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A Thesis  
Submitted to the University of Gezira in Fulfillment  
of the Requirements for the  
Award of the Degree of Doctor of Philosophy  
in  
Nutrition

Department of Food Safety and Hygiene  
Faculty of Health and Environmental Sciences  
University of Gezira

September/ 2014
The Effect of Roasted Sesame (Sesamum indicum L) Seeds as Supplement of Iron on Some Hematological Parameters in Pregnant Women in *Um Elgura Town* - Gezira State-Sudan.

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Date of Examination: 25/ September / 2014
Dedication
To the spirits of my parents
To
My Husband and my lovely Kits
(Dania, Zeinab and Mohammed)

To
My Brothers and sister
"فَكُلُواْ مِمَّا رَزَقَكُمُ اللهُُّ حَلالاً طَيِّبً ا وَاشْكُرُواْ نِعْمَتَ اللهَِّ إِن كُنْتُمْ إِيَّاهُ تَعْبُدُونَ "

صدق الله العظيم

سورة النحل{114}

If you want to stay healthy, eat food as medicine otherwise, you have to eat medicine as food.
ACKNOWLEDGEMENT

My praise and thanks to Almighty Alla the most Gracious and most Merciful who gave me the mind, health, strength and patience to complete and conduct this study and helping me in all my life.

I would like to express my sincere gratitude's and appreciations to major supervisor Professor Mohamed EL Sanousi Mohamed EL Sanousi. Faculty of Medicine. University of Gezira for his patience, helpful advice and valuable guidance and encouragement. may allah blesses him and rewards him strength and health

Deep sense of gratitude is expressed to Co-supervisor Professor Sir Elkhatim Balla Elhardall Faculty of Engineering and Technology University of Gezira for his helpful advice, moral support and supervision.

I’m very thankful to all members and lab technicians of National cancer institute for their help.

Special thanks to the German Academic Exchange Service (DAAD) for funding this work.

I'm very thankful to all studies pregnant women in Um Elgura Town for their help

Finally my deep sense of gratitude is extended to my lovely family, sincerely husband for his assistance and friendly attitude and willingness at all time and lovely brothers and sister for their moral support, encouragement and patience throughout the period of the study.

My grateful thanks also extended to every person who assists me at any phase in doing this work.
ABSTRACT

Pregnant women especially in developing countries are the most vulnerable groups to anemia. Anemia in pregnancy is a common problem and a major cause of morbidity and mortality especially in malaria endemic areas. This is an experimental community based study carried out 2012-2014, study aimed, to test the effect of roasted sesame supplement meal as a natural source of iron on certain hematological parameters in pregnant women in Um Elgura town Gezira State-Sudan. A hundred pregnant women represent (32%) of total study population (311), were selected randomly. The iron content in sesame has been estimating to determine appropriate amount of daily intake, which was 100 gm. Data was collected by; questionnaire and two laboratory tests were done before and after the used of sesame seeds for testing of hematological parameters included, Complete Blood Count test, serum iron, total iron binding capacity and transferring saturation. The results showed that Hemoglobin concentration level increased significantly after intervention in most of participants, as well as increased level of serum iron, and transfrein saturation significant decreased in TIBC, most there was no statistically significant decrease of Haematocrit before and after taking. 58% of participants had no effects on Gastro-Intestinal Tract symptoms. Quarter of participants were relieved from heartburn and constipation. 90% had poor antenatal care and only 34% of participants were regular taking iron before this study. The study recommended promoting the use of sesame because it contains a high percentage of iron can meet the daily needs of iron during pregnancy in addition to that it does not cause side effects, such as caused by iron pills. More attention and research in the use of sesame as a pregnancy supplement and encouraging and improving prenatal care and providing nutrition education for mothers in this important period.
ملخص الدراسة

مشكلة شائعة وأحد الأسباب الخاصة في البلدان النامية في وهو النساء الحوامل هم أكثر الفئات عرضة لفقر الدم الرئيسية للمرضى وفيت الأمهات خاصة في المناطق الموبوءة بالملاريا. أجريت هذه الدراسة التجريبية في مدينة أم القرى في السودان هدفًا وقف الحمل وتفادي أي آثار جانبية قبل الولادة. تم تأسيس عينة عشوائية عرفت لتلبية طلبات هذه الدراسة. تم اختيار عينة عشوائية تتكون من 100 من النساء الحوامل، تم تعبئة النماذج والأدوات لتحديد نسبة الحديد بالسمسم ومن ثم تم اعطائهن السمسم لمدة شهر بمقدار 100 جرام يوميًا. تم جمع المعلومات عن طريق الاستبيان لمعرفة الأعراض الجانبية لتناول السمسم وإجراء مجموعة من الاختبارات لمعرفة مستوي مكونات الدم قبل وبعد تناول السمسم، وشملت: عدد الخلايا الهيماتوكريت (الكسر الحجمي)، عدد خلايا الدم، عدد عضلات الدم، عدد عضلات الدم، عضلات الدم، وتحديد حجم خلايا الدم، ووضع تركيز الهيماتوكريت في خلايا الدم بالإضافة إلى الحديد في مصل الدم، وتنفيذ اختبارات الترانسفرين كمؤشر لمعرفة مستوي الحديد. أظهرت النتائج أن كل 100 جرام من السمسم الأبيض المحصور يحتوي على 14 ملجم من الحديد. معظم المشاركات حدثت لهن زيادة كبيرة في مستوى الهيماتوكريت في الدم، وظهور الترانسفرين بعد التدخل وانخفاض كبير في سعة الدم الكلية، بينما كشفت النتائج أيضاً أن مستوى التعليم للنساء الحوامل وآزواجهن منخفض. أن 90% من الحوامل لايتبعون الرعاية الصحية قبل الولادة وإن 34% فقط يتلألألجذور الحديد، واصطالت الفوليك يعادل نظام قبل إجراء هذه الدراسة. أوصت الدراسة بتشجيع استخدام السمسم للفواريد النباتية من الحديد أثناء الحمل بالإضافة إلى أنه لايشبأ آثار جانبية مثل التي تسببها حبوب الحديد كما أوصت بتحقيق وتحسين الرعاية قبل الولادة وتقديم التثقيف الغذائي للنساء في هذه الفترة الهامة.
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<td>4</td>
<td>Method of estimation Serum iron (SI)</td>
<td>144</td>
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<td>5</td>
<td>Result of hematological parameters</td>
<td>145</td>
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</table>
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AI</td>
<td>Adequate Intake</td>
</tr>
<tr>
<td>ANC</td>
<td>Ante-Natal Car</td>
</tr>
<tr>
<td>AOAC</td>
<td>Association of Official Analytical Chemists</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>CBC</td>
<td>Complete Blood Count.</td>
</tr>
<tr>
<td>GIT</td>
<td>Gastro-Intestinal Tract</td>
</tr>
<tr>
<td>HB</td>
<td>Hemoglobin concentration.</td>
</tr>
<tr>
<td>HCT</td>
<td>Haematocrit.</td>
</tr>
<tr>
<td>HDL</td>
<td>High Density Lipoprotein (good cholesterol)</td>
</tr>
<tr>
<td>IDA</td>
<td>Iron Deficiency Anemia</td>
</tr>
<tr>
<td>IOM</td>
<td>Institute of Medicine. Washington</td>
</tr>
<tr>
<td>LBW</td>
<td>Low Birth Weight</td>
</tr>
<tr>
<td>LDL</td>
<td>Low Density Lipoprotein (bad cholesterol)</td>
</tr>
<tr>
<td>MCH</td>
<td>Mean Corpuscular Hemoglobin.</td>
</tr>
<tr>
<td>MCHC</td>
<td>Mean Corpuscular Hemoglobin Concentration.</td>
</tr>
<tr>
<td>MCV</td>
<td>Mean Corpuscular Volume.</td>
</tr>
<tr>
<td>MM</td>
<td>Maternal Mortality</td>
</tr>
<tr>
<td>RBC</td>
<td>Red Blood Count.</td>
</tr>
<tr>
<td>RDA</td>
<td>Recommended Dietary Allowance.</td>
</tr>
<tr>
<td>SI</td>
<td>Serum iron</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
</tr>
<tr>
<td>TIBC</td>
<td>Total Iron Binding Capacity</td>
</tr>
<tr>
<td>TS</td>
<td>Transferrin Saturation.</td>
</tr>
<tr>
<td>UL</td>
<td>Tolerable Upper Intake Level</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nation Children's Fund</td>
</tr>
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<td>WHO</td>
<td>World Health Organization.</td>
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</table>
Chapter One

Introduction

1.1. Preface

Pregnancy is an important time in women’s life, during which pregnant women need more food than adults do. At least 11kg should be gained during pregnancy (Hutcheon et al, 2012). The baby count for only part of this weight gain, the mother's own must make extra blood, muscle, fluids, and tissue that are needed for baby's development. Poor nutrition during pregnancy is a major public health problem globally. There is compelling evidence from epidemiologic studies that poor nutrition during pregnancy, in the form of insufficient intake, low protein, or deficiencies in micronutrients, is associated with poor developmental outcomes in children including lower cognitive functioning, deficits in attention, and disruptive behavior problems (Liu and Raine, 2006)

Pregnancy is for most women a time of great happiness and fulfilment. However, during pregnancy, both the woman and her developing child face various health risks. For this reason, it is important that all pregnancies should be monitored by skilled care providers (WHO, 2014a)

Nutritional status of a mother is very basic and important determinant of maternal health and child health, shortage of proteins, energy foods, minerals, particularly iron and vitamins leads to poor health of the mother, a pregnant women needs to eat good foods and should eat meals that contain a mixture of different foods, which is usually nutritious (well balance). A Pregnant woman should have enough iron in her blood to keep herself and her baby healthy (Anwar, 2012).

Iron is a mineral that is naturally present in many foods, added to some food products, and available as a dietary supplement. Iron is an essential component of hemoglobin. Most of the 3 to 4 grams of elemental iron in adults is in hemoglobin an erythrocyte protein that transfers oxygen from the lungs to the tissues. Each gram hemoglobin contains about 3.34 mg of iron (Wessling et al., 2014). Smaller amounts of iron are found in myoglobin, a protein that provides oxygen to muscles, iron supports
metabolism and also necessary for growth, development, normal cellular functioning and synthesis of some hormones and connective tissue (Aggett et al., 2012), much of the remaining iron is stored in the form of ferritin or hemosiderin (a degradation product of ferritin) in the liver, spleen, and bone marrow or is located in myoglobin in muscle tissue. Humans typically lose only small amounts of iron in urine, feces, the gastrointestinal tract, and skin. Losses are greater in menstruating women because of blood loss. Hepcidin, a circulating peptide hormone, is the key regulator of both iron absorption and the distribution of iron throughout the body, including the plasma (Drakesmith and Prentice, 2012; Wessling et al., 2014).

Iron in the diet may be considered in tow forms, hem-iron in animal products and non hem – iron vegetable and cereals. Iron is absorbed in the small intestine in ferrous state. Its absorption depends on iron status of individual, the lower body iron store, the greater is the absorption. Iron absorption is greater when there is increased demand for iron e.g., during pregnancy (IOMFNB, 2001). This physiological control of iron contents in the human body by changes in absorption is unique. Control of the contents of all other materials is by changes in excretion. The absorbed iron is stored in liver, spleen, bone marrow and kidney, when red cells are broken down the liberated iron is reutilize in formation of new red cells. Deficiency of dietary iron gives rise to iron deficiency anemia. Worldwide, iron deficiency is the most common cause of anemia in pregnancy. Women often become anemic during pregnancy because the demand for iron and other vitamins is increased. The mother must increase her production of red blood cells and, in addition, the fetus and placenta need their own supply of iron, which can only be obtained from the mother (Philip and Patrick, 2005).

Anaemia in pregnancy, defined as a hemoglobin concentration (Hb) < 110 g/L, affects more than 56 million women globally, two thirds of them being from Asia. Multiple factors lead to anaemia in pregnancy, nutritional iron deficiency anaemia (IDA) being the commonest (Goonewardene, et al., 2012) Iron deficiency anaemia is associated with increased maternal and prenatal morbidity and mortality, and long-term adverse effects in the new born. Strategies to prevent anaemia in pregnancy and its adverse effects include treatment of underlying conditions, iron and folate supplementation given weekly for all menstruating women including adolescents and daily for women during pregnancy.
and the post partum period, and delayed clamping of the umbilical cord at delivery. Oral iron is preferable to intravenous therapy for treatment of iron deficiency anemia. B12 and folate deficiencies in pregnancy are rare and may be due to inadequate dietary intake with the latter being more common. These vitamins play an important role in embryo genesis and hence any relative deficiencies may result in congenital abnormalities (Malik et al., 2012). In order to have enough red blood cells for the fetus, the body starts to produce more red blood cells and plasma. It has been calculated that the blood volume increases approximately 50 per cent during pregnancy, although the plasma amount is disproportionately greater. This causes a dilution of the blood, making the hemoglobin concentration falls. This is a normal process, with the hemoglobin concentration at its lowest between weeks 25 and 30. Anemia during pregnancy has serious clinical consequences. It is associated with greater risk of maternal death, in particular from hemorrhage and also associated with increases stillbirths, parental deaths, low-birth-weight babies and prematurety. Severely anemic pregnant women are less able to withstand blood loss, and may require blood transfusion which is not always available, in poor countries and is not without risk. In malaria – endemic countries, anemia is one of the commonest preventable causes of death in pregnant women and also in children under five years old (Elsanousi et al 2002; WHO 2003)

Despite that only 1 to 3 mg of absorbed iron is required daily at different stages of life, most diets remain deficient. Failure to include iron-rich foods in the diet and inappropriate dietary intake coupled with wide variation in bioavailability (based on the presence of iron absorption inhibitors in the diet) are some of the important factors responsible for iron deficiency. Iron supplementation can be targeted to high-risk groups e.g., pregnant women and can be cost-effective. Iron fortification of food can prevent iron deficiency in at-risk populations. Selective plant breeding and genetic engineering are promising new approaches to improve dietary iron nutrition quality (Chander et al., 2008).

Pregnant women who eat well are more likely to produce healthy babies and recover quickly after childbirth. In addition to providing an adequate diet are always informants in prevention and treated anemia. During pregnancy, extra iron is needed to meet the requirement of the fetus, placenta and for the whole pregnancy about 1000 mg,
this is concentrated in the seconded half of pregnancy. When there is no body iron stores to meet these needs during the second half of pregnancy this would require absorption of over 6 mg of iron per day, which can only be achieved by therapeutic supplementation.

A healthy and balanced diet is quite important in life time and during pregnancy in particular. The maternal diet must provide sufficient energy and nutrients to meet the mother's usual requirements, as well as the needs of the growing fetus and enabling mother to maintain her own stores of nutrients required for fetal and infant health as well as for future breastfeeding practices. The main recommendation is to follow a healthy, balanced diet (Erich et al., 2008). Pregnancy is an occasion when women become more aware of the importance of healthy nutrition and seek for more nutrition-related information. Compared to the period before preconception and pregnancy, pregnant women are more eager to know what they should eat and what not (Basher et al., 2011). A poor pregnancy diet can lead to various nutritional deficiencies. Proper nutrition is a part of pregnancy that cannot be forsaken. A balanced diet full of whole grains, fruits and vegetables will help keep health throughout pregnancy (Eicher et al., 2009). Inadequate nutrition, especially early in the pregnancy, may impair fetal brain development and cause abnormalities in endocrine functioning, organ development and the energy metabolism of child (Shieh and Carter 2011). Education is an important factor in health promotion. Determination of training needs is essential to achieve this goal (Shieh and Weaver, 2011).

A mother who before conception was eating a good mixed diet does not need to change her habits when she become pregnant (Passmore and Eastwood, 1986).

Many pregnant women are confused about what they should eat during pregnancy to make sure that the fetus is properly nourished. To large extent this will depend on her cultural background.

In different cultures there are many believes and practices about pregnancy, either concerning the mother food or the child development. Eating of certain food is believed to affect characteristic of the child e.g., generous or selfish, beautiful or ugly etc., there is no scientific evidence for these believes. A pregnant woman require some general dietary advice as how best to modify their usual diet so as to supply the extra needs for nutrients.
The detail nature of this advice depends on the economic status of family and food available. During pregnancy weight and diet should be monitored.

Iron supplementation is the most common strategy currently used to prevent iron deficiency in developing countries. This is likely to remain the case until either significant improvements are made in the diets of entire populations or food fortification is achieved. Supplementation is most often used to treat existing iron deficiency anaemia. It should also be considered as a preventive public health measure to control iron deficiency in populations at high risk of iron deficiency and anaemia by supplementation programmers, especially for pregnant women. (WHO, 2009).

1.2. Problem Statement.

Anemia is a global public health problem affecting both developing and developed countries. The global prevalence of anemia is estimated to be 30.2% in non-pregnant women rising to 47.4% during pregnancy (Benoist et al., 2008).

The global prevalence of anemia in pregnancy is estimated to be approximately 41.8%, varying from a low of 5.7% in the USA to a high of 75% in Gambia. Some women are anemic prior to the index pregnancy and others become progressively anemic during pregnancy. In the USA, anaemia in pregnancy was estimated to increase from 1.8% to 8.2% and 27.4% in the first, second and third trimesters respectively (Scholl, 2005; Benoist et al., 2008)

More than 56 million women are estimated to be affected globally, approx 32 million of them being from Asia. In Georgia, 200 pregnant women were studied for the level of iron and ferritin, the ID anemia found in 22% especially in the third trimester, and quantity of ferritin was at the lower border of the normal (Tamazashvili and Kintraia, 2006)

The greatest burden of anemia is born by Asia and Africa where it is estimated that 60% and 52% of pregnant women, respectively, are anemic and between 1% and 5% are severely anemic (hemoglobin <7 g/dl) and is associated with women of age less than 20 years, third trimester of pregnancy, rural residents, and multiparous women (Lonnerdal, 2010). Prevalence rates of anemia (hemoglobin <110g/L) among pregnant women, currently ranging between 40% and 50% in South Asia, continue to be among the highest in the world (McLean et al., 2009)

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The prevalence of anemia in pregnant women in an urban area of Pakistan was 90.5%; of these, 75.0% had mild anemia (hemoglobin from 9.0 to 10.9 g/dL) and 14.8% had moderate anemia (hemoglobin from 7.0 to 8.9 g/dL). Only 0.7% were severely anemic (hemoglobin < 7.0 g/dL) (Baig-Ansari et al., 2008).

Throughout Africa, in healthcare center in Enugu, southeastern Nigeria, the prevalence of anemia in pregnancy at booking is still high in Enugu (40.4%) of the women were anemic (hemoglobin [Hb] < 11.0 g/dL). The majority (90.7%) of these anemic patients were mildly anemic, whereas 9.3% were moderately anemic. There was no case of severe anemia (Hb < 7.0 g/dL). The prevalence of anemia at booking was significantly higher in those who registered for antenatal care in the third trimester than in those who registered in the second trimester (Cyril, 2007).

Dim and Onah, (2007) reported a 40% prevalence of anemia in pregnant women in Enugu, South east Nigeria. Similar study done in Grey-town South Africa by. Monjurul-Hoque et al., (2006) reported that the prevalence of anemia in pregnant women was 15.7%

In Ethiopia, anemia is the severe problem affecting 62.7% of pregnant mothers and 52.3% non-pregnant women (McLean et al., 2009), other study done in Shalla Woreda, West Arsi Zone, Oromia Region, Ethiopia by Obse et al., (2013) reported that, the prevalence of anemia was 36.6% in pregnant women attending ANC in study area.

A cross-sectional study was carried out between October 2007 and January 2008 to investigate the prevalence and types of anemia among pregnant women of eastern Sudan. Two hundred and seventy-nine pregnant Sudanese women were recruited. Anaemia (Hb < 11 g/dl) and iron deficiency (ferritin <15 microg/l) were prevalent in 80.3 and 14.3% of the study sample, respectively. Of the total sample, 11.1% had iron-deficiency anemia. Serum folate (<6.6 ng/ml) and vitamin B(12) (<150 pg/ml) deficiency was reported in 57.7% and 1%, respectively (Abdelrahim, 2009).

In Wad Medani hospital, central Sudan a cross-sectional study was conducted to investigate the prevalence of anemia, iron, zinc and copper deficiencies among pregnant women and to examine the relationship of these micronutrients with haemoglobin (Hb) levels, by Bushra et al., (2010) who found, one hundred four (52.5%) out of 200 pregnant women had anaemia (Hb < 11 gm/dl) and 3 (1.5) % had severe
anaemia (Hb < 7 gm/dl). Iron deficiency (S-ferritin < 15 µg/l), iron deficiency anaemia (<11 gm/dl and S-ferritin < 15 µg/l) were prevalent in 25 (12.5%) and 13 (6.5%) of these women, respectively. Another cross-sectional study was conducted in antenatal care clinic of the Arba Waeshreen Hospital in Gezira, central Sudan, by Abdelgadir (2012) found that, out of the 292 women, 119 (40.8%) had anaemia (HB < 11 g/dl); eight (2.7%) had severe anaemia (HB < 7 g/dl).

1.3. Rationale

- Pregnancy is an important time in women's life, during which pregnant women should be monitored by skilled care providers.
- Anemia in pregnancy is a common public health problem and iron deficiency is a major cause of anemia in pregnant women in Africa.
- Iron deficiency anaemia during pregnancy has serious clinical consequences. It is associated with greater risk of maternal death, in particular from hemorrhage and also associated with increases stillbirths, parental deaths, low-birth-weight babies and prematurely.
- Nutritional status of mother is very basic and important determinant of maternal health and child health.
- A Pregnant woman should have enough iron in her blood to keep herself and her baby healthy.
- In Sudan many strategies were developed to control the problem, such as iron and folic acid supplementation, family planning, environmental sanitation, control of parasites and nutritional education.
- All pregnant women should take iron supplementation, but is known to produce intestinal side effects (such as heartburn constipation, nausea and bloating).
- Increased incidence of anemia among pregnant women in Gezira state, (40.8%) of pregnant women are anemic.
- In Sudan, there are many local foods rich in iron available, familiar and cheap such as dates, fenugreek, Guddaim (*Grewia tenax*) and some legumes.
1.4. Objectives

1.4.1. General Objective:

To test the effect of roasted sesame seeds supplement as of iron on certain hematological parameters in pregnant women in Um Elgura town Gezira State-Sudan

1.4.2. Specific objective:

1. To determine the level of certain hematological parameters before and after used supplement for pregnant women:
   a. Complete Blood Count (CBC) test included
      • Red blood Cells Count (RBC)
      • Hemoglobin concentration (HB).
      • Hematocrit (HCT)
      • Mean cell volume (MCV).
      • Mean Corpuscular Hemoglobin Concentration (MCHC).
      • Mean Corpuscular Hemoglobin (MCH).
   b. Serum iron (SI)
   c. Total Iron Binding Capacity (TIBC).
   d. Transferring Saturation (TS).

2. To compare the effect of sesame and iron tablets regarding.
   * Side effects

3- To determination iron content per one gram of sesame
4- To determination the negative and positive nutritional habits in pregnant women.

1-5 Hyposises :

• Sesame is better and acceptable supplement than iron tablets during pregnancy.
• Sesame is associated with lower side effects comparative with iron supplement tablets.
Chapter Two
Literature Review

2.1. Iron:

Iron, one of the most abundant metals on earth, is essential to most life forms and to normal human physiology, the body contains small amounts of many minerals, some of which are essential nutrient since they are components of many enzyme systems. There are about 4 g of iron and 2 g of zinc in an adult body and these two elements are involved in many metabolic mechanisms. The other essential minerals are present in smaller amounts and have more limited roles. Iron differs from other minerals because iron balance in the human body is regulated by absorption only because there is no physiologic mechanism for excretion. Iron is an integral part of many proteins and enzymes that maintain good health. In humans, iron is an essential component of proteins involved in oxygen transport. It is also essential for the regulation of cell growth and differentiation (Hurrell and Egli, 2010; Aggett et al., 2012).

2.2. Physiological role of iron:

Almost two-thirds of iron in the body is found in Hb, the protein in red blood cells. Hb binds oxygen as the blood passes through the lungs, and distributes this oxygen to the body tissues. Smaller amount of iron are found in myoglobin, a protein that helps supply oxygen to muscle, it transports and store oxygen. Most other functional iron-containing proteins are enzymes. The so-called heme-enzymes, such as cytochromes, catalase and peroxides, depend on heme as a coenzyme. They act as electron carriers within the cell. A very large number of other iron-containing enzymes have also been described. They play key roles not only in the oxygen and electron transport but also as signal–controlling substances in some neurotransmitter systems in the brain (Beard 2001).

Iron stores have no physiological function other than to serve as a buffer against increasing iron demands such as during pregnancy or with a cute blood loss. Iron is stored in the cell as ferritin, soluble complexes of a core of F$_3^+$ compounds surrounded by a coat of proteins (a poferritins) and as haemosiderin, insoluble complexes, probably
farmed from ferritin. The total store in the body is normally about 1g, mostly as ferritin. Ferritin is a ubiquitous intracellular protein that stores iron and releases it in a controlled fashion. The protein is produced by almost all living organisms, including algae, bacteria, higher plants, and animals. In humans, it acts as a buffer against iron deficiency and iron overload. Ferritin is found in most tissues as a cytosolic protein, but small amounts are secreted into the serum where it functions as an iron carrier. Plasma ferritin is also an indirect marker of the total amount of iron stored in the body, hence serum ferritin is used as a diagnostic test for iron deficiency anemia.

Some ferritin is present in all cells, but most is in the fixed phagocytes of liver, spleen and bone marrow. When the stores of are increased, haemosiderin can be seen be naked eye in the liver and spleen after the addition of ferricyanide which stains it a deep Prussian blue. A condition known as siderosis. The amount of storage iron in the body can be assessed by measuring plasma ferritin by immunoassay (Cook, 1995; Wang et al., 2010).

2.3. **Recommended intake for iron:**

Intake recommendations for iron and other nutrients are provided in the Dietary Reference Intakes (DRIs) developed by the Food and Nutrition Board (FNB) at the Institute of Medicine (IOM) of the National Academies (formerly National Academy of Sciences). DRI is the general term for a set of reference values used for planning and assessing nutrient intakes of healthy people (IOM, 2001). These values, which vary by age and gender, include:

- **Recommended Dietary Allowance (RDA):** average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.
- **Adequate Intake (AI):** established when evidence is insufficient to develop an RDA; intake at this level is assumed to ensure nutritional adequacy.
- **Estimated Average Requirement (EAR):** average daily level of intake estimated to meet the requirements of 50% of healthy individuals. It is usually used to assess the adequacy of nutrient intakes in population groups but not individuals.
- **Tolerable Upper Intake Level (UL):** maximum daily intake unlikely to cause adverse health effects.
Table (2-2) lists the RDAS for iron, in milligrams, for infants, children and adults. The current iron RDAs for nonvegetarians. The RDAs for vegetarians are 1.8 times higher than for people who eat meat. This is because heme iron from meat is more bioavailable than nonheme iron from plant-based foods, and meat, poultry, and fish increase the absorption of nonheme iron (IOMFNB, 2001). For infants from birth to 6 months, the FNB established an AI for iron that is equivalent to the mean intake of iron in healthy, breastfed infants. Healthy full term infants are born with as apply of iron that lasts for 4 to 6 months. There is not enough evidence available to establish a RDA for iron for infants from birth through 6 months of age. Recommended iron intake for this age group is loosed on an AI that reflects the average iron intake of healthy infants fed breast milk. Breast milk contains highly bioavailable iron but in amounts that are not sufficient to meet the needs of infants older than 4 to 6 months. Infant formulas are fortified with 12 mg iron per liter (Baker and Greer, 2010; Aggett et al., 2012).

Data form the National Health and Nutrition Examination Survey (NHANES) suggest that males of all racial and ethnic groups consume recommended amounts of iron. However, iron intake are generally low in females of childbearing age and young children (Bialostosky et al., 2002), there are some differences in the iron dietary reference values given by the different organizations and nations, adolescent girls women of childbearing age and adolescent boys have the highest recommended intake value (Hurrell, 2002). In particular, adolescent females have high iron requirements as they have to cover their growth needs and menstrual losses besides the obligatory losses, following menarche, adolescent females often do not consume sufficient iron to offset menstrual losses. As a result, a peak in the prevalence of iron deficiency frequently occurs among females during adolescent. Demand of iron is increased in the growth phase of early childhood and during pregnancy (Both well, 2000; WHO 2001; Kumar, et al., 2007).

Iron requirements of pregnant women are approximately double that of nonpregnant women because of increased blood volume during pregnancy, increased needs of fetus, and blood losses that occur during delivery (Tapie et al., 2001). After delivery, the iron used for the increased erythrocyte mass is returned to stores. During lactation, iron needs are equal or even lower than in the non-pregnant state because
lactation a menorrhea more than compensates for iron cost through breast milk (Both well, 2000; WHO, 2001). Researchers also examine specific groups within the NHANES population – for example, researchers have compared D1 of adults who consider themselves to be food insufficient (and therefore have limited access to nutritional adequate foods) to those who are food sufficient (and have easy access to food). Older adults from food sufficient families had significantly lower intakes of iron than older adults who are food sufficient. In one survey, 20% of adults age 20 to 59 and 13.6% of adults age 60 and older from food sufficient families consumed less than 50% of RDA for iron, as compared to 13% of adults age 20 to 50 and 2.5% of adults age 60 and older from sufficient families (Dixan, et al., 2001).

Table (2-1): Recommended Dietary Allowances (RDAs) for Iron

<table>
<thead>
<tr>
<th>Age</th>
<th>Males (mg/day)</th>
<th>Females (mg/day)</th>
<th>Pregnancy (mg/day)</th>
<th>Lactation (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth to 6</td>
<td>0.27</td>
<td>0.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 to 12 months</td>
<td>11</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 3 years</td>
<td>7</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 to 8 years</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>9 to 13 years</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 to 18 years</td>
<td>11</td>
<td>15</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>19 to 50 years</td>
<td>8</td>
<td>18</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td>51 + years</td>
<td>8</td>
<td>8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

IM,FNB,DC,( 2001); WHO,UNICEF, (2001)
2.4. Dietary iron:

There are two forms of dietary iron $\text{Fe}^{2+}$ (ferrous) and $\text{Fe}^{3+}$ (ferric), the majority of ferrous iron is found in heam-iron, and the majority of ferric iron is found in non heam-iron. Heam iron is derived from hemoglobin, the protein in red blood cell that delivers oxygen to cell and myoglobin a protein that helps supply to muscle (Mary, 2012). Heam iron is found in animal foods that originally contained hemoglobin, such as red meat, meat product liver, poultry, fish … etc., Iron in plant foods such as cereals, beans, vegetables dried fruit, etc, is arranged in chemical structure called non heam iron (Miret et al., 2003). Neutral sources of iron are important and favorite to taking iron supplement from some women during pregnancy this is because iron supplements can have unpleasant side effects such as constipation and other uncomfortable tummy upsets.

Approximately 90% and dietary iron in the United Kingdom (UK) diet is non heam iron. Currently it is estimated that between 10 and 15% as dietary iron is bioavailable. In the average UK diet, iron mainly comes from, cereal product 44%, meat and meat products 17% and vegetable 10% (Henderson et al., 2003). In the United States, Canada, and many other countries, about half of dietary iron comes from wheat, cereal, and other grain products such as, flours are fortified with iron (Whittaker et al., 2001, Murray et al., 2010; Aggett, 2012).

2.5. Dietary iron absorption:

The amount of iron which is absorbed from food depends on form of iron and on other constituents of the diet. Healthy adults absorb about 10% to 15% of dietary iron, but individual absorption is influenced by several factors. Storage levels of iron have the greatest influence on iron absorption. Iron absorption increases when body stores are low. When iron stores are high, absorption decreases to help protect against toxic effects of iron overload (Hallberg and Hulthen 2000).

Iron absorption is also influenced by the type of dietary iron consumed. In animal food nearly all the iron is present as heam iron and so is present in the $\text{Fe}^{2+}$ (ferrous) form. Heam iron is absorbed very much better than inorganic iron from vegetables food (non-heam iron) and is little affected by other constituents in the diet. Haem absorption
increases in iron deficiency and is reduced when the body is overload with iron. Absorption of haem iron range from 15% to 35%, in contrast, 2% to 20% of non-haem iron in plant foods such as rice, maize, black beans, soybean and wheat is absorbed (Tapie et al, 2001; Mary, 2012).

The iron from all these sources needs to be in soluble form before absorption is believed to occur. A common nonhaem iron pool containing this soluble iron is formed in the women of the upper gastrointestinal tract, and absorptive mechanisms extract iron from this pool. The amount of iron absorbed depends not only on mucosal behavior in the intestinal wall but also on the presence of ligands in the meal. Which either promote or depress iron absorption from the pool, because non-haem iron absorption occurs before food has been exposed to digestive enzymes in the intestines, it is not surprising that the ligands present in undigested or partially digested foods play a major role in absorption (Derman et al., 1980).

2.5.1. Factors influencing iron absorption and bioavailability:

The amount of iron absorbed from a meal is determined by iron states, the content of heme and non heme iron – and the bioavailability of the 2 kinds of iron, which in turn is determined by the balance between dietary factors enhancing and inhibiting the absorption of iron, especially non heme iron. It is well known that the variation in dietary iron absorption from meals is due more to differences in the bioavailability of the iron, which can lead to a > 10 – fold variation in iron absorption, than to a variation in iron content. Therefore, several attempts have been made to devise algorithms to estimate the bioavailability of the dietary iron content of meals the aim of the first attempts was to illustrate the fact that the composition of meals greatly influences the absorption of dietary non heme iron . Later, attempts were made to improve the algorithm. A simpler method using a score system to estimate the expected bioavailability of dietary non heme iron was also suggested.

On the basis of intake data and isotope studies, iron bioavailability has been estimated to be in the range of 14 – 18% for mixed diets and 5 – 12% for vegetarian diets in subjects with no iron stores, and these values have been used to generate diet ray reference values for all population groups (Hunt, 2003 ; Hurrell and Egil, 2010).
2.5.1.1. **Physiological states affecting iron absorption:**

The absorption of iron is known to increase in conditions in which tissue iron is reduced, including anabolic states, such as periods of growth and in pregnancy. During the latter half of pregnancy, the efficiency of iron absorption is increased from both the diet and inorganic iron (WHO 2001; Kumar, et al., 2007).

Reports concerning the size of the increase vary, depending on the test conditions (including quantity and form of iron administered, iron status of the individual, method of measuring absorption, and stage of pregnancy). Whittaker, et al., (1991) used stable, isotopically labeled iron to measure iron absorption in pregnant women from 5 mg iron as ferrous sulphate. They observed increases between 12, 24 and 36 weeks gestation from a mean of 7.6% to 21.1% and 37.4% respectively. Absorption was still elevated (26.3%) 12 weeks post delivery.

2.5.1.2. **Effect of quantity of iron in food on bioavailability:**

On the basis of intake data and isotope studies, iron bioavailability has been estimated to be in the range of 14 – 18% for mixed diets and 5 – 12% for vegetarian diets in subjects with no iron stores, and these values have used to generate dietary reference value for all population groups (Hurrell and Egli, 2010).

Typical diets can be separated into three broad categories of low, intermediate and high bioavailability, with mean absorption from the mixture of heam and non heam iron of approximately 5, 10 and 15 percent respectively by individuals with very low iron stores but normal hemoglobin concentrations.

A low bioavailability diet (5% of iron absorbed) is a simple monotonous diet containing cereals and root vegetables with negligible quantities of meat, fish, or ascorbic acid – rich foods. This diet contains a preponderance of foods that inhibit iron absorption (maize, beans and whole wheat flour) and is common in many developing countries, particularly among lower socioeconomic groups.

An intermediate bioavailability diet (10% of iron absorbed) consists mainly of cereals and root vegetables, but contains some ascorbic acid – rich foods and meat. A high bioavailability diet can be reduced to this intermediate level by regular consumption.
of inhibitors of iron absorption, such as tea, coffee, cereal fiber, beans and high calcium foods with main meals.

A high bioavailability diet (15% of iron absorbed) is a diversified diet containing generous quantities of meat, poultry, fish and / or foods containing high amounts of ascorbic acid. This is the type of diet generally consumed by people in developed countries.

The Institute of Medicine. Food and Nutrition Board (2001) estimated that overall iron bioavailability from a mixed American or Canadian diet was 18%, a value similar to the 17% estimated by (Hallberg and Rossander-Hul, 1991) The WHO/FAO (2006) proposed iron bioavailabilities of 15%, 12%, 10%, or 5%, which depend on dietary composition, the highest bioavailability for diversified diets that contain generous amounts of meat and/or food rich in ascorbic acid, the lowest bioavailability for diets based on cereals and/or tubers with negligible amounts of meat and ascorbic acid–containing foods.

2.5.1.3. Dietary factors:

Iron absorption is greatly influenced by a number of dietary factors. Absorption enhancing factors are ascorbic acid and, meat, fish and poultry. Inhibiting factors are plant components in vegetables, tea and coffee e.g., polyphenols, phytates and calcium (Zijp et al., 2000; Murray et al., 2010)).

2.5.1.3.1. Enhancers iron absorption:

2.5.1.3.1.1. Ascorbic acid:

Ascorbic acid is a potent enhancer of nonheme-iron absorption, increasing the absorption of native food iron and of iron fortificants, which dissolve in the gastric juice and enter the common iron pool. The enhancing effect appears to be due to both the reducing power and the chelating action of ascorbic acid. Ascorbic acid has been shown to at least partially overcome the negative effects of all major inhibitors of iron absorption, as recently reviewed by Hurrell (2002). This vitamin is therefore an important factor for enhancing nonheme-iron absorption, and information about its intake is important when evaluating iron bioavailability from diets. Ascorbic acid is commonly added to iron-fortified foods to ensure adequate iron absorption. Several derivatives of ascorbic acid are less sensitive to heat and oxygen. Teucher et al., (2004) and Pizarro et
al., (2006) recently reported that ascorbyl palmitate retains its enhancing effect on iron absorption after it is baked into iron-fortified bread. Erythorbic acid, an ascorbic acid derivative, is widely used as an antioxidant in processed foods in industrialized countries.

Addition of 50 mg ascorbic acid, for example to wheat rolls with no detectable phytate increased mean iron absorption from 22.4% to 37.6% (Hallberg et al., 1986). Vitamin C found in fruit, fruit juice and vegetables, enhances iron absorption by reducing the ferric iron to the more readily absorbed ferrous form. In addition, it also protects any iron in the ferrous form from being oxidized back to the ferric form (Sandrine, et al., 2008).

In study by Diaz et al., (2003) showed, the intake of 25 mg ascorbic acid as limeade twice a day for 2 wk more than doubles iron absorption from typical Mexican meals. The increase in the efficiency of iron absorption, combined with the high content of iron and iron inhibitors present in rural Mexican diets, justifies testing the effectiveness of increasing ascorbic acid intake in the form of limeade as a practical approach for improving iron status in ID populations, such as the population of rural Mexico.

In iron deficient individuals, vitamin C greatly enhances iron absorption from food when consumed in the same meal. In individuals with normal iron status, vitamin C has a lesser effect on improving iron absorption. The absorption enhancing effect in much smaller when the vitamin C is taken 4 to 5 hours before the meal. Both synthetic and dietary ascorbic acid enhance iron absorption. For meals consumed in the morning the iron enhancing effect of vitamin (is high with meals consumed later in the day, the effect may be some what dampened (Hallberg et al., 1989). During pregnancy there is a moderate extra drain on ascorbic acid, particularly during the last trimester. It has been reported that 8 mg/day of ascorbic acid is sufficient to prevent scorbutic signs in infants aged 4–17 months. FAO/WHO (2002) therefore provided an extra 10 mg/day throughout pregnancy, to bring the recommended intake to 55 mg/day. This enables reserves to accumulate to meet the extra needs of the growing foetus in the last trimester.

2.5.1.3.1. 2. Organic acids:

Organic acid such as citric, malic or tartaric (found in fruit and vegetables), lactic acid (found in fermented products such as sauerkraut) and fructose (found in fruit) have
been found in some studies to enhance the absorption of non hem iron. The nature of this effect has still yet to be established, although the lower pH in the duodenum, caused by these acids helps to activate phytase (the enzyme responsible for breakdown of phytate) in those products (Bonsmann, et al., 2008).

2.5.1.3.1. 3. Animal products:

Meat, liver, fish and poultry, all meat proteins will improve the absorption of non hem iron. Several studies have shown that meat, poultry fish and other sea food increase the absorption of non heam iron, but animal proteins (milk protein, egg proteins and albumin) inhibit iron absorption (Bonsmann, 2008). It was previously thought that soy protein also had an inhibitory effect on iron absorption (Hurrell et al., 1992) but new research shows that iron in soy is in the form of ferritin and is highly available. It has no negative effect on iron status, (Murray et al., 2003 , Zhou et al., 2011) and is as well absorbed as iron from ferrous sulfate (Lönnerdal, 2009).

2.5.1.3.2. Inhibitors iron absorption:

2.5.1.3.2.1. Phytates:

Phytic acid is found in cereal grain and legume seeds and it the major determinant of the low iron bioavailability in these foods. It strongly inhibits iron absorption in a dose dependent relationship and even small amount have a marked effect (Aggett et al., 2012).

Different methods to reduce phytic acid during food preparation had appositive effect on iron absorption . Conventional heat treatments, such as those used in domestic cooking or industrialized processing, have generally been reported to cause more losses of phytic acid. These phytate losses reported during the different cooking processes are presumably due to a combination of heat and / or enzyme degradation and of leaching of the phytic acid into the cooking water. Milling of wheat, are polishing of rice grains, removes the bran and decreases phytic acid by up to 90% traditional processes such as soaking, germination and fermentation can inactivate grain phytases. Soaking of legume seeds such as peas, groundnuts and pigeon peas, has been reported to reduce phytic acid by about 20%. Whereas germination of legume seeds or cereal grains reduced their phytic acid content by about half, fermentation is more effective since the organic acids produced by the microorganisms reduce the pH of the aqueous cereal mixture close to the optimum pH for phytase activity, and phytate degradation can be extensive or complete.
in products such as lactobacilli – fermentation sorghum (Fox and Eberl, 2002; Hurrell and Egli, 2010).

2.5.1.3.2.2. Polyphenols:

Polyphenols commonly present in many vegetables include phenolic acids, flavonoids and their polymerization products. There are numerous kinds of phenolic compounds in beverages drinks such as tea and coffee herbal teas, coca and red wine. These compounds from insoluble complexes with iron and may exist as an "iron tannin" complex and thus inhibit iron absorption. This inhibition was considered to be due to polyphenols present in these beverages. Addition of tannic acid to a meal was shown to reduce iron absorption. Further studies showed that gallic acid and tannic acid had identical inhibitory effects on iron absorption and identical iron binding properties (Cook et al., 1995 and Heath; Tait, 2002).

Coffee and tea are widely consumed as beverages with meals or directly after meals. These beverages have shown to strongly inhibit the absorption of nonheme iron. A cup of tea (≈ 200 ml) reduces iron absorption by ≈ 75 – 80%. Variations in the results of different studies are probably related to different amount of phenolic compounds in the tea resulting from differences in the amounts, brands, and steeping time of teas used. A cup of coffee (≈ 150 ml) reduces iron absorption by ≈ 60%. When tea or coffee was served with meal containing ≈ 100 g meat, the inhibition of iron absorption was reduced by 50% (Brune et al., 1989).

In individuals with low intake of heme iron, low intakes of enhancing factors and/or high intakes of inhibitors, iron absorption may be an issue. Depletion of iron stores enhances iron absorption, but this effect is not adequate to compensate for the inhibition of iron absorption in such as in adequate dietary situation. For subjects at risk of iron deficiency, the following recommendations are made. Increase heme – iron intake (this form of dietary iron present in meat, fish and poultry is hardly influenced by other dietary factors with respect to its absorption); increased meal time ascorbic acid intake; fortify foods with iron. Recommendation with respect to tea consumption (when in a critical group) include consume tea between meals instead of during the meals simultaneously consume ascorbic acid and / or meat, fish and poultry (ZijP et al., 2000 and Hurrell and Egli, 2010).
2.5.1.3.2.3. Calcium:

Calcium has also been considered an inhibitor of both haem and non-haem iron absorption. The level of iron inhibition by calcium depends on the quantity of calcium consumed, the meal size and meal composition. The inhibition may be more apparent in small, single-food meals than in complex meals, but recent research suggests that, over a long period of time, calcium has a limited effect on iron absorption “possibly due to an adaptive physiological response” (Mølgaard et al., 2005). Nevertheless, it may be best to avoid consuming high-calcium supplements with meals (Mangels, et al., 2011).

Strong dose–effect relation between the amount of calcium in a meal and the reduction in non heme–iron absorption has been observed. The relative reduction of iron absorption was the same for the same amount of calcium given as a calcium salt, milk or cheese. No inhibition was seen when the amount of calcium in a meal was < 50 mg (10 mg native and 40 mg added Ca) and the inhibition was maximal at a content of ≈ 300 – 600 mg. Moreover, calcium also inhibited the absorption of heme iron similarly (Hallberg et al., 1992). Suggesting a common step in the transport of these 2 kinds of iron; the effect was not located in the intestinal lumen but within the mucosal cell. Iron absorption increased after the addition ascorbic acid to a meal containing calcium; however, the relative increase was the same as would have occurred had no calcium been present (Hallberg et al., 1992).

While some studies have found that oxalic acid (present in spinach, silverbeet and beetroot leaves) may inhibit iron absorption, recent studies suggest that its effects are relatively insignificant (Bonsmann et al., 2008).

2.6. Definition of anemia:

Anemia is a global public health problem affecting both developing and developed countries; approximately 1.3 billion individuals suffer from it. Pregnant women are the most vulnerable groups to anemia. Anemia in pregnancy is a common problem in most developing countries and a major cause of morbidity and mortality especially in malaria endemic areas. In pregnancy, anemia has a significant impact on the health of the fetus as well as that of the mother. 20% of maternal deaths in Africa have been attributed to anemia (Idowu et al., 2005; Alem et al., 2013).
Anemia is present when there is a decrease in the level of hemoglobin or haematocrit in the blood between the reference level for the age and sex of the individual. Mabry – Hernandez, (2009) reported, Anemia is a condition in which the body does not have enough healthy red blood cells. Iron is an important building block for red blood cells. When the body does not have enough iron, it will make fewer red blood cells or red blood cells that are too small. This is called iron deficiency anemia. In screening for iron deficiency, the WHO reported that individuals with more marked anemia usually have ferritin ≤60 μg/dl, and transferrin saturation <16 % (Habib et al., 2009).

Table (2-2): Haemoglobin and haematocrit cut – off level for anemia

<table>
<thead>
<tr>
<th>Age / sex</th>
<th>Haemoglobin (Hb) below B/L</th>
<th>Haematocrit (HCT) below %</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 – 59 months</td>
<td>110</td>
<td>33</td>
</tr>
<tr>
<td>5 – 11 years</td>
<td>115</td>
<td>34</td>
</tr>
<tr>
<td>12 – 14 years</td>
<td>120</td>
<td>36</td>
</tr>
<tr>
<td>Females &gt; 15 years:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Not pregnant</td>
<td>120</td>
<td>36</td>
</tr>
<tr>
<td>- Pregnant</td>
<td>110</td>
<td>33</td>
</tr>
<tr>
<td>Males &gt; 15 years</td>
<td>130</td>
<td>34</td>
</tr>
</tbody>
</table>

WHO/ UNU / UNICEF (2001)

In adults and adolescents: if haemoglobin is:

- < 90 g/l anemia is moderate.
- < 70 g/l (or haematocrit < 20%) anemia is severe.
- < 40 g/l anemia is life threatening.
2.6.1. Types of anemia:

The various types of anemia, classified in terms of the red cell in dices, particularly the mean corpuscular volume of red cells, (MCV, are shown in figure (2-1). There are three major types:

- Hypochromic microcytic with a low MCV.
- Normochromic normocytic with a normal MCV.
- Macrocytic with a high MCV.
Fig. (2-1): Classification of anemia, MCV men corpuscular volume.
Kummar and Clark, (2005)
2.6.1.1. Iron deficiency Anemia:

The World Health Organization (WHO) considers iron deficiency the number one nutritional disorder in the world. As many as 80% of the world's population may be iron deficient while 30% may have iron deficiency anemia (CDC 1998; WHO, 2002). Women in their reproductive years, infants, children and young adolescents are especially at risk. Although the prevalence of iron deficiency anemia is higher in developing countries, this form of anemia is also common in the United States particularly in toddlers, adolescent girls, and women of childbearing age. Factors underlying iron deficiency differs somewhat in various population groups and can be best considered in the context of normal iron metabolism (Kumar et al., 2010 and CDC, 2011). Iron balance therefore maintained largely by regulating the absorption of dietary iron (Kumar et al., 2007).

This deficiency is partly induced by plant – based diets, such as vegetarian diets, containing low levels of poor bioavailable iron. IDA is common in both rural and urban areas in tropics and it is as widespread in less industrialized countries as in developing countries. Several works show a prevalence of nutritional anemia of around 20 – 50% in the former and between 2 and 28% in developed countries (Hunt, 2003).

There is strong evidence that iron deficiency anemia during the first few years of life is associated with poor cognitive and motor development and behavioral problems. Longitudinal studies indicate consistently that children who were anemic in early childhood continue to have poor cognitive and motor development and school achievement into middle childhood (Grantham, 2001). Also iron deficiency is stated that adverse effects include poor pregnancy outcome and lower working capacity in adults (CDC, 2011).

In a study in Costa Rica of 5 year-old children, who had iron deficiency anemia in infancy were considered to be at risk of long-lasting developmental disadvantage as compared with their peers with better iron status. Moreover, the effects of iron deficiency anemia in infancy and early childhood are not likely to corrected by subsequent iron therapy (WHO, 2001).
2.6.1.1.1. Early Diagnosis:

Most iron deficiency develop gradually (over month and years) and usually begins with a negative iron balance, many patient do not notice any symptoms until their anemia is severe (CDC, 2001). Although iron deficiency is well defined category of anemia does occur, in the other hand iron deficiency may reduce storage iron without causing anemia. Early diagnosis of iron deficiency essential in non anemic infants and toddlers (under 2 years of age).

Prevention of cognitive and psychomotor skills deline in young children reties on detection of iron deficiency before full manifestation of anemia in present in the circulating blood. In addition a correct diagnosis is essential for proper treatment. Confusing iron deficiency with other forms of anemia impacts proper treatment early diagnosis of iron deficiency in equally important in pregnant women to reduce maternal. Fetal morbidity diagnosis by symptoms and complete count blood test (CBC) ferritin and others. CBC is often included as a part of women’s yearly gynecologic exam. When symptoms develop, they most often nonspecific and con include fatigue, decreased exercise tolerance and sometimes difficulty concentrating (Mary, 2012).

2.6.1.1.2. Etiology of iron deficiency anemia:

Although an individual’s need for dietary iron is small and will only manifest, itself after iron storage sites in the body have been depleted. Iron deficiency anemia is one of the most frequently encountered types of anemias. Four pathophysiological categories can contribute to the development of iron deficiency anemia, its may result from various categories with multiple conditions in each category. The major categories that result in iron deficiency anemia are:-

- **Decreased iron intake:**

  A deficiency of this type results when not enough iron is consumed to meet the normal daily required amount of iron (e.g, fad diets and imbalanced vegetarian diets). This negative balance initially depletes the storage form of iron while the blood hemoglobin level, a marker of iron status, remains normal. Iron deficiency anemia is an advanced stage of iron depletion. It occure when storage sites of iron are deficient and blood levels of iron can not meet daily needs. Blood hemoglobin levels are below normal with iron deficiency anemia (IOMFNB, 2001; Mary 2012).
• **Increased iron utilization:**
  
  An increased demand for iron that is not met, such as during pregnancy, to support fetal growth and maternal health, the growth years, or periods of increased blood regeneration.

• **Excessive loss of iron physiological or pathological:**
  
  An excessive loss of iron can result from acute or chronic hemorrhages are heavy menstruation. Pathological iron loss in adult males and postmenopausal females with iron deficiency. An evaluation of abnormal occult bleeding, especially gastrointestinal (G1) bleeding, is needed.

• **Faulty or incomplete iron absorption (Physiological iron deficiency):**
  
  Conditions of faulty or incomplete iron absorption can be caused by a chlohydria in certain disorders or following gastric resection; or chronic diarrhea. If a gastroenterolgic evaluation fails to disclose a likely cause of iron deficiency anemia, ore in patients refractory to oral iron treatment, screening for celiac disease. Autoimmune gastritis and helicoloacter pylori is recommended. Twenty to twenty – seven percent of patients with unexplained IDA have autoimmune gastritis, 50% have evidence of active H. pylori infection, and 4% – 6% have celiac disease.

  Iron deficiency may have result from several other less commonly occurring conditions including a disorder of iron utilization, sideroblastic anemia; selected hemoglobin apathies; anemia related to chronic disorders; chronic inflammation; parasitic infections such as hook worm; and a deficiency of plasma iron transporting protein, transferring (Tapie, *et al.*, 2001; Mary 2012).
<table>
<thead>
<tr>
<th>Underlying causes</th>
<th>Immediate causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low food supply</td>
<td>Inadequate diet</td>
</tr>
<tr>
<td>Emoneous feeding</td>
<td></td>
</tr>
<tr>
<td>Low socioeconomic status</td>
<td></td>
</tr>
<tr>
<td>Low intake of available iron</td>
<td>Poor absorption</td>
</tr>
<tr>
<td>Unsuitable meal composition</td>
<td></td>
</tr>
<tr>
<td>Excess of inhibitors</td>
<td>Iron efficiency</td>
</tr>
<tr>
<td>Lack of enhances</td>
<td>anemia</td>
</tr>
<tr>
<td>Growth, pregnancy and lactation</td>
<td>Increased requirements</td>
</tr>
<tr>
<td>A cut bleeding (heavy periods)</td>
<td>Blood loss</td>
</tr>
<tr>
<td>Chronic blood losing parasitism</td>
<td></td>
</tr>
<tr>
<td>Poor sanitation</td>
<td>Infection</td>
</tr>
<tr>
<td>I inadequate health services</td>
<td></td>
</tr>
</tbody>
</table>

Fig (2-2): A etiology of iron deficiency:

2.7. Hematology of pregnancy

Pregnancy places extreme stresses on the hematological system and an understanding of the physiological changes that result is obligatory in order to interpret any need for therapeutic intervention (Hoffbrand and Moss 2011).

Blood volume increases progressively from 6 – 8 weeks gestation (pregnancy) and reaches a maximum at approximately 32 – 34 weeks with little change thereafter. Most of the added volume of blood is accounted for by an increased capacity of the uterine reast renal, striated muscle and cutaneous vascular system, with no evidence of circulatory overload in the healthy pregnant women. The increase in plasma volume (40 – 50%) is relatively greater than that of red cell mass (20% – 30%) resulting in hemodilution and a decrease in hemoglobin concentration. Intake of supplemental iron and folic acid is necessary to restore hemoglobin levels to normal (12 g/dL).

The increased blood volume serves two purposes. First, it facilitates maternal and fetal exchanges of respiratory gases, nutrients and metabolites; second, it reduces the impact of maternal blood loss at delivery. Typical losses of 300 – 500 ml for vaginal birth and 750 – 1000 ml for caesarean sections are thus compensated with the so-called "autotransfusion" of blood from the contracting uterus (Christopher et al., 1998)

On the average there is a 1000 ml increase in plasma volume and a 300 ml increase in red cell (RBC) mass (a 3: 1 ratio). Since the hematocrit (HCT) reflects the proportion of blood made up primarily of red blood cells (Table 2-3). HCT demonstrates a "physiologic" decrease during pregnancy (the so-called physiologic anemia of pregnancy). This decrease in hematocrit is not actually an anemia. Anemia in pregnancy is generally defined as a hematocrit less than 30% or hemoglobin of less than 10 g/dL. Because of monthly blood loss with menstrual flow and contemporary dietary practices, which may lack sufficient iron and protein, women often enter pregnancy with lowered iron store and sometimes a lowered hematocrit. When faced with the expansion of the maternal red cell mass and fetal iron needs, additional demands on the mother for iron outstrip the stores that are available, the result is roun– deficiency anemia. It is for these reasons that supplemental iron is appropriately prescribed for pregnant women. IDA is by for the most frequent type of anemia seen in pregnancy – accounting for 90% or more of
all cases. Because iron deficiency is the most common form of anemia in pregnancy, extensive evaluation of anemic pregnant potions should be delayed until an empiric observed. If the presumed IDA is severe, the classic findings are small, pale erythrocytes manifest on blood smears (microcytic, hypochromic) and red cell indices that indicate a low mean corpuscular volume (MCV) generally < 80 F/liter and low mean corpuscular hemoglobin concentration (MCHC) – generally < 30%. Further laboratory studies usually demonstrate a decreased serum iron (generally < 50 μ g/dL), an increased total iron binding capacity (TIBC) and decrease in serum ferritin. (Kratz et al., 2004; Abbassi et al., 2009; Akinami et al., 2013).

In study done in Bangladesh by Wahed et al., 2008) found that, hemoglobin percent and packed cell volume was significantly decreased in 2nd and 3rd trimester of pregnancy when compared with the control group and same category of women who were not supplemented with iron. It is evident that the significantly low hemoglobin percent and packed cell volume (PCV) in pregnant women is due in part to dietary iron deficiency. Therefore, iron therapy in pregnancy is helpful to maintain the hemoglobin percent and packed cell volume nearer to that of non pregnant normal women.

Akingbola, et al (2006) in study done to provide reference values for Nigerian pregnant women, found the mean values of haematological indices were as follows -- First trimester: Haemoglobin (Hb) 112.44 g/l, haematocrit (Hct) 35%; Second trimester: Hb 100.39 g/l, hct 29.3%, and the Third trimester: Hb 98.06 g/l, hct 29.4 %. The following haematological indices: WBC, platelet counts, RBC, PCT, and PDW, of women between the trimesters showed statistical significance (p value < 0.001 in each case). The WBC is inversely proportional to the PCT and the MCV in the pregnant women was slightly raised. Also study showed, pregnancy is characterised by lowest values of haemoglobin parameters in trimester three and there are statistically significant differences between the WBC, platelet counts, RBC, PCT, and PDW of women between the three trimesters.
Table (2-3): Hematologic laboratory values in pregnancy

<table>
<thead>
<tr>
<th>Test</th>
<th>Non pregnant adult</th>
<th>First Trimester</th>
<th>Second Trimester</th>
<th>Third Trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb (g/dL)¹</td>
<td>12 - 15.8</td>
<td>11.6 - 13.9</td>
<td>9.7 - 14.8</td>
<td>9.5 - 15</td>
</tr>
<tr>
<td>HCT (%)¹</td>
<td>35 – 44</td>
<td>31 – 41</td>
<td>30 – 39</td>
<td>28 - 40</td>
</tr>
<tr>
<td>RBC (ml/mm³)¹</td>
<td>4 - 5.2</td>
<td>3.42 - 4.55</td>
<td>2.81 - 4.49</td>
<td>2.72 - 4.43</td>
</tr>
<tr>
<td>WBC (X 10⁹/L)¹</td>
<td>3.5 - 9.1</td>
<td>5.7 - 13.6</td>
<td>5.6 - 14.8</td>
<td>5.6 - 16.9</td>
</tr>
<tr>
<td>MCV (µm³)³,⁴</td>
<td>79 - 93</td>
<td>85 - 97.8</td>
<td>85.8 - 99.4</td>
<td>82.4 - 99.4</td>
</tr>
<tr>
<td>MCH (Pg/cell)³,¹</td>
<td>27 – 32</td>
<td>30 - 32</td>
<td>30 – 33</td>
<td>29 - 32</td>
</tr>
<tr>
<td>MCHC (g/L)²,³</td>
<td>310 - 370</td>
<td>325 – 353</td>
<td>324 – 352</td>
<td>319 - 355</td>
</tr>
<tr>
<td>Serum iron (µg/dL)¹</td>
<td>41 -141</td>
<td>72 – 143</td>
<td>44 – 178</td>
<td>30 - 193</td>
</tr>
<tr>
<td>TIBC (µg/dL)³,²</td>
<td>228 - 428</td>
<td>235 – 408</td>
<td>302 – 519</td>
<td>380 - 597</td>
</tr>
<tr>
<td>Serum Transferrin (mg/dL)¹</td>
<td>200 - 400</td>
<td>254 – 344</td>
<td>220 – 441</td>
<td>288 - 530</td>
</tr>
</tbody>
</table>

2.8. Diet in pregnancy

A healthy diet is associated with a successful pregnancy. Malnourished mothers are at increased risk for complications and death during pregnancy and childbirth. In addition, their children are likely to have low birth weight, fail to grow at a normal rate, and have higher rates of disease and early death (Tinker, 2000). Pregnancy imposes the need for considerable extra calorie and nutrient requirements. A balanced and adequate diet is therefore, of utmost importance during pregnancy and lactation to meet the increased needs of the mother, and to prevent “nutritional stress”. A mother who before conception was eating a good mixed diet does not need to change her habits when she becomes pregnant (Passmore and Eastwood, 1986; Park, 2007).

A pregnant woman requires some general dietary advice as to how best to modify their usual diet so as to supply the extra needs for nutrients. The detail nature of this advice depends on the economic status of family and food available. During pregnancy weight and diet should be monitored. During pregnancy your nutrient requirements increase to support your health and the needs of your growing baby. Particular attention should be given to the following nutrients:

- **Protein**

  More protein is needed during pregnancy to support your baby’s growth and changes in your own body such as increased breast tissue. In general, a healthy balanced diet will provide enough protein to meet your needs during pregnancy. The needs for protein are normally met when the diet provide sufficient energy. Bats store protein in the maternal tissues in early pregnancy and transfer it in later pregnancy to the rapidly growing fetus.

- **Iron**

  Pregnant women needs for iron increase significantly during pregnancy, particularly during the second and third trimesters when the amount of blood in your body increases and to meet the needs of your placenta and the growing baby. To avoid iron deficiency it is important to eat plenty of iron rich foods. Red meat is one of the richest sources of iron. Chicken, pork and fish contain moderate levels. Smaller amounts of iron can also be found in legumes, green leafy vegetables and iron fortified cereals. Meat provides the
most readily absorbed form of iron but eating foods that are rich in vitamin C (e.g. tomatoes and oranges) will help your body absorb iron from plant sources.

- **Folate and folic acid**
  
  Folate is a B vitamin found naturally in green leafy vegetables, fruit (e.g. citrus, berries and bananas) and legumes. When this vitamin is added to food or used in dietary supplements, it is known as folic acid. Not having enough folate during early pregnancy has been linked to increased risk of neural tube defects such as spina bifida. To reduce the risk of neural tube defects in babies, the National Health and Medical Research Council (NHMRC) recommend that, as well as eating a healthy diet rich in folate, women need an extra 400 micrograms of folic acid a day for at least one month before conception, and for the first three months of pregnancy. This can be achieved by taking a folic acid supplement.

- **Calcium**
  
  Throughout pregnancy and especially during the third trimester, your baby needs calcium to build healthy bones. Milk is the best source and daily intake of up to half a litre (600 mg of calcium) ensures an adequate intake. Vitamin D is required for adsorption of the calcium and when there in any doubt about exposure to sun light supplements of vitamin should be given. Fortunately, during pregnancy you absorb calcium more efficiently from your diet, so your growing baby’s needs are met. Recommendations for calcium during pregnancy and breastfeeding are therefore the same as for non-pregnant women (10³mg per day). The calcium needed by both the mother and baby during pregnancy can be provided by 3 to 4 serves of dairy foods a day. One serve is equal to:

  a) a glass of milk (250mL)
  b) a tub of yogurt (200g)
  c) 2 slices of cheese (40g)
• **Iodine**

Iodine is essential to the development of your baby’s brain and nervous system. During pregnancy your iodine requirement increases by 47 per cent and by 80 per cent during breastfeeding. Iodine occurs at low levels in the Australian food supply and varies depending on season and processing practices. Dairy, seafood and fortified bread can be valuable sources however iodine supplementation is recommended during this time to ensure your baby’s demands for growth are met.

• **Zinc**

Zinc is essential for normal growth and development in bones, the brain and many other parts of the body. It is widely available from a variety of foods making it possible for pregnant women to achieve their zinc needs through diet alone. Zinc is most easily absorbed from animal sources such as red meat, fish and dairy and to a lesser extent plant sources including nuts, legumes and cereals (NA, 2012).

Pregnant women should be advised to eat more fruit and vegetables and less – fatty foods including confectionery and cakes. This termed a prudent diet. However, the women should be able to choose and should flaw a diet which is similar to that after family. A pregnant woman should try to eat the following each dairy day:

- Fish or meat 120 g and one egg.
- Milk 500 ml or cheese 30 g.
- An orange, and apple or some other fruit.

Green leafy vegetable at least three times a week when the woman has complied with the above. She can eat any other food to satisfy her hanger as long as this is in agreement with the earlier suggestion for prudent diet. Most pregnant women who eat a prudent diet don’t need vitamin supplements (Derek, 1999). Advice to avoid excess of table salt and salty food, given to all people applies during pregnancy.

**2.8.1. Food beliefs in pregnancy**

Many pregnant women are confused about what they should eat during pregnancy to make sure that the fetus is properly nourished. To large extent this will depend on her cultural background. In different cultures there are many believes and practices about pregnancy, either concerning the mother food or the child development. Pregnant women avoid specific foods due to several reasons. Some pregnant women
avoid foods as a result of a strong dislike (aversion) developed following pregnancy. Other women avoid on medical grounds. In developing countries, however, a substantial number of pregnant women avoid specific foods due to cultural beliefs or impositions. The practice of avoidance of foods due to cultural food beliefs is referred to as food taboos (Tsegaye, et al., 1998). In various studies it was seen that pregnant women in various parts of the world are forced to abstain from nutritious foods as a part of their traditional food habits (Rajkumar and Anuj, 2010). Mother and child are the most appropriate section because the health of pregnant mother and unborn child is current burning problem in nation. The vulnerable section of society needs utmost care and attention. By helping pregnant mother we will be helping whole family to be healthy and satisfied and which in turn will have positive effect on society (Park, 2009).

Abderahman, (1997) reported in many countries mothers believed if they eat too much, the baby will grow too big which will lead to long painfull and difficult labour. This is not true and it is harmful believe, that the baby will not grow more than certain size, if the mother eats well, both she and her baby will be strong and healthy at the time of delivery.

Another study is conducted to determine dietary practices and food taboos practiced by Chinese women in Kuala Lumpur by Poh et al., (2005) who found that, hot foods were most commonly used and “cold” foods were avoided. Ginger, rice wine and sesame seed oil, considered “hot” foods, were used in large amounts in the cooking. Rice, chicken and pork were also consumed in large amounts. Most vegetables and fruits were considered “cold” and were prohibited during pregnancy.

One of the strong beliefs is that papaya can cause abortion. In a study done by Puri and Kapoor, (2006) it was reported that 16.5% of the adolescent girls believe that papaya can cause abortion. Similarly in our study among adults; more than 80% people believe that papaya should not be consumed. Papaya is considered to be a fruit which is ‘hot’. Conventionally ‘hot’ food items are avoided during pregnancy as it is thought that it will cause abortion. Similarly ‘cold’ foods are avoided during lactation as it might affect the quality and quantity of milk production (Mukhi, 1990). The main constituents of papaya latex are papain and chymopapain, which are potent uterinestimulants. A fully ripe papaya contains very little or a negligible quantity of the latex which will not
provoke uterine contractions, so it can be eaten. On the other hand, the unripe or semiripe papaya (which contains high concentration of the latex that produces marked uterine contractions) may have an adverse effect during pregnancy and should be avoided (Adeyi et al., 2002).

2.8.2. Common discomforts during pregnancy

- **Nausea and vomiting**

While a healthy diet is important, if you are suffering from nausea and vomiting or ‘morning sickness’ it’s more important to eat what you can keep down in the first few weeks. If you’re taking a pregnancy supplement, take it each day at a time when you feel less ill. The following tips may also help:

- Eat small amounts often. Carbohydrate-rich snacks are a good option e.g., cheese and crackers, toast, cereal or fruit.
- Drink plenty of fluids outside of mealtimes
- Minimise odours while cooking (exhaust fan, open window)
- Avoid fatty or spicy foods
- Keep dry crackers at your bedside to eat before getting up in the morning.

- **Heartburn**

Heartburn is most commonly experienced in the third trimester as a result of your baby’s increasing size along with a slowing of the passage of food through the intestine.

- Eat small amounts often
- Stay upright after eating
- Drink fluids outside of mealtimes
- Avoid acidic, fatty or spicy foods
- Milk and yogurt may help to relieve symptom
• **Constipation**

Constipation may occur later in pregnancy and can be assisted by:

- Eating high-fibre foods such as wholegrains, fruit and vegetables
- Drinking plenty of fluids
- Gentle physical activity (NA, 2012).

### 2.9. Weight gain in pregnancy

Monitoring of weight and weight gain during pregnancy is a routine practice in antenatal care. Inadequate and excessive gestational weight gains are both risk factors of adverse pregnancy and birth outcomes. Institute of Medicine guidelines for maternal weight gain in pregnancy attempt to balance the risks associated with excess gestational weight gain (such as unplanned cesarean delivery and fetal macrosomia) with the risks associated with inadequate gestational weight gain (including fetal growth restriction and preterm birth). Establishing the optimal range of gestational weight gain, therefore, requires a solid evidence base on the association between total weight gain in pregnancy and a broad range of short- and longer-term maternal and child health outcome (CDC, 2009; Hulsey et al., 2005; Nahar et al., 2007; Sekiya et al, 2007 ;Stotland et al, 2004).

Pregnant women at least 11kg should be gained during pregnancy, weight gain during pregnancy was calculated from the maximum weight measured during pregnancy and the mother’s self-reported prepregnancy weight. The maximum weight during pregnancy was abstracted from the medical chart by an obstetrician associated with the MUSP. At the first antenatal clinic visit, women were asked to report their prepregnancy weight; women were also weighed at the clinic. Health care providers need to be explicit about their recommendations regarding weight gain during pregnancy. However, it remains controversial whether energy restriction should be advised to pregnant overweight women to control the potential risk of gaining excessive weight during pregnancy, because such a restrictive diet can affect the growth of the fetus. Clinicians may encourage women to lose pregnancy weight by 6 months postpartum; however, this need to be done judiciously, as rapid weight loss may affect breastfeeding (Mamun et al., 2009 Hutcheon et al, 2012).
The gestational weight gain measures remained correlated with gestational duration, and, because many adverse pregnancy outcomes are also strongly associated with gestational duration, their use introduces a nontrivial degree of bias to our understanding of the relation between weight gain and pregnancy outcomes (Hutcheon et al., 2012). Also Mamun et al. (2010) reported that, Weight gain during pregnancy independently predicts the long-term weight gain and obesity of women. It is normal for women to gain 3.5 kg (8 lb) in weight by the end at the first 20 weeks of pregnancy and thereafter to gain about 0.5 kg or 1 lb a week until term, when the total gain is 12.5 kg (28 lb). Table (2-6) give an analysis of how these weight gains are made up. Beside the products of conception and increased size of the per reproductive organs, blood volume expands; as the plasma increases a little more than the red cell; it is normal for the hemoglobin concentration in the blood to fall slightly by the end of the pregnancy.

In the last 10 weeks there is an increase in the extra cellular water, additional to the increase in plasma. The extra fat deposited is about 4 kg, this is an energy store of 150 Mj (3600 Kcal), enough to supply the needs of the body for two to three weeks in an emergency. This is deposited throughout pregnancy, but especially in the period between 10 and 20 weeks.

Maternal prepregnancy body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared by using self-reported prepregnancy weight, which was recorded at baseline from maternal questionnaires, and height, which was measured at the first antenatal clinic visit (Mamun et al., 2010). Women those prepregnancy weights is in the normal range (body mass index, BMI, 19 – 24.9) or who is over weight (BMI 25 – 29.9) should avoid excessive weight gain (more than 15 kg) as she may find it difficult to regain her prepregnancy weight after birth. The situation is different for obese and under weight women, both during pregnancy and after birth. An obese woman (BMI greater than 30) should be encouraged to limit her weight gain during pregnancy as she an increased risk that pregnancy – included hypertension may occur and that she will have a large baby. She should have a glucose tolerance test performed to exclude gestational diabetes mellitus and she should be advised to eat a prudent but not a very low calorie diet as such a diet does not confer any benefit on meter or fetus. An
under weight women (BMI less than 19) should avoid becoming pregnant until she has gained weight as she has 920% of giving birth to low-birth weight baby (Derek, 1999).

A baby that weight less than 5.5 lbs (2.5 kg) is more likely to have both physical and mental problems. It may not grow normally; it may suffer more from infections and malnutrition than babies of normal weight.

Table (2-4): Analysis of the weight gain in pregnancy

<table>
<thead>
<tr>
<th></th>
<th>Increase in weight up to 10 weeks (g)</th>
<th>20 weeks (g)</th>
<th>30 weeks (g)</th>
<th>40 weeks (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetus, placenta and liquor</td>
<td>55</td>
<td>720</td>
<td>2530</td>
<td>4750</td>
</tr>
<tr>
<td>Uterus and breasts</td>
<td>170</td>
<td>765</td>
<td>1170</td>
<td>1300</td>
</tr>
<tr>
<td>Blood</td>
<td>100</td>
<td>600</td>
<td>1300</td>
<td>1250</td>
</tr>
<tr>
<td>Extra cellular water</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1200</td>
</tr>
<tr>
<td>Fat (by difference)</td>
<td>325</td>
<td>1915</td>
<td>3500</td>
<td>4000</td>
</tr>
<tr>
<td>Total gain</td>
<td>650</td>
<td>4000</td>
<td>8500</td>
<td>12500</td>
</tr>
</tbody>
</table>

Passmore and Eastwood, (1986)
2.10. The role of antenatal care

Antenatal care (ANC) is one of the key strategies in maintaining safe motherhood. Good care during pregnancy is important for the health of the mother and the development of the unborn baby. Pregnancy is crucial time to promote health behavior and parenting skills. Good ANC links the women and her family with the formal health system, antenatal visits can play a critical role in establishing confidence between the women, the family and the health care provider. Increases the chance of using a skilled attendant at birth and contributes to good health through the life cycle. In adequate care during this time breaks a critical link in the continuum of care and affects both women and babes (WHO 2014). The following activities should be part of antenatal care:

a. Promotion of health during pregnancy through advice and education activities.

b. Screening identification and referred if necessary of women with .

c. Monitoring of health throughout pregnancy in order to detect and deal with problems, if and when they occur.

d. Antenatal visits can play a critical role in establishing confidence between the women, the family and the health care provider.

Khanal et al., (2014) in Nepal found that, attending antenatal care was found to be consistently associated with low birth for the pooled survey data. Not attending antenatal care increased the odds of having a LBW infant by more than two times, iron supplementation to treatment and prevention of anemia, which very where play a major role in maternal mortality which is an integral part of antenatal care in Nepal was also significantly associated with birth weight. ANC provides an opportunity for a pregnant woman to have her health checked, manage any problems that arise during pregnancy and obtain counselling services. Counselling advice to pregnant woman revolves around taking adequate rest, reducing physical workload, and eating adequate nutrition including iron-folic acid supplementation in Nepal (MOHM, 2010). In Nepal, iron-folic acid supplementation is provided at no cost at government health facilities throughout the country. An earlier double blinded cluster randomised study from the Eastern Nepal reported the beneficial effect of iron-folic acid supplementation during pregnancy in reducing LBW, showing an increase in the mean birth weight by 37 grams (MOHM,2010 and Christian et al, 2003).
Nepal is one of the exemplary countries successful in reducing the child and maternal mortality in this century.

Ideally the mother should attend the ANC, one per month during the first 7 months, twice a month during the next 2 months; and thereafter, once a week, if very things is normal. In the first visit, irrespective of when it occurs, should include medical history, clinical examination laboratory examination and x-ray, it needed, (Park, 1997).

Women in many parts of the world may be prevented from receiving ANC by many physical, cultural, technical and economic barriers, especially in rural area. In developing countries only 67%. Women receive ANC compared to 97% in developed countries. In India also observed that social status and economic condition were important determinants of utilization of ANC (Nisar and White, 2003)

Also in Karachi Nisar and White, (2003) found that the antenatal care is the basic component of maternal care on which the life of mothers and babies depend and poverty negatively effects the utilization of health services,infrequent/ irregular checkups were 61% whereas regular checkups were 26% and these figures are also comparable with 28% in a WHO study which recommends four antenatal care visit model ( Akhund and Avan ,2011)

2.11. Anemia in pregnancy:
Anemia is common in pregnancy and iron deficiency is a major cause of anemia in pregnant women. This is due to increased demands of the fetus, growing uterus, placenta, and poor nutritional habits (Hassan, et al., 2014)

Anemia continues to be a public health problem of global proportions. Severe anemia (hemoglobin <70 g/L) is of particular concern because it poses a significant health and mortality risk. Pregnant women and young children (6–24 month) are the tow groups at highest risk. Severe anemia in pregnant women is associated with an elevated risk of maternal and prenatal mortality (Bhutta, et al., 2008). Antenatal, iron-folic acid supplementation reduces low birth weight and preterm in both developed and developing country settings (Siega-Riz, et al., 2006).

Iron deficiency anemia is uncommon in the United States. Overall, the prevalence of iron deficiency anemia has remained stable over the past decade at 7% in children aged 1 to 2 years; 9% in adolescent females; and 2%-5% in non-pregnant females. More detailed data on
the prevalence of iron deficiency anemia in infants of different ages has not been identified. The prevalence among pregnant women is uncertain. (Helfand, et al., 2006)

2.11.1. Definitions and epidemiology:

During pregnancy, anemia is defined as a hemoglobin concentration (Hb) <110 g/L at sea level. Which are two standard deviations below the mean Hb expected. Consequent to the physiological hemodilution which is maximal during 20–24 weeks of gestation, the Hb varies with the period of gestation. The Hb increases with high altitudes and in those who smoke. (WHO, 2011) In those who smoke, the decrease in plasma volume and increase of Hb, both of which adversely affects fetal growth, are adaptations to increased carboxyhaemoglobin which has no oxygen carrying capacity. Quitting smoking can reduce the Hb to its original levels within five years. Although the Hb can increase in pregnant women who smoke, a decrease of Hb with smoking (Strinc, et al., 2005 and Subramoney and Gupta, 2008) and the use of smokeless tobacco have been shown. Genetic differences may also affect the Hb (James, et al., 2009). A hematocrit of <33% could also be considered for the diagnosis of anemia in pregnancy. Severe anaemia in pregnancy (Hb < 70 g/L), requires urgent medical treatment and Hb <40 g/L is an emergency carrying a risk of congestive cardiac failure, sepsis and death (WHO, 2011). Traditionally, anaemia is defined as a decrease in the ability of blood to carry oxygen due to a decrease in the total number of erythrocytes (each having a normal quantity of haemoglobin), a diminished concentration of haemoglobin per erythrocyte, or a combination of both (WHO, 2008). A haemoglobin concentration below 11.0g/dl or packed cell volume (PCV) of less than 33.0% is regarded as anaemia during pregnancy by the World Health Organization and Unicef (2004).

Globally, WHO criteria, 52% of pregnant women from undeveloped or developing countries are anemic compared with 20% for industrialized nations, UNICEF and WHO (2001). The highest prevalence is among pregnant women in India (88%), followed by Africa (50%) Latin America (40%) and the Caribbean (30%), Lee and Okam (2011).

The World Health Organization (WHO) defines anemia or hematocrit less than 33%, at any point during pregnancy (UNICEF and WHO, 2001). The US centers for disease control and prevention (CDC) defines anemia of pregnancy as hemoglobin level of less than 11g/dL, or hematocrit less than 33%, in the first or third trimester or
hemoglobin less than 10.5 g/dl or hematocrit less than 32% in the second trimester (CDC, 1998).

2.11.2. Caused of anemia in pregnancy:

2.11.2.1. Iron deficiency:

The most important pathological cause of anemia of pregnancy is iron deficiency, arising as a consequence of increased fetal use of iron clinicians long recognized that hydremia alone could not account for the hemoglobin levels of less than 79/dL in 10% to 70% of pregnant women reported in early twentieth century studies. A central role for iron deficiency in anemia of pregnancy was demonstrated in 1950s by the frequent finding of kypochromia, microcytosis and a nisocytosis in the blood smears of pregnant women with anemia, and the resolution of such abnormalities of following iron supplementation (Frenkel and Yardley’ 2000).

Pregnant women are recognized as the group most vulnerable to IDA. In Asia, the prevalence of anemia was estimated to be 44% in non-pregnant and 60% in pregnant women (Rush, 2000). Most women enter pregnancy with iron stores inadequate to meet the increased iron needs required for red blood cell mass expansion in the mother as well as for the development of the fetus and the placenta. 1

Almost all iron need occur during the second half of pregnancy, when fetus organ formation occurs. Iron requirements, are not as great in the first trimester because of the absence of menstruation and limited fetal needs. On average, daily iron needs are between 6 and 7 mg as apposed to 1 mg / day in normal physiological conditions. During the last 6 to 8 weeks of pregnancy, the need increases to up to 10 mg / day. Although iron absorption is substantially increased during pregnancy and is adequate in healthy iron. In women who enter pregnancy with low iron stores, iron supplements often fail to prevent iron deficiency (Allen, 2000). Furthermore, conditions such as abnormal placenta implantation may induce chronic blood loss and increase iron requirements during pregnancy.

The risk factors effectuated on ID in pregnancy, in addition to poor nutritional intake, factors that impair iron absorption may precipitate iron deficiency in pregnancy, including bariatric surgery, antacids, and deficiencies of micronutrients such as vitamin A, vitamin C, zinc, and copper (Killip et al., 2007; Love and Billett 2008).
2.11.2.1.1. Consequences of iron deficiency in pregnancy:

Severe anemia may be associated with adverse effects on both the mother and the fetus. A study of a cohort of 629 pregnant women in Pakistan showed that the risk of preterm delivery and low birth weight was 4 and 1.9 times higher, respectively, in anemic women (Hb < 110 g/L) than in pregnant women without anemia (Lone et al., 2004).

Anemia during pregnancy has serious clinical consequence. It is associated with greater risk of maternal death, in particular from hemorrhage. Severely anemic pregnant women are less able to withstand blood loss and may require blood transfusion which is not always available in poor countries and is not without risk ((Rush, 2000; WHO, 2003), also pregnant women with anemia are at a greater risk of perinatal mortality and morbidity (Rasmussen, 2001; Yip and Ramakrisunan, 2002). Anemia during pregnancy is also associated with increased stillbirths, perinatal deaths, low-birth – weight babies and prematurely.

A study of iron status and its association with pregnancy outcome in Korean pregnant women., the study showed that 30, 2% of the subjects were anemic judged by HG concentration of < 10.5 g/dL. When subjects were classified in to fertile groups based on Hb levels, the lowest tertile (HbT1) group had significantly lower concentration of cord serum iron albumin than those in the highest tertile (HbT3) group. New born infants from the HbT1 group had significantly higher rates of preterm delivery, low birth weight and low Apgar scores than those in other groups. Logistic regression analysis showed that maternal serum albumin and Hb level were the most important predictive variables for low birth weight (Lee et al., 2006)

2.11.2.2. Folate and cobalamin (B12) deficiency:

Folate deficiency is historically regarded as the second most common cause of anemia of pregnancy after iron deficiency, although in many modern series vitamin B12 deficiency may be more prevalent, particularly in underprivileged areas. In studies from India, Turkey, Africa, Newfoundland, and Venezuela, 10% to 100% of pregnant women have a diagnosis of folate deficiency (defined as a serum level of <2.5–3.0 ng/mL), whereas 30% to 100% have vitamin B12 deficiency (defined as a serum level of <160–200 pg/mL). The prevalence of folate or vitamin B12 deficiency increases with gestation (Kalaivani, 2009, Garcia et al., 2005 ; Karaoglu, et al., 2010)
Folic acid is necessary for cell growth and repair and essential for the formation and maturation of red blood cells. Deficiency of folate leads to slowing of DNA synthesis and impaired cell proliferation. This, in turn, leads to intramedullary death of many of these abnormal cells and shortened lifespan of circulating red blood cells. As early as the 1950s, pre-natal folate supplementation was recognized as a means to prevent pregnancy-related megaloblastic anemia. (Tamura and Picciano, 2006).

Folate is a central component of human erythropoietin besides iron and vitamin B\textsubscript{12}. Folate deficiency is historically regarded as the second most common cause of anemia of pregnancy after iron deficiency, although in many modern series vitamin B\textsubscript{12} deficiency may be more prevalent, particularly in underprivileged areas. In studies from India, Turkey, Africa, new found land, and Venezuela, 10% to 100% of pregnant women have a diagnosis of folate deficiency (defined as a serum level of <2.5 – 3.0 mg/ml) whereas 30% to 100% have vitamin B\textsubscript{12} deficiency (defined as a serum level of < 100 – 200 pg/ml). The prevalence of folate or vitamin B\textsubscript{12} deficiency increases with gestation (Ackurt \textit{et al}, 1995 Kalaivan, 2009; House \textit{et al}, 2000, Garcia \textit{et al}, 2005, Karaoglu \textit{et al}, 2010).

Fetal growth depends on folate and vitamin B\textsubscript{12} because both are involved in the synthesis of tetrahydrofolate, an integral component of deoxyribonucleic acid synthesis and nuclear maturation. Dietary folate is absorbed in the jejunum; poor nutrition and intestinal malabsorption can precipitate folate deficiency in pregnancy. Vitamin B\textsubscript{12} is absorbed in the ileum, malabsorption, ileal resection, intestinal parasites, a trophic gastritis and antihistamines inhibitors can all increase the risk of vitamin B\textsubscript{12} deficiency in pregnancy (Frenkel and Yardley, 2000).

One of the first clinical manifestation of folate deficiency is the production of megablastic marrow cell, erythrocytes and ultimately macrocytic anemia (Scholl and Johnson, 2000).

Most pregnant women with folate or vitamin B\textsubscript{12} deficiency do not exhibit erythrocyte macrocytosis, although 2% to 5% of pregnant women with normocytic anemia have mild megaloblastic changes in the bone marrow that resolve with folic acid supplementation. Elevation in homocysteine or methylmalonic acid levels accompanies most cases of clinically significant vitamin B\textsubscript{12} deficiency in pregnancy. About 20% of
pregnant women have a (physiologic) decline in vitamin B\textsubscript{12} levels with no change in homocysteine or methylamalonic acid levels, ((Frenkel, Yardley, 2000).

Folate deficiency was found in 21\% of pregnant women in Malawi and was frequently associated with other micronutrient deficiency (Broek and Letsky, 2000). Whether folate deficiency in this population was primarily the result of dietary insufficiency. In a cross – sectional study in pregnant women in Tanzania, odd ratio for anemia was increased with low serum folate concentration (Hinderaker et al., 2002), whereas it was a decreased in a study in Nepal (Bondevik et al., 2000). Folate trials have focused primarily an pregnancy and several studies indicate that folate supplementation faints to raise Hb concentration or lower the risk of anemia, while it can prevent the redevelopment of megaloblastosis (Fishman et al., 2000).

A second nutritional cases of megaloblastic anemia in vitamin B\textsubscript{12} deficiency. In studies in Mexico and Guatemala, vitamin B\textsubscript{12} deficiency was found in 19\% – 47\% of young children, school children, adults and pregnancy and lactating women (Allen et al., 1995). A study in anemia preschoolers in Mexico showed that children with higher initial vitamin B\textsubscript{12} concentration were more likely to respond to iron supplements with improved Hb concentration than children with low vitamin B\textsubscript{12} status (Allen et al., 2000). However, Fishman et al., (2000) reviewed the effect of vitamin B\textsubscript{12} supplementation on pregnant women and found no effects on Hb concentration. In premature and low birth weight infants, vitamin B\textsubscript{12} supplementation may improve Hb status and reduce the severity on the anemia.

The WHO recommends folate supplementation for all pregnant women at a dose of 400 mg/d from the beginning of pregnancy to 3 months post partum (UNICF, WHO, 2001). The US National Institutes of Health (NIH) recommends a higher daily allowance of vitamin B\textsubscript{12} in pregnant women than in non pregnant women (2.6 US 2.4 mg/d) to support fetal nairologic development.

2.11.2.3. Vitamin B6:

Vitamin B6 exists as pyridoxine, pyridoxal and pyridoxamine. Vitamin was first identified as the factor in the vitamin B complex, distinct from thiamin (B\textsubscript{1}) and riboflavin (B\textsubscript{2}). Vitamin B\textsubscript{6} is found widely in plant and animal foodstuffs in three forms
which are readily interconverted in tissues and equal biological value (Kumar and Clark, 2005).

The vitamin provides the co-enzyme for over 60 different decarboxylation and transamination reaction, involving amino acid. Some of these have been used as clinical tests of vitamin \(B_6\) status. Some drugs (e.g. isoniazid, hydralazine and penicillamine) interact with pyridoxal phosphate, producing \(B_6\) deficiency.

In study conducted by Hisano et al., (2010) in Tokyo, about vitamin \(B_6\) deficiency and anemia in pregnancy, who found that, several pregnant women with anemia were nonresponsive to iron supplementation also had vitamin \(B_6\) deficiency with the administration of vitamin \(B_6\). The researcher recommended that, it is important to take in to account the deficiency of vitamin \(B_6\) beside iron in the evaluation of anemia during pregnancy.

2.11.2.4. Other micronutrient deficiencies:

Deficiencies in micronutrients other than folate and vitamin \(B_{12}\) remain the important causes of anemia of pregnancy world wide, affecting primarily women from under privileged areas. The prevalence of anemia due the specific micronutrient deficiencies is difficult to assess because multiple nutritional deficit may coexist within the same community. Confection by human pathogens may compound the effects of micronutrient deficiency on pregnant in certain populations (Ackunt et al., 1995).

Deficiencies in vitamin A, vitamin C, zinc and copper have all been reported in association with anemia of pregnancy, possibly because of the inhibitory effects of such deficiencies on gastrointestinal iron absorption, although the interactions between specific micronutrients are complex and may improve maternal anemia and other gestational and neonatal outcomes in specific population although the risks and benefits of individual micronutrients are uncertain, as are the magnitude of the observed hematologic and nonhematologic benefits compared with the combination of iron and folate alone (Haider and Bhutta, 2006; Fauzi et al., 2007).
2.11.2.5. Infections diseases and anemia of pregnancy:

2.11.2.5.1. Hook worm infection:

Infection with hookworm is a common cause of anemia where there is 'wet' cultivation of the land. The clinical and hematological features are similar to those of chronic hypochromic anemia. A heavy infection with hook worms is always associated with anemia. Smaller loads may be carried without ill – effect. Haemorrhages occur at the site of the attachment of the worms to the intestinal mucous membrane. These are certainly in part responsible for the anemia it has been calculated that each worm may ingest from 0.03 to 0.15 ml of blood daily, and Hookworm contribute to anemia by needing on blood and live in the duodenum and jejunum, the same site where most iron is absorbed .The association between hookworm infection, intestinal blood loss and severity of anemia depend on the level of infection, a patient with a heavy infection, namely about 1000 worms (while would give a stool count of about 20.000 ava/g faeces) would sustain a heavy loss of blood and anemia would quickly develop.

Among pregnant women with hook worm infection, the burden of infection is a strong predictor of material iron stores, with severity of anemia correlating with the number of hookworm eggs isolated from stool (Dreyfuss et al., 2000; Brooker et al., 2008). The WHO recommends universal deworming of pregnant women in hookworm – endemic areas with antihelminthic medications (eg. aloendazole or mebendazole), in conjunction with iron and folate supplementation, although the hematologic benefits of deworming are uncertain (Brooker et al., 2008, Ndibazza et al., 2010).

In study done in Ethiopia by Melku et al., (2014) found that, , high prevalence rate of anemia was found among mothers who were HIV seropositive (38.7%), infected with hookworm (34.8%), underweighted (30%), with more than four gravidae (32.3%), having chronic disease (27.3%), and at 3rd trimester (18.9%) hookworm infection, and HIV seropositivity were significantly associated with maternal anemia

2.11.2.5.2. Malaria:

Malaria is another cause of anemia. The responsible facters are multiple, involving both the destruction and the decreased production of erythrocytes. However does not cause iron deficiency. When malarial infection is associated with pregnancy and
maturation, the anemia may present as megaloblastic anemia due to folate deficiency. But is more usually hypochromic and microcytic because of iron deficiency. Since the blood destruction is intravascular, most of the iron liberated from the destroyed red cells is retained in the body and can be used again for synthesis of hemoglobin. If were not for this conservation of iron, the incidence and severity of the anemia would be much greater than it is (Passmore and Eastwood, 1986; Haldar and Mohandas, 2009).

Malaria, a parasitic infection transmitted by mosquitoes, is one of the most devastating infectious diseases, killing more than 1 million people annually. Pregnant women, children, and immunocompromised individuals have the highest morbidity and mortality, and Africa bears the heaviest burden. The World Health Organization defines malaria as a disease of poverty caused by poverty. Pregnant women infected with malaria usually have more severe symptoms and outcomes, with higher rates of miscarriage, intrauterine demise, premature delivery, low-birth-weight neonates, and neonatal death. They are also at a higher risk for severe anemia at higher risk for congestive heart failure, mortality associated with hemorrhage at the time of delivery and maternal death. (Dunn and Nour, 2009; Menedez 2000; Elsanousi et al., 2007).

The pathological effects of malaria during pregnancy and the implications for the newborn's development and survival. Empirical data from throughout Africa on associations between placental malaria and birth weight outcome, birth weight outcome and infant mortality, and the rates of LBW in areas with various levels of malaria transmission are evaluated to assess the increased risks of LBW and infant mortality associated with malaria. It is estimated that in areas where malaria is endemic, around 19% of infant LBWs are due to malaria and 6% of infant deaths are due to LBW caused by malaria. These estimates imply that around 100,000 infant deaths each year could be due to LBW caused by malaria during pregnancy in areas of malaria endemicity in Africa (Helen and Guyattm, 2004).

Malaria is the second most common cause of infectious disease-related death in the world, after tuberculosis. It is estimated to affect between 350 to 500 million people annually and accounts for 1 to 3 million deaths per year (CDC, 2009) Sub-Saharan Africa has the largest burden of malarial disease, with over 90% of the world’s malaria-related deaths occurring in this region. Twenty-five million pregnant women are currently at risk
for malaria, and, according to the World Health Organization, malaria accounts for over 10,000 maternal and 200,000 neonatal deaths per year (WHO, 2009).

Pregnant women are 3 times more likely to suffer from severe disease as compared with their nonpregnant counterparts and have a mortality rate from severe malarial infection that approaches 50%. Pregnant women suffer disproportionately from severe anemia as a result of malarial infection. Current prevention of malarial disease in pregnancy relies on providing women with insecticide-treated bed nets and intermittent presumptive treatment and effective educational outreach programs (Dunn and Nour, 2009).

2.12. Iron and folate supplement

Iron supplementation in indicated when diet alone cannot restore deficient iron levels to normal within an acceptable time from. Supplements are especially important when an individual is expensing clinical symptoms of iron deficiency anemia, the goals of providing oral iron supplement are supply sufficient iron to restore normal storage levels of iron and to replenish hemoglobin deficient, when hemoglobin levels are blow normal, physicians often measure serum ferritin, the storage form of iron. A serum ferritin level less than or equal to 15 µg/L confirms iron deficiency anemia in women, and suggests a possible need for iron supplement ation (CDC, 1998).

Iron and folic acid supplementation are used to prevent anemia during pregnancy, in communities where iron deficiency is common. All pregnant women should take iron supplementation as soon as they are free from nausea and vomiting of early pregnancy. Treatment of established iron deficiency in pregnancy is aimed at correcting the anemia by the last month of pregnancy of possible and then replenishing the iron store. A dose of one tablet of iron and folic acid, containing 60mg of element iron (180 mg of ferrous sulphate) and 0.5 mg of folic acid should be given daily. The daily administration should be continued until 2-3 month after hemoglobin level has returned to normal, so that iron replenished. All iron supplementations are not the same, the most common form of iron supplementation is ferrous sulfate but is known to produce intestinal side effects ( such as heartburn constipation, nausea and bloating ) in many users (WHO,2001 ; Mohamed, 2004a). Supplement iron is available in tow forms: ferric ferrous iron salts (ferrous fumarate, ferrous sulfate, and ferrous gluconate) are the best absorbed forms of iron
supplements (Hoffman, 2000). Element iron is the amount of iron in supplement that is available for absorption as follows: Ferrous fumarote (33%), ferrous sulfate (20%) and ferrous gluconate (12%) DFC, (2004).

All pregnant women in areas of high prevalence of malnutrition should routirrrely receive iron and rotate supplement, together with appropriate dietary advice to prevent anemia. Where the prevalence of anemia in pregnant women is high (40% or more). Supplementation should continue for three months in the postpartum period. In order to improve material and prenatal health (WHO, 2013).

Weekly iron and folic acid supplementation (WIFS) is an approach that can be effective for ensuring adequate iron status of women, particularly before pregnancy and during the first trimester in communities where food – based strategies are not yet fully implemented or effective. Short – and medium term WIFS has been effective in reducing the prevalence of anemia of anemia among women of reproductive age in several community settings where the necessary support, social marketing and interpersonal advocacy ensured adequate compliance (WHO, 2009).

Various studies have demonstrated that WIFs can improve iron status in women of reproductive age when supplementation is continuous for periods from several months to two years. A current review (Margetts, 2007) conducted that WIFS taken for at lesist 12 weeks improved iron status, as judged by increased hemoglobin and in some studies serum ferritin levels. The impact of weekly supplementation with 60 mg of iron was similar to daily supplementation except in sevely anemic women.

Where the prevalence of anemia in pregnant women is < 40%, a dose of 60 mg iron and 400 µg folic acid daily for 6 months is considered to meet the physiological requirements for iron in pregnancy. If the duration of supplementation is shorter, a higher dose (120 mg) is recommended. However, the majority of the systematic reviews on this topic refer to a dose of a round 100 mg iron and 350 – 500 µg folic acid daily for 16 weeks or more during pregnancy (Mohamed, 2004a; Mohamed, 2004b ; Mohamed, 2004c). In areas with a higher prevalence of anemia, it is recommended that supplementation continue for three moths post partum.

Based on the possible association between maternal anemia and negative prenatal out come (Xiong et al., 2000), is assumed that effective iron supplementary programs
where anemia is prevalent may reduce the incidence of low birth weight and parinatal mortality, as well as maternal mortality and obstetrical complications associated to severe anemia. According to currently available reviews, however, while there is clear evidence of appositive effect of routine iron supplementation during pregnancy in preventing low hemoglobin at delivery or at six weeks post partum, there is no evidence of any effect; beneficial or harmful on clinical outcome for the mother and her baby (Mohamed, 2004a and b).

In study done by (Keenan, et al. 2013) who found that, Nutritional interventions during pregnancy have been successfully used to target neurodevelopmental problems, such as increasing folic acid intake during pregnancy to decrease the incidence of neural tube defects. Results from the current study can be used to support the testing of nutritional preventive interventions for the most-common childhood behavior problems. The lack of a positive effect might be due to the small sample size in the studies that tried to assess those clinical aspects. The results of the largest trial included in one review suggest that routine iron supplementation may reduce the need for post partum blood transfusions (Mohamed, 2004a).

Therapeutic dose of iron supplements, which are prescribed for iron deficiency anemia, may cause gastro intestinal side effects such as nausea, vomitines, constipation, diarrhea, dark colored stools, bloating and/or abdominal distress (CDC 1998).

Since the effectiveness of oral iron supplementation is hindered by many factors, including supply problems and poor adherence to regimens owing to the frequency of side effects (Mohamed 2004; Sloan et al., 2002, Torlesse and Hodges 2000), a variety of other interventions have been proposed to prevent and correct iron deficiency anemia, including food fortification, healthy dietary education and antiparasitic treatment (Van Teijlingen et al., 1998).

There is promising evidence from studies where by iron cooking posts are introduced at community level. Cooking in iron posts has led to significant increase in hemoglobin concentration, especially among adults (Geerligs et al., 2003) but there are problems of acceptability (post are heavy and when not properly dried will become rusty) (Geerligs 2002).
Table (2-5). Guidelines for Iron Supplementation to Pregnant Women

<table>
<thead>
<tr>
<th>Women prevalence of anemia in pregnancy</th>
<th>Dose</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40%</td>
<td>60 mg iron + 400 µg folic acid daily</td>
<td>6 months in pregnancy</td>
</tr>
<tr>
<td>40%</td>
<td>60 mg iron + 400 µg folic acid daily</td>
<td>6 months in pregnancy and continuing to 3 months postpartum</td>
</tr>
</tbody>
</table>

WHO, 2003

Notes:

- If 6 months duration cannot be achieved in pregnancy, continue to supplement during the postpartum period for 6 months or increase the dose to 120 mg iron in pregnancy.
- Where iron supplements containing 400 µg of folic acid are not available, an iron supplement with less folic acid may be used. Supplementation with less folic acid should be used only if supplements containing 400 µg are not available.
2.13. Iron toxicity

Iron toxicity is the potential for iron toxicity because very little iron excreted from the body. Thus iron can accumulate in body tissues and organs when normal storage sites are full, e.g., people with hemochromatosis are at risk of developing iron toxicity because of their high iron stores.

In children, death has occurred from ingesting 200 mg of iron. It is important to keep iron supplements tightly capped and away from children’s reach. Doses of iron prescribed for iron deficiency anemia in adults are associated with constipation, nausea, vomiting and diarrhea especially when the supplements are taken on an empty stomach (IOM, 2001).

In 2001 The Institute of Medicine of the National Academy of Sciences Set Tolerable Upper Intake Level (UL) for iron from healthy people. There may be times when a physical prescribes an intake higher than the upper limit, such as when individuals with iron deficiency anemia need higher doses to replenish their iron stores (IOM, 2001).

2.13. Chemical composition of sesame seeds (Sesamum indicum L)

Sesame (Sesamum indicum L.) is one of the world’s important oil crops known to humankind. Its primary marketable products are the whole are the whole seeds, seