of pregnancy. Therefore, the caloric value/intake of the mother should rise from 2,300 in the first trimester to 2,600 in the second and up to 3,300 in the third trimester.(Cooper <u>et al</u> . 1968).

2.12.2 Protein requirement during Pregnancy

Protein intake must be increased during pregnancy because of the need for growth and replacement of tissues in the mother and fetus. Low protein content directly affects the fetus especially in the third trimester, as a result the infant will be born short and low in weight. Abortion is also associated with low protein intake. (Cooper et al , 1968)

2.12.3 Calcium and Phosphorus requirement during Pregnancy

Calcium and Phosphorus are essential to cover the mothers needs and for the bones and teeth of the growing fetus. Proper utilization is dependent on Vitamin D in the diet. (Cooper et al , 1968)

2.12.4 Iron Requirement during Pregnancy

During pregnancy, the requirement for iron increases to meet the demands of the developing fetus, placenta , increasing maternal erythrocyte mass in addition to the normal daily requirements of the non-pregnant woman. These extra demands depend on her dietary intake, efficiency of absorbing iron and the level of her iron stores (Taylor et al , 1982) . Therefore iron in the diet is very important in supplying the mother and the fetus with their needs for haemoglobin synthesis. Low haemoglobin level during pregnancy indicates inadequate diet. Foods high in iron include meat (of all kinds), leafy green vegetables, dried peas etc(Cooper et al , 1968).

2.12.5 Vitamin Requirements during Pregnancy

All vitamins are essential for metabolism of living tissue and in growth. Water soluble A,D,E,K and fat soluble B & C are very important and deficiency in any one of these leads to deleterious effects on the infant e.g. Vitamin A deficiency during pregnancy leads to eye diseases in the new born infant (Cooper et al , 1968).

Table VII

Recommended Daily Dietary Requirement for a moderately active woman during pregnancy (Cooper et al , 1968)

Nutritional essentials	Non-pregnant	Pregnant
Calories	2,300	2,600
Proteins	58	78
Calcium , gm	0.8	1.5
Iron, mg	12	15
Vitamin A, iu	5,000	6,000
Thiamine, mg	1.2	1.3
Riboflavin, mg	1.5	2.0
Niacin, mg	17	20
Ascorbic acid, mg	70	100
VitaminD, iu	,,	400

2.13 Increases Demand for Iron during pregnancy

The iron requirements during pregnancy is for fetus, placenta, increase in maternal red cell mass and basal iron losses and this adds up to 840mg. In normal non-pregnant women , the iron content is approximately 2.1g (70% is functional and 30% storage iron) . Iron required by a pregnant women, approximately 40% of the total body iron of non-pregnant women, should be met by increased dietary iron absorption, cessation of menstrual blood loss and maternal iron stores (Hallberg, 1994).

Non-haem iron absorption in a pregnant woman increases from 5% in the first trimester to 36 and 66% in the second and third trimester respectively. The most important factors in regulating iron absorption is the amount of iron in food + iron status.However, haem iron absorption is more efficient (16-26%) than that of non-haem iron (1-15%)(Barrett et al , 1994).

During normal pregnancy, there is any increase in the absorption of iron from food and this is a physiological consequence and is not the result of developing anaemia during pregnancy. This increase is large enough to meet the increased requirements during pregnancy provided that the dietary intake is adequate. At 24 weeks of gestation , the mean absorption of iron is 5 times higher than at 12 weeks, it doubles again and by 36 weeks it increases by 9.1 times(Barrett et al , 1994). In early pregnancy, only basal iron requirement (0.8mg) i.e 6% of daily iron intake is required for iron balance. As pregnancy age proceeds , an extra 300mg is required for expansion of red cell mass and during the third trimester another 300mg is needed for developing the fetus and the placenta. Therefore, iron absorption from food increases from 6 to 32% (Barrett et al , 1994).

A WHO report (1992) stated that during pregnancy , growth of the fetus and the placenta and the larger amount of circulating blood of the expectant mother leads to an increase in the demand for nutrients especially iron and folic acid. Most women in third world countries start pregnancy with depleted body stores for those nutrients means that their extra requirement is even higher than usual. The total iron needed during the whole pregnancy is estimated at about 1000mg. The requirements for iron are six times greater for a pregnant women than for a non-pregnant one. This cannot be met by diet alone , but is derived at least partly from maternal reserves.

When these reserves are already low due to malnutrition and/or frequent pregnancies, anaemia occurs. It has been estimated that even when food intake is adequate, it may take two years to replenish body iron stores after a pregnancy (WHO, 1992).

High iron requirements are limited to the second and third trimester. Although iron absorption increases during the third trimester , it does not cover the requirements needed (Hallberg, 1988).

Table VIII

Iron requirement during pregnancy

(Hallberg, 1988)

During pregnancy	mg/individual
Fetus	300
Placenta	50
Expansion of red cell mass	450
Basal iron losses	240

2.14 What is Anaemia ?

Literally anaemia means shortage of blood. An estimation of 1.3-2.15 billion people are anaemic. 90% of them living in developing countries (WHO, 1992). In a WHO Report (1992) it was stated that anaemia was responsible for 20% of maternal deaths in Africa .

Anaemia may be classified into 2 types , those due to

1. Loss of blood (haemorrhage)
2. Deficiency of certain substances essential for haemoglobin or red cell formation

Anaemias due to deficiencies

This group includes the anaemias caused by 2 types of deficiencies :

1. Deficiency in substances necessary for haemoglobin formation i.e. iron, protein, folic acid

2. Deficiency in substances necessary for red cell formation and the release of these cells from the bone marrow (Cooper,1968).

Nutritional Anaemia may also be defined according to the red cell morphology

i- Microcytic Aanemia (small red blood cells) as in iron deficiency anaemia

ii- Macrocytic anaemia (large red blood cells)

iii- Amount of haemoglobin (hypochromic anaemia)

iv- Megaloblastic anaemia (abnormal cells)

v- Pernicious anaemia

2.17 Iron Deficiency Anaemia

"Iron Deficiency Anaemia is anaemia caused due to shortage of iron and is referred to as chronic , nutritional hypochromic anaemia where the red blood cells are reduced in size and the haemoglobin amount is low." (Davidson and Passamore , 1986).

Globally, Iron Deficiency Anaemia (IDA) is the most common nutritional disorder .IDA results when the amount of iron absorbed in the body is insufficient to meet its nutritional requirements and increases when this deficiency is prolonged . In Africa , the prevalence of IDA in men is 10 -20% in men and up to 50% in women . Iron deficiency anaemia is said to effect nearly1 billion people, specially child bearing age women and prèschool children (ACC/SCN, 1991). It is more prevalent among women than men, young than the more mature, among the poor than the rich and blacks compared with other ethnic groups (Pilch et al 1984).

Iron deficiency anaemia causes hypochromic and microcytic anaemia where there is inadequate iron for the formation of haemoglobin and red blood cells are small (ACC/SCN, 1991).

2.16 Evolution of Iron Deficiency Anaemia

There are specific stages in the evolution of iron deficiency

I. Iron stores fully depleted : This marks the onset of tissue iron deficiency and iron-deficient erythrpoesis (IDE) .

II. Deficit in tissue iron leads to low haemoglobin concentration which marks the onset of iron deficiency anaemia (IDA).

IDE and haemoglobin concentration distinguishes mild iron deficiency without anemia from Iron Deficiency Anaemia.

(Cook et al , 1984)

Cook et al . 1990 , stated that body iron status varies with the degree of iron deficit in its storage and functional compartments :

1. Replete non-anaemic
2. Deficient non-anaemic (serum ferritin, transferrin saturation)
3. Deficient erythropoesis (morphology of red blood cells i.e. microcytic, hypochromic, erythocyte protoporphyrin)
4. Deplete anaemia (Haemoglobin)

2.17 Forms of Iron Deficiency Anaemia

There are two forms of Iron Deficiency Anaemia

1. Latent : unrecognizable by external appearance

2. Manifest : recognizable clinical symptoms

In Latent Iron Deficiency Anaemia , iron stores are low, plasma iron level is reduced , low haemoglobin, iron binding capacity increases i.e. ferritin is free and uncombined.

In Manifest Iron Deficiency Anaemia , inaddition to conditions in Latent deficiency, outward symptoms are paleness, weakness and pallid appearance (Wilson et al , 1965).

2.18 Identifying the causes of Iron Deficiency

Cook et al (1990) stated that in normal subjects, iron deficiency may be due to :

1- Rapid body growth
2- Excessive menstrual blood loss
3- Pregnancy
4- Frequent blood donations
5- Endurance training
6- Chronic aspirin usage
7- Diet with low iron bioavailibility

2. 19 Vitamin A and Iron Deficiency

Vitamin A deficiency also disturbs iron metabolism and this may aggravate the consequences of Iron Deficiency Anaemia .
(ACC/SCN , 1991)

2.20 Causative Factors for Iron Deficiency Anaemia

Inadequate amounts of iron in the body may be due to :

1. Inadequate iron intake
2. Poor absorption due to disease
3. Abnormal loss of blood from body

(Wilson et al, 1965)

2.21 WHO Standards for Anaemia

1. Iron replete with normal haemoglobin
2. Anaemic but not due to iron deficiency
3. Iron Deficient but not yet anaemic
4. Iron anaemic and Iron deficient

(WHO , 1995)

Table IX

Hb levels indicative of Anaemia in Population living at sea level

(WHO, 1968)

Age / sex group	Hb level g/dl
Children 6 months to 5 years	<11
Children 6 to 14 years	<12
Adult males	<13
Adult females (non pregnant)	<12
Adult females (pregnant)	<11

Table X

Degree of Anaemia

(WHO , 1968)

Grades	**Hb Level (g/dl)**
Mild	> 10
Moderate	7 - 10
Severe	< 7

Table XI

Serum Ferritin levels indicative of Anaemia

Degree / level	**Value**
Iron deficiency	< 10 - 12ug/l
Iron depletion without frank deficiency	20 -30ug/l
Normal range	30 - 300ug/ l
Iron over load	300 - 500ug/l

2.22. Physiological and Functional Effects of Iron Deficiency Anaemia

2.22.1 Alimentary Function

Impaired Vitamin B12 absorption occurs in IDA. Ga[illegible] achlorohydria was found to be due to IDA as well as low Vitam[illegible] [illegible] absorption i.e. malabsorption syndrome occurs.

2.22.2 Symptoms , Activity and Exercise Tolerance

In IDA , there is a shift (decrease) in oxygen affinity of haemoglobin with an increased cardiac output. Anaemic persons have substantially reduced exercise tolerance when compared with non-anaemic subjects. This intolerance is proportional to haemoglobin deficit.(Beutler , 1986).

2.22.3 Cardiovascular function

Increased cardiac output, regional flow and decrease in oxygen affinity of haemoglobin.(Beutler , 1986).

2.22.4 Pulmonary Function

Anaemic patients have an increased respiratory rate, decrease in tidal volume , increased in physiological dead space and decrease alveolar ventilation.

2.22.5 Endocrine System

Diminished pituitary size in severe IDA (Beutler , 1986).

2.22.6 Nervous System

Neurons need iron inorder to sustain metabolism function. IDA leads to growth retardation and impaired intellectual performance. (Beutler , 1986).

2.22.7 Iron and Infectious Diseases

IDA enhances the susceptibility to infection (Beutler , 1986).

2.23 Iron Deficiency Anaemia and course and outcome of Pregnancy

Maternal IDA leads to :

1. Increased placental weight
2. Low fetal weight
3. Increased perenatal delivery
4. Perenatal mortality

(Scholl. Hediger. 1994)

2.24 Effect of Iron Deficiency on the Mother

1. Increased fatigue
2. Decreased work performance
3. Cardiovascular stress due to inadequate haemoglobin and low blood oxygen saturation
4. Impaired resistance to infection
5. Poor tolerance to heavy blood loss
6. Surgical interventions at delivery
7. More likely to require blood transfusions
8. Higher risk of cesarean section

(USPSF . 1993)

2.25 Effect of Iron Deficiency on the Fetus and Newborn

1. Low birth weight
2. Prematurity
3. Preterm birth
4. Perinatal mortality

(USPSF . 1993)

2.26 Effect of Iron Deficiency on Infants and Children (up to 9 years)

1. Impaired motor development and coordination
2. Impaired language development and scholistic coordination
3. Psychological and behavioural effect (inattention, fatigue , insecurity)
4. Decreased physical activity

(DeMaeyer . 1989)

2.27 Effect of Iron Deficiency Anaemia of Mother on the New Born Child

In the fetus, iron is transported through the placenta against the concentration gradient and this provides enough iron for fetal erythropoesis (Milan , 1987). When the mother is iron deficient , the infant will be born with an inadequate iron store. Therefore, although haemoglobin levels may be original at birth, the iron stores in the body are not adequate to meet the increase for the production of red-cell mass that occurs during rapid growth of infancy. This forms what is called" Congenital Iron Deficiency Anaemia". (Jellife , 1955) . Although the haemoglobin level of the newborn is not affected by maternal iron stores, the serum ferritin of infants born to anaemic mothers is low (Hokama et al , 1996). Milan et al (1987) stated that low levels of serum ferritin in maternal blood are associated with low levels of cord blood. In the third trimester, there is a transfer of iron from mother to fetus which is reflected by declining ferritin concentrations of mother . Therefore, high maternal stores and consequent high neonatal iron stores may be beneficial in reducing the risk of iron deficiency in the first year of life (Kelly, 1978).

During the first three months of an infants life, he is assumed to have sufficient iron as most of the total body iron is contained within the circulating haemoglobin. However, after three months , iron stores are mobilized to meet erythropoetic demands to expand haemoglobin mass as breastmilk alone is not enough to meet growth demands. Therefore, plasma ferritin declines and infants with small iron stores will deplete their iron earlier than iron replete infants (Hokama et al , 1996).

2.28 Pregnancy and Haemodilution

The prevalence of anaemia during pregnancy increases from the first to the third trimester and this is due to the expansion of maternal plasma volume. This is a normal physiological response to pregnancy. The expansion of blood cell mass during pregnancy and the expansion of plasma volume is not synchronous. As a result , haemoglobin concentration and haematocrits decline throughout the first and second trimester but rise again in the third trimester . Women who test positive for anaemia early in pregnancy are true positives compared with those who test positive in their third trimester (Scholl , Hediger , 1994). Chesley (1972) stated that during pregnancy there is an increase in the volume of plasma by (600 - 1700 ml) and erthyrocyte mass by (270 - 495 ml) i.e. dilution 5 - 15%. Some of the plasma content increases, some decreases and another stays the same .

2.29 Malnutrition in Sudan

Khattab (1989) stated that the nutritional problems faced by the Sudan are as follows :

1. Protein-energy malnutrition (PEM)
2. Vitamin A deficiency
3. Iodine deficiency Disorders (IDD)
4. Nutritional anaemia particularly, iron deficiency anaemia (IDA).

The most common causes for malnutrition include :

1. Low Incomes : Low income is the major reason behind the inadequate level of food consumption (whether in quality or quantity).

2. Food System Deficiencies : Purchasing power is affected by the food system whether through prices or available products.

3. Sociocultural Beliefs : traditional food habits and taboos greatly affect the nutritional status of the individual

4. Unfavorable Health environment : Congestion , lack of water and hygiene, health care and sewage and drainage systems all lead to malnutrition (Khattab, 1989).

The natural result of these changes was a major migration of people from the Southern and Western States and their settlement around the major urban cities. (Khattab, 1989).

2.30 Iron Deficiency Anaemia in Sudan

Baseline data is still lacking to show the actual prevalence of Iron Deficiency Anaemia in Sudan. The FAO Profile (1990) stated it as a public health problem however research is still virgin in this area. Nutritional anaemia is one of the 10 major reasons for hospital admission in Sudan (Kamal, 1991). In a WHO report (1992) , it was stated that in a study conducted in Wad Medani, Central Sudan, the prevalence of anaemia was found to be 36%. In one hospital in Khartoum, 37% of the pregnant mothers suffered from iron or folic acid deficiency. Krawinkel (1990) stated that serum ferritin in Sudanese mothers was found (13 + 1.2ug/l).

2.31 Causative factors for Iron Deficiency Anaemia in Sudan

(Khattab , 1989)

1. Chronic blood loss (due to parastic infection, etc)
2. Faulty iron intake or absorption
3. Vommiting and diarrhoea
4. Increased iron requirement for growth of blood volume
5. Defective release of iron into plasma from iron stores due to chronic inflamation or chronic disorder
6. Insufficent dietary intake
7. Poverty
8. Low purchasing power
9. Food habits and taboos
10. Depletion of iron stores due to repeated pregnancy and lactation
11. Infection
12. Illiteracy and lack of nutrition education.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Omdurman Province was chosen as the study area for the study due to the diversity of the population i.e presence of different ethnic groups , tribes and religions. AlDayat Maternity Hospital was selected as the site for sample collestion as pregnant ladies of differet socio-economic levels, ethnic groups from the different areas of Omdurman and a reasonable number form Khartoum habitants visit its antenatal clinic.

All women informed verbal consent before the commensment of the study.

3.2 Study Sample

3.2.1 Target Group

The subjects were randomly selected from AlDayat Maternity hospital and they totaled to 30 women. Their ages ranged from 18 to 45 .

Criteria of selection

i) Pregnant ladies in their first trimester (later to be followed till they reached their third trimester)

ii) Free from diseases

iii) Not under iron supplementation program.

3.2.2 Control Group

Ten female subjects were selected as the control group.

Criteria of Selection

i) Non-pregnant, mensturating females

ii) Free from any diseases

iii) If married, last pregnancy was to be two years prior to taking the blood sample.

Random selection of the control group was carried out in different areas of Omdurman Province. Their ages ranged from 21 to 47 of which 4 were married and 6 single.

3.3 Material

The materials used in this study were as follows :

3.3.1 Questionnaire

A questionairre was filled out by the subjects which included the following information :

a) Anthropometric data

b) Socio economic status

c) Maternity information

d) Diet and Nutrition information

e) Food habits and taboos

f) Health related data

3.3.2 Blood samples for determination of haemoglobin and serum ferritin level

Two venous blood samples were collected from the target group.

The first blood sample in the first trimester (5ml) and the second blood sample in their third trimester (5ml).

One venous blood sample (5ml) was taken from the control group.

The two key parameters in the monitoring of the iron status during pregnancy were haemoglobin and serum ferritin and for both groups the same mentodology was carried out .

3.4 Haemoglobin and Serum Ferritin Determination

From the venous blood samples collected, 20ul of blood was taken from each sample for haemoglobin level determination. The remainder of the samples were centrifuged at 1000g for ten minutes , the serum removed and placed in storage tubes and then stored at - 20C until analysed for serum ferritin level.

3.4.1 Method

3.4.1.1 Determination of haemoglobin Level

Study samples for haemoglobin were analysed at the Blue Nile Hospital Medical Laboratory .

20ul of blood was added to 4ml of Drabkins solution (Haemoglobincyanide) and mixed thoroughly. After 3 -5 minutes, the mixture was compared with the standard and a reagent blank in a photoelectric colorimeter with a 540 nm filter. The readings were in percentile and were converted into g/dl using the following formula :

$$\frac{\% \times 14.6 g/dl}{100}$$

3.4.1.2 Determination of Serum Ferritin Level

Serum ferritin was measured using ImmunoRadioMetric Assay (IRMA) which is an immuno technique using an Antigene - Antibody comple i.e rabbit antiferritn , antiserum and a mouse antiferritin antibody were used.

The study samples for serum ferritin were analysed at the Sudanese Atomic Energy Research Station .

Study Sample

Fifty microliter of a sample/standard were pipitted in a test tube which containded coated beads of the first antibody in additon to 200ul of phosphate buffer (pH= 7.4) . The tubes were vortexed and placed for 2 hours in a rotary mixer for incubation. After that the solution was discarded from the tubes and the beads were added with antiferritn (I125 - antiferritin tracer) and washed 3 times with Coash (phosphate buffer). The result was an Antigene -Antibody complex. Then, 300ul assay buffer and 50ul of the second antibody were added to the beads in the test tubes which were again vortexed and rotated for 2 hours. The beads were than washed with the wash buffer and the result was an Antibody-Antigene-Antibody complex. The tubes were then placed in a gamma counter for 100secs and the value of each sample was read.

Standards

Eight standards with the followimg concentrations 0,10, 20, 62, 250, 500. 1000 and 200ug/L were used for the calibration curve and were subjected to the same IRMA process.

Quality Control Samples

Three quality control samples were used in this test i.e A1B1C1 before the test and A2 B2 C2 after the test.

Therefore the IRMA process was as follows :

Standard - QC samples - Study samples - QC samples.

3.5 Statistical Analysis

The data collected was then analysed using SPSS (Statistical Package for Social Science) software package.

Students t-test and correlation anaysis were used for statistical analysis.

CHAPTER FOUR

RESULTS

4. 1 : Mean values of Age, Weight and height of Study and Control Groups

Group	Number	Age ± S.D	Weight ± S.D	Height ± S.D
Study Group	30	26.9 ± 6.46	57.87 ±10.87	162.2 ± 7.11
Control Group	10	28.8 ± 6.02	63.3 ± 14.0	163.4 ± 5.98

The study group consisted of 30 pregnant women with average age, weight and height 27 years, 58Kg and 162 cm respectively; whereas the control group consisted of 10 mensturating women of mean age, weight and height 29 years , 63kg and 163cm respectively.

4. 2 : Body Mass Index (BMI) of Study and Control Group

Group	Number	BMI
Study Group	30	21.9 ± 3.4
Control Group	10	32.5 ± 3.4

The control group has a better BMI than the study group 32.5 and 21.9 respectively. Both goroups had good BMI > 15.

Table 4.3: Breastfed children by Study and Control Groups

Family	Study Group	Frequency	Control Group	Frequency
Yes	16	88.9%	3	100%
No	4	11.1%		

In the study group 88.9% of the women breastfed their children while the whole percentage of the control group breastfed their children.

Table 4. 4 : Mean Values of Mother's Age at 1st Birth and Duration of Breastfeeding of Study and Control Groups

Group	Number	Age ± S.D	Number	Duration ± S.D
Study Group	30	21.4 ± 4.67	30	1.59 ± 0.58
Control Group	3	24.66 ± 5.0	3	2.00 ± 0.00

Mean value of mother's age at 1st birth was 21.4 and 24.66 for the study and control groups respectively whereas duration of breastfeeding was 1.5 years for the study group and two years for the control group.

Table 4.5: Number of Children and Spacing Between Children of Study and Control Groups

Group	Number	Parity ± S.D	Spacing bet. children + S.D
Study Group	17	1.9 ± 2.16	2.19 ± 1.03
Control Group	3	1.0± 1.7	3.3 ± 1.15

In the study group the parity was 2.16 + 1.9 whereas that of the control group was 1.7 + 1.0 the spacing between children was more spaced out in the control group.

Table 4.6 : Number of times Meat eaten per week by Study and Control Groups

Meat/week	Study Group	Frequency	Control Group	Frequency
< 1	7	26.9%	-	-
2-3	12	46.1%	2	20%
> 4	11	27%	8	80%

In the study group 46.1% of the pregnant women consume meat 2-3 times per week where as 27% eat meat more than four times per week. The larger percentage of the control group 80% consume meat more than four times per week.

Table 4.7: Mean values of Haemoglobin at 1st trimester (Hb1) and 3rd trimester for Study group (Hb2) and Haemoglobin (Hb1) value for the Control Group

Group	Number	Hb1 ± S.D	Hb2 ± S.D
Study Group	30	10.55 + 0.81	10.29 + 1.03
Control Group	10	10.61 + 1.103	-

Level of significance $= p>0.05$

There is no significant difference in the mean values of haemoglobin in the first trimester and second trimester . The value of haemoglobin of the control group is nearly the same.

Table 4.8: Mean values of Serum Ferritin at 1st trimester (Fe1) and 3rd trimester for Study group (Fe2) and Serum Ferritin (Fe1) value for the Control Group

Group	Number	Fe1 ± S.D	Fe2 ± S.D
Study Group	28	40.00 + 36.08	20.69 + 16.65
Control Group	10	28.64 + 33.09	-

Level of significance $= p<0.01$

There is a high level of significance at p<0.01 in the serum ferritin levels in the first trimester and third trimester in the study group. There is also high significant difference between the level of serum ferritin in the first trimester and that of the control group.

Table 4.9: Prevelance of Iron deficiency anaemia (< 12ug/l) in Study and Control Group (1= 1st trimester , 2 = 3rd trimester)

Group	1	Prevelance	2	Prevelance
Study Group	5	16.5%	8	26.4%
Control Group	4	40%		

The prevelance of IDA is higher in the control group 40% however the prevelance of IDA increases in the third trimester for the study group.

Table 4.10 : Number of Meals per day consumed by Study and Control Groups

Meals/day	Group 1	Frequency	Group 2	Frequency
1	2	6.7%	0	0%
2	11	36.7%	3	30%
3	17	56.7%	7	70%

The larger percentage of women in both study and control groups consumed three meals per day

Table 4.10.1: Relationship between Number of meals/day and Haemoglobin (Hb1) content for the Study Group in the First Trimester and the Control Group

	Hb1 ± S.D		Hb1 ± S.D	
no.of meals	Number	Study	Number	Control
1	2	10.44 ± 0.72	0	-
2	11	10.36 ± 0.72	3	10.56 ± 0.85
3	17	10.73 ± 0.87	7	10.63 ± 1.25

Level of significance = $p>0.05$
There is no significant difference in the level of haemoglobin in both groups.

Table 4.10.2 : Relationship between Number of meals/day and Haemoglobin (Hb2) content for the Study Group in the Third Trimester

no. meals/day	Number	Hb2 ± S.D
1	2	10.93± 0.92
2	11	10.33 ± 0.72
3	17	10.31 ± 0.62

Level of significance = $p>0.05$
There is no significant difference in the level of haemoglobin .

Table 4.10.3 Relationship between number of meals/day and SerumFerritin (Fe1) content for the Study Group in the First Trimester and the Control Group

		Fe1 ± S.D		Fe1 ± S.D
no.of meals	Number	Study	Number	Control
1	2	31.29 ± 12.89	0	-
2	10	35.81 ± 19.10	3	31.99 ± 17.27
3	16	45.97 ± 46.13	6	26.96 ±40.28

Level of significance = $p<0.05$

There is high significant difference between those who consumed three meals a day in the study group and those who consumed one meal per day whereas the difference is not very significant between those who consumed one meal and two meals respectively. The level of serum ferritin in the control and study group for those who consumed three meals per day is also significantly different.

Table 4.10.4: Relationship between number of meals/day and Serum Ferritin (Fe2) content for the Study Group in the Third Trimester.

no. meals/day	Number	Fe2 ± S.D
1	2	27.55 ± 19.59
2	10	20.54 ± 15.25
3	16	19.93 ± 17.93

Level of significance = $p<0.05$

There was a prominent reduction in the level of serum ferritin in the third trimester and there is significant difference between the three different levels of meal consumption. The level of serum ferritin in those consuming one meal per day is high as there were only 2 cases and therefore the result is considered as insignificant.

Table 4.11 : Consumption of Tea and/or Coffee after meals by Study and Control Groups

Tea/Coffee	Group 1	Frequency	Group 2	Frequency
Tea	21	70%	8	80%
Coffee	3	10%	1	10%
Both	6	20%	1	10%

The consumption of tea and coffee was added to the study as it was found that the consumption of these two beverages greatly affected the level of iron absorption. Tea being the highest beverage consumed in both the study and control groups. The larger percentage of the study and the control groups consumed tea after meals.

Table 4.11.1 Relationship between Tea/Coffee intake after meals and Haemoglobin (Hb1) content for the Study Group in the First Trimester and the Control Group

	Hb1 ± S.D		Hb1 ± S.D	
Tea/Coffee	Number	Study	Number	Control
Tea	21	9.87 ± 1.25	8	11.68 ± 0.00
Coffee	3	10.39 ± 0.64	1	10.53 ± 1.17
Both	6	10.86 ± 0.98	1	10.22 ± 0.00

Level of significance = *p>0.05*

There is no significant difference in the level of haemoglobin in both groups and between the different beverages.

Table 4.11.2: Relationship between Tea/Coffee intake after meals and Haemoglobin (Hb2) content for the Study Group in the Third Trimester.

Family	Number	Hb2 ± S.D
Tea	21	9.24 ± 0.44
Coffee	3	10.51 ± 0.55
Both	6	10.05 ± 0.41

Level of significance = *p>0.05*

There is no significant difference in the level of haemoglobin between the different beverages.

Table 4.11.3 : Relationship between Tea/Coffee intake after meals and Serum Ferritin (Fe1) content for the Study Group in the First Trimester and the Control Group

	Fe1 ± S.D		Fe1 ± S.D	
Tea / Coffee	Number	Study	Number	Control
Tea	20	40.47 ± 38.88	7	17.32 ± 17.27
Coffee	3	55.10 ± 45.85	2	106.67 ± 0.00
Both	6	41.97 ± 34.44	1	29.96 ± 0.00

Level of significance = $p<0.05$

In both the study and control groups the lowest level of serum ferritin was in those who consumed tea directly after meals whereas those who consumed coffee had a good level of serum ferritin.

Table 4.11.4 : Relationship between Tea/Coffee intake after meals and Serum Ferritin (Fe2) content for the Study Group in the Third Trimester.

Family	Number	Fe2 ± S.D
Tea	19	14.76± 5.70
Coffee	3	23.53 ± 17.92
Both	6	14.66 ± 14.69

Level of significance = $p<0.05$

The level of serum ferritin greatly decreased from the first trimester to the third trimester and the highest level of reduction was in those who consumed tea after meals,

Table 4.12: Family Size of Study and Control Groups

Family	StudyGroup	Frequency	Control Group	Frequency
Small	14	46.7%	7	70%
Large	16	53.3%	3	30%

Small family : household number ≤5
Large family : household number ≥8
Approximately half of the study group lived in large families whereas the larger percentage of the control group 70% lived in small families.

Table 4.12.1: Relationship between Type of Family and Haemoglobin (Hb1) content for the Study Group in the First Trimester and the Control Group

	Hb1 ± S.D		Hb1 ± S.D	
Family	Number	Study group	Number	Control group
Small	14	10.73 ± 0.72	7	10.93 ± 1.15
Large	16	10.43 ± 0.87	3	9.88 ± 0.59

Level of significance = $p>0.05$
There is no significant difference in the level of haemoglobin in both groups.

Table 4.12.2: Relationship between Type of Family and Haemoglobin (Hb2) content for the Study Group in the Third Trimester.

	Hb2 ± S.D	
Family	Number	Study group
Small	14	10.36 ± 0.53
Large	16	10.22 ± 0.72

Level of significance = $p>0.05$
There is no significant difference in the level of haemoglobin in both groups.

Table 4.12.3: Relationship between Family Size and Serum Ferritin (Fe1) content for the Study Group in the FirstTrimester and the Control Group

	Fe1 ± S.D		Fe1 ± S.D	
Family	Number	Study	Number	Control
Small	12	42.58 ± 40.80	7	32.24 ± 40.10
Large	16	36.57 ± 30.04	3	21.43 ± 15.58

Level of significance = $p<0.05$

There is significant difference in the level of serum ferrtin in both the study and control groups where the level of serum ferritin is higher in nuclear families than that of extended families.

Table 4.12.4 : Relationship between Family Size and Serum Ferritin (Fe2) content for the Study Group in the Third Trimester .

	Fe2 ± S.D	
Family	Number	Study
Small	14	23.28 ± 19.89
Large	14	18.09 ± 13.67

Level of significance = $p<0.05$

The level of serum ferritn decreased in the third trimester in both extended and nuclear families and the difference is very obvious between the level of serum ferritin within the third trimester between the nuclear and extended families.

Table 4.13 : Socio-economic Level Distribution of Study and Control Groups

Class	Study Group	Frequency	Control Group	Frequency
High	10	33.3%	5	50%
Middle	6	20%	1	10%
Low	14	46.7%	4	40%

Approximately half of the study group are low class citizens whereas the remaining percentage is divided between the two groups. On the other hand 50% of the control group are high class citizens whereas 40% are low class individuals.

Table 4.13.1 :Relationship between Socio-economic Level and Haemoglobin (Hb1) content for the Study Group in the First Trimester and the Control Group

	Hb1 ± S.D		Hb1 ± S.D	
Class	Number	Study	Number	Control
High	10	10.56 ± 1.01	5	10.86 ± 1.22
Middle	6	10.31 ± 0.91	1	10.22 ± 0.00
Low	14	10.69 ± 0.60	4	10.40 ± 1.20

Level of significance = $p>0.05$

There is no significant difference in the level of haemoglobin between the study group in the first trimester and the control group.

Table 4.13.2 : Relationship between Socio-economic Level and Haemoglobin (Hb2) content for the Study Group in the Third Trimester .

Class	Number	Hb2 ± S.D
High	10	10.39 ± 0.70
Middle	6	10.03 ± 0.89
Low	14	10.34 ± 0.46

Level of significance = $p>0.05$

There is no significant difference in the level of haemoglobin in the different socio-economic classes.

Table 4.13.3 : Relationship between Socio-economicClass and Serum Ferritin (Fe1) content for the Study Group in the First Trimester and the Control Group

		Fe1 ± S.D		Fe1 ± S.D
Class	**Number**	**Study**	**Number**	**Control**
High	9	57.28 ± 45.32	4	41.44 ± 48.47
Middle	6	49.87 ± 44.19	1	29.96 ± 0.00
Low	13	23.49 ± 13.23	4	15.15 ± 11.03

Level of significance = $p<0.05$

There is high significant difference in the level of serum ferritin in the study and control groups between the high and low socio-economic classes. The same applies between the middle and low . However there is also high significant difference between the level of serum ferritin in the first trimester and the control group and between the high and middle socio-economic groups.

Table 4.13.4 : Relationship between Class and Serum Ferritin (Fe2) content for the Study Group in the Third Trimester .

Class	Number	Fe2 ± S.D
High	9	26.82 ± 25.17
Middle	6	21.67 ± 7.81
Low	13	16.01 ± 10.79

Level of significance = $p<0.05$

There is high significant difference in the third trimester between all the three socio-economic classes. There is a large decrease in the level of serum ferritin from the 1st to the 3rd trimester for the high and middle classes .

Table 4.14. : Foods Eaten Almost Daily by the Three Socio-economic Classes of the Study and Control Groups

A) High Class

Breakfast	Foul , tamia, yougrt, cheese , tahnia, sausages, fried meat , eggs
Lunch	Mulah (potatoes, Mulukhia, Bamia, Warag, Rigla, Aswad) Kofta, meat (fried , stew), chicken (fried, stew), fish , rice, macaroni,, salads (green, with peanut butter, with yougrt, eggplant)
Dinner	Milk, cheese, yougrt, foul, meat (fried)
Snacks	Fruits (orange, mango, grapefruit, gauava, banana) dates, milk, fresh fruit juice, honey , jam

B) Middle Class

Breakfast	Foul , tamia, yougrt, cheese , tahnia, Mulah (tagaleeia, weikah) , eggs, Madidat Dukhun
Lunch	Mulah (potatoes, Mulukhia, Bamia, Warag, Rigla, Aswad), meat (fried , stew), rice, salads (green, with peanut butter, with yougrt, eggplant)
Dinner	Milk, cheese, yougrt, foul, meat (fried)
Snacks	Fruits (orange, grapefruit, banana) , milk, fresh fruit juice, jam

C) Low Class

Breakfast	Foul , tamia, yougrt , Mulah Weika
Lunch	Mulah (Mulukhia, Weika, Warag, Rigla, Garaa, Rice) salads (green, with peanut butter)
Dinner	Milk, foul
Snacks	Milk, Madidat Dukhun

CHAPTER FOUR

DISCUSSION

Iron deficiency anaemia (IDA) has been reported to have affected more than 1 billion people, specially child bearing age women and preschool children (ACC/SCN, 1991). Pregnant women are at special risk and in developing countries severe anaemia is the main cause of up to 20% maternal deaths (WHO, 1995).

4.1 Prevelance of IDA during pregnancy in the first and third trimester in women in Khartoum State

The results of this study showed that the prevelance of IDA among the study group was 26.7% in the first trimester and has increased to 39.6% in the third trimester (refer to Table 4.9) . This result agrees with what has been reported by the WHO (1992) which stated that the prevelance of IDA among pregnant women in WadMedani province was 36% whereas in Khartoum 37% of the pregnant mothers were found to be anaemic. AlNawrani (1997) also found that the prevelance of IDA among pregnant women in Khartoum State was 41%.

4.2 Assessment of the Prevelance of IDA during pregnancy at the first and third trimesters

4.2.1 Haemoglobin concentration

In most developing countries , Haemoglobin concentration is used as the main indicator of IDA. However, as haemoglobin can be affected by hemodilution, haemoglobin level may not reflect actual iron status.

WHO (1968) stated that the levels of haemoglobin concentration which indicated IDA are <12g/dl for non-pregnant females and <11g/dl for pregnant females.

In this study , the results showed that both the study and control groups had IDA as indicated by the mean levels of haemoglobin that were both lower than the WHO standards . However, there was no significant difference (p>0.05) in the level of haemoglobin between the first and third trimesters . There was also no significant difference (p>0.05) in the level of haemoglobin between the study and control group (refer to Table 4.7). This result concided with that of Krawinkel et al (1990). However, AlNawrani (1997) reported a higher value for haemoglobin concentration which was 13.10 + 1.64 g/dl.

The result obtained in this study can be explained by the findings of Scholl and Hediger (1994) who stated that the haemoglobin concentration and haematocrits declined through the first and second trimesters but rose again at the end of pregnancy due to the expansion of maternal plasma volume and later the increase in the number of blood cells ,as a result of a physiological process.

4.2.2 Serum Ferritin concentration

Serum ferritin is considered as a good indicator of IDA.According to WHO cut-off points , the level of serum ferritin indicative of IDA is < 20ug/l for non-pregnant women and <12ug/dl for pregnant females.

In this study, the mean serum ferritin level of the study group in the first trimester was normal , however there was significant difference in the result of the third trimester (refer to Table 4.8). This result is much higher than that reported by Krawinkel (1990) who found that the serum ferritin of Sudanese mothers to be 13.00 ± 1.2 ug/l. In a WHO report (1992) the results did not agree with the findings of this study as it was stated that most of the women in third world countries started their pregnany with already depleted body iron stores.

This study showed that although the mothers didnot start their pregnancy with low serum ferritin, the level of serum ferritin declined throughout pregnancy. The reason behind this decline is due to the transfer of iron from the mother to the fetus and that in turn lead to the decrease in the level of serum ferritin (Milan et al , 1987).

4.3 Relationship between prevelance of IDA and Dietary Intake

4.3.1 Number of meals per day.

The results of this study showed that the number of meals consumed per day greatly affected the level of serum ferritin in the study group both in the first and third trimester. Statistical analysis showed that there was a high signficant difference ($p < 0.05$) between those who consumed 1,2 and 3 meals per day(refer to Table 4.10.3). There was also a high significant difference ($p < 0.05$) in the level of serum ferritin between the first and thrid trimester which showed a sharp decline in the level of serum ferritin (refer to Table 4.10.4). The reason behind this decline is the fact that during pregnancy iron is need to cover the requirements of growth of the fetus, placenta and the expansion of circulating blood. This requirement which is 6 times greater cannot be met by diet alone but needs to be derived from maternal body stores (WHO,1992). Hallberg (1988) reported that even though iron absorption increased during the third trimester, it did not cover the requirements of pregnancy. Therefore, it can be stated that even if the mothers eat three meals per day and they started their pregnancy with adequate iron stores, the level of serum ferritin will decrease due to the large need for iron during that period.

The composition of meals of the high, middle and low socio-economic classes (refer to Table 4.14) indicated that the high and middle socio-economic classes diets similar whereas the low socio-economic class consumed diets that were less varied and unbalanced.

4.3.2 Number of times meat consumed per week

There is no significant difference in the level of haemoglobin and serum ferritin in the study group between those who consumed meat rarely and those who consume an adequate quantity of meat . This is probably due to the small difference in the amount of meat consumed by the different groups. It could also be due to the unavailibility of iron that is caused by the inhibitors that reduce iron absorption such as tannins and phytic acid.

4.3.3 Tea and coffee consumption

The results showed that the level of serum ferritin was greatly affected by beverages (tea and/or coffee) consumed (refer to Table 4.11.3). The level of serum ferritin grealty decreased in the third trimester between the different beverages. The highest level of reduction was in those consuming tea after meals whereas the level of serum ferritin of those consuming coffee was reasonably good .These findings agree with the findings of Rossander et al (1979) who stated that tea reduced the absorption of iron to less than half while Hallberg, 1994, stated that coffee inhibits iron absorption but not as high as tea.

4.4 Relationship between prevelance of IDA and Family size

The size of the family showed that it grealty affected the level of serum ferritin(refer to Table 4.12.3). The low level of serum ferritin may be due to the fact that in larger familes, the mother sacrifices her share of the meal for other members of the family. However, in both small and larger families there was a significant decrease in the level of serum ferritin. However, the level in larger familes was very much below compared to the WHO standards. Therefore, the level of serum ferritin before pregnancy in very important to ensure adequate maternal body reserves in the third trimester.

4.5 Relationship between prevelance of IDA and Socioeconomic level

Serum ferritin level was greatly affected by the socio-economic status (refer to Table 4.13.3). The high socio-economic level group had the highest level of serum ferrtin 57.28 ± 45.32 whereas the low socio-economic group had the lowest level This agrees with the findings of Pilch et al (1984) who stated that IDA is prevelant more among the poor than among the rich. The level of serum ferritin decreased much further in the third trimester and it reached below the WHO cut-off level in the low socio-economic group (16.01 ± 10.67) and marginal in the middle socio-economic group.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1 - Although there was a significant decrease in the level of serum ferritin, most of the pregnant women began their pregnancy with adequate iron stores which later declined in the third trimester hence, they need to ensure more foods rich in iron in order to maintain their serum ferritin levels..

2. The decline in the level of serum ferritin is due to a physiological process therefore the other factors (number of meals per day, socio-economic status etc) contribute to this decrease to a large extent.

3. The main factors that affect the level of iron stores are socio economic status , family size and consumption of tea and coffee after meals.

Recommendations

Some Sudanese pregnant women begin their pregnancy with already deficient iron stores. Therefore , these stores have to be improved before the start of pregnancy and preferably early in life inorder to ensure good health and adequate iron stores . This can only be achieved by a proper program which includes the following :

I . Prevention of iron defieicny based on food educational programmes

Iron absorption is greatly affected by the composition of meals. It is therefore very important develope realistic food educational programmes inorder to achieve the following :

- Identify the foods that inhibit iron absorption e.g phytates , tannins etc.
- Replace those foods with other foods that donot have a deletarious effect on iron bioavailbility eg. animal products and leafy vegetables.
- Add foods in diet that stimulate iron absorption eg. fruits and vegetables that provide a rich source of Vitamin C.
- Different food preparation methods should be examined to identify those that do not affect iron availibility
- Modify meal composition to include all foods that supply the body with all the necessary nutrients i.e. balanced and adequate diets
- As people have different tastes in food , special care must be taken to modify meals to make them more acceptable .
- Small scale experiments must be carried out to see the effectiveness of the different foods and diets.
- Studies should be carried out to determine the iron content in different types of foods and the effect of cooking methods on the absorbability and bioavailability with particular regard to iron.
- Encourage the consumption of foods rich in Vitamin C e.g guava, green pepper , lemon etc. and foods rich in iron.
- Study the traditional beliefs and taboos and how they affect the availibility of iron
- Fortification and supplementation of diets by addition of iron components given an appropriate vehicle,
- Control of gastro-intestinal diseases that reduce iron absorption and haemoglobin level e.g hookworms and parasites. Other diseases like malaria , bilharzia and dysentry have an adverse effect on iron availibility and haemoglobin level. Efforts should be made to control them.

References

ACC/SCN. (1991) . Controlling Iron Deficiency. Report based on ACC/SCN Workshop. Nutrition Policy Paper . 1 - 26 .

Barrett . J.F.R; Wittaker , P.G; Williams, J.G. and Lind, T. (1994). Absorption of non-haem iron from food during normal pregnancy. British Medical Journal . 309 : 79 -88.

Beutler

Fairbanks . V.F (1986). The Effects of Iron Deficieny. Iron Deficiency in Biochemistry and Medicine . 1307- 1311.

Brown . E.B. (1963). The Absorption of Iron. Am. J. Clin. Nutr. 12 : 205 - 207 .

Brune, M.; Rossander, L. and Hallberg, L. (1989). Iron Absorption in Intestinal Adaptation to High Phytate Intake. Am.J. Clin. Nutr. 49 : 542 - 545.

Cavill . J. and Fisher , J. (1977) . Iron Stores in Pregnancy. Br. J. Haem. 37 : 145 - 149.

Chesley. L.C. (1972) . Plasma and red cell volumes during Pregnancy. Am. J. Obstet Gynecol. 112 : 440 - 450.

Cooper , L.F.; Berber, E.M. and Mitchell, H.S. (1968). Nutrition during Pregnancy. 149 - 156 .

Cook , J.D. and Monsen, E.R. (1976). Food iron absorption in human subjects. Comparison of the effect of animal proteins on non-haem iron absorption. Am. J. Clin. Nutr. 29 :859 - 867 .

Cook , J. D. (1984). Iron Deficiency Anaemia. Billaires Clinical Haematology. 7 ; 787 - 804 .

Cook , J. D. and Skinkne , B.S. (1986). Iron Defeicnecy : Definition and Diagnosis. J. of Intern. Med. 226 : 349 - 355.

Davidson S.; Passamore R. and Brock J.F. (1972). The Anaemias 422 - 434

De Maeyer, E.M. (1989). Preventing and Controlling Iron Deficiency Anaemia through Primary Health Care. A Guide for Health Administrators and Programme Managers. WHO.

Gleerup. A.; Rossander, L.; Gramat, K. and Hallberg , L. (1995). Iron Absorption form the Whole Diet. Am. J. Clin. Nutr. 61 : 97 - 104.

Gubler , C.J. Absorption and Metabolism of Iron. (1956.). Science. 123 - 187.

Hallberg , L.; Bjorn , R.; Howard, E. and Rossander, L. (1979). Dietary haem iron ansorption. A Disscussion of possible mechanisms for absorption promoting the effect of meat and for the regulation of iron absorption. Scand. J. Gastroentr. 14 : 769 - 779 .

Hallberg , L.; Brune, M. and Rossander, L. (1986). Effect of Ascorbic acid on iron absorption from different types of meals. Studies with ascorbic acid rich foods and synthetic ascorbic acid given in different amounts with different meals . Human Nutrition : Applied Nutrition. 40 : 97 - 113 .

Hallberg ,L. (1988) Iron Balance in Pregnancy : Vitamins and Minerals in Pregnancy and Lactation . Nestle Nutrition Workshop Series. 126 - 139.

Hallberg ,L.; Rossander ,L. and Brune, M. et al. (1992). Iron absorption from bread : Inhibiting Effect of Cereal Fibre, Phytate and Inositol Phosphates with different numbers of phosphate groups. J. of Nut. 122 : 442 - 449 .

Hallberg, L.; Rossander, L.; Brune , M. and Gleerup, A. (1992). Calcium and Iron Absorption : Mechanism of action and nutritional importance. European Journal of Clinical Nutrition. 46 : 317 - 327.

Hallberg , L. (1994). Preventing Iron Deficiency. Baillieres Clinical Haematology. 7 : 277-286 .

Hallberg, L.(no date). Overview of Dietary Iron Absorption and the Combatment of Iron Deficiency . 1 - 20 .

Herman, R. Iron Deficiency .(1994) . Australian Family Physician . 23: 1457 - 1461 .

Hokama , T.;Takenaka ,S.; Hirayama, K.; et al. (1996). Iron Status of Newborns to Iron Deficient Anaemic Mothers. Jou. of Trop. Paed. 42 : 75 - 77.

Hurrel , R. ; Juilleral , M. ; Reddy, M.; et al. (1992). Soy Protein Phytate and iron absorption in humans. Am. J. of Clin. Nutri. 56 : 573 - 578 .

Jellife , O. (1955). Infant Nutriton in the Subtropics and Tropics. 46 : 126 - 146.

Kelly , A.M.; MacDonald, D.J. and Mc Dougall, A.N. (1978). Observations on Maternal and Fetal Ferritn Concentrations at term. Obstet Gyneacol. 85 : 338 - 343 .

Khattab, A. (1989). Micronutrient Deficiencies in Sudan : A Situation Analysis. (Personnal Communication) 1 - 14 .

Krawinkel M.; Bethge M.; ElKarib A.O; Ahmed H.M. and Mirghani O.A.(1990) Prevelance of Anaemia and Iron Deficiency in Mothers and their newborn children in WadMedani. INCERN, 177: 79 - 82

Lind, T.; Hytten , F.E. and Thomson , A.M. (1975). Anaemia in Pregnancy. Br. Med Jou. 627 - 631.

Lipschitz , D.A.; Cook, J.D. and Finch, C.A. (1974). A Clinical Evaluation of Serum Ferritin as an index of iron stores. N. Eng. J. Med. 290 : 1213 - 1216.

Mac Pharlane, B. J. ; Van der Riet , W.W.B. ; Bothwell ,T.H. ; Baynes, R.D. ; Siegenberg , D. ; et al. (1990). The effect of traditional oriental soy products on iron absorption . Am. J. Clin. Nutri. 290 : 1679 - 681.

Mc Fee, J.G. (1983). Anaemia in Pregnancy. Obstet and Gynecol Survey. 28 : 769 - 778.

Milman , N.; Ibsen ,K.K. and Christensen J.M.(1987). Serum Ferritin and iron status in mother and newborn infant. Acta Obstet and Gynaecol Scand. 66 : 205 - 211.

Mohamed K.A. (1991) Sudan Paper , International Conference on Ending Hidden Hunger, Montreal, Canada.

Moore, C.V. and Dubach , R. (1962). Iron in Mineral Metabolism Vol.2 (Comar and F. Bronner editors).

Moore, C.V. (1964). Iron and the Essential Trace Elements. Modern Nutrition in Health and Disease. 280 - 286 .

Monsen ,R. et al. (1978). Estimation of Available Dietary Iron. Am J. Clin. Nutr. 31 : 134 - 141.

Nawrani E. (1997) Serum Ferritin in Normal Subjects and Assessment of iron status during Pregnancy.

Nichollas , L. (1968). Minerals : Calcium and Phosphorous. Tropical Nutrition and Dietetics . 26 - 38 .

Niranjan , S. (1994). Iron Deficency Anaemia in Childhood. J. Indian. Med. Ass. 92 : 373 - 375.

Pilch , S.M and Senti , F.R. (1984). Assessment of iron nutritional status in US population based on the data collection in the Second National Health and Nutrition Examination Suvery.

Roodenburg, A.J. (1995). Iron Supplemntation during Pregnancy. Eu. Jo. of Obstet and Gynecol. 61 : 65 - 71.

Rossander, L.; Hallberg, L. and Bjorn - Rasmussen , E. (1979). Absorption of iron from breakfast meals. Am J. Clin. Nutri. 32 :2484 - 2489 .

Sayers , M.H. ; Lynch, S.R.; Jacobbs , P.; Charton , R.W. and Bothwell, T.H.(1973). The effects of ascorbic acid supplementation on the absorption of iron in maize, wheat and soya. Br. J. Haematol. 24 : 209 - 218.

Savenberg, B.; Arvidson, B.; Norrby, A.; Rybo, G. and Solvell L. (1975). Absorption of supplmental iron during pregnancy :A Longitudinal study with repeated bone-marrow studies and absorption measurements. Acta Obstet Gynecol Scand. 48 : 87 - 108 .

Scholl, T.O. and Hediger, M,L.(1994). Anaemia and Iron Deficiency Anaemia : Compiltation of data on Pregnancy Outcome. Am. J. Clin. Nut. 59 : 4925 - 5015.

Stevens , A. (1994), Ferritin, Immunoassay International Series. 26 - 27.

Taylor, D.; Mallen , C.; Mac Dogall, N. and Lind ,T. (1982). Effect of Iron Supplementation on Serum Ferritin Levels during and after pregnancy. 89 : 1011 - 1017 .

Tanzer , F. and Gultenkin, A. (1995). The Influence of Iron Deficiency Anaemia on the Haemoglobin Concentration of the Infant . 41 : 369 - 371.

US Preventive Services Task Forces .(1993).Routine Iron Supplementation During Pregnanacy. 270 : 2848 - 2854 .

Walters , G.O.; Miller, F.M.; and Worwood, M. (1973). Serum Ferritn Concentration and iron stores in normal subjects. J. Clin. Path. 26 : 770 - 772 .

Wilson, C.D.; Fisher, K.H. and Fuqua, M.E. (1965). Iron and Iodine . Principles of Nutrition. 2 : 156 - 165 .

WHO . (1968). WHO Technical Report Series . Report of a WHO Scientific Group.

WHO. (1970). Requirements of Ascorbic Acid, Vitamin D, Vitamin B12, folate and iron.

WHO. (1992) Maternal Health and Safe Motherhoood Programme . 2nd edition 1 -5

WHO. (1992) WHo Interview : Safemotherhood in Tanzania 1 -20.

Annex I

Average value of Iron in some selected foods - 100g edible portion

Sudan Food Compostion Table

Food	Iron (mg)
Tomatoes	0.3
Spinach	1.0
Peanuts	12.0
Watermelon	2.0
Grapefruit	0.8
Lemon	0.2
Mangoe	2.6
Orange	0.6
Banana	1.4
Cocacola	1.6
Jam	0.4
Tahnia	2.3
Cow's milk	0.2
Cooked Foods	
Eggs	2.6
Rice	1.7
Bread	1.8
Kisra	1.0
Asida	0.2
Suksukania	0.1
Macaroni	0.4
Biscuits	0.9
Foul	1.5
Stews	
Mulah Ahmar	2.1
Mulah Aswad	0.7
Mulah Warag	2.2
Mulah Gara	2.4
Mulah Gawirma (onions)	0.6
Mulah Potatoes	0.4
Mulah Rigla (Pursalin)	4.3
Mulah Unrugeiga (dried okra)	0.6
Mulah Bamia (Okra)	0.8
Mulah Mulukia (whipped)	10.7
(normal)	2.4

Annex II

Questionnaire on the Prevalence of Iron Deficiency Anaemia Among Pregnant Women in Omdurman Maternity Hospitals

1. Name :
2. Age :
3. Weight : Height :
4. Residence :
5. Education : Illiterate Primary Secondary Higher
6. Occupation :
7. Family : Extended Single
8. No. of Children :
9. Spacing between children :
10. Age at first birth :
11. Do you breastfeed ? Yes No
12. Till what age do you breastfeed ?
13. Mode of delivery :

DIET (Recall Method)

14. Number of Meals per day :
15. Constituents of the meals for the past week:

Day	Breakfast	Lunch	Dinner	Snacks
1				
2				
3				
4				
5				
6				
7				

16. How many times a week do you eat meat ?
Per day :
Per week :
Per month :

17. Name the types of foods that you eat almost daily :
Meats:
Vegetables:
Tubers :
Cereals :
Milk and milk products :

18. Have you measured your Hb level before ? Yes No

19. How many times have you measured your Hb level ?

20. Have you measured the level of iron in your blood before ? Yes No

21. How many times have you measured your iron level ?

22. Are you taking iron tablets ?

23. Have you taken iron tablets before ?

24. Are you taking Multivitamin tablets ?

25. Do you suffer from any pregnancy illness (morning sickness) ? Yes No

If yes explain :

21. Did you suffer from any of the following diseases
- Malaria
- Thyphoid
- Dysentry
- Hookworm / tapeworm / Gardia

- Gastrointestinal bleeding
- Gastroctomy
- Achlohydria
- Malaginancy of GIT
- Haemorrage

22. Do you suffer from the following symptoms :
- Lethargy
- Weakness
- Dizziness
- Palpitations particularly on exertion
- Brittle hair
- Nails spoon shaped

23. Hb level

24. Iron level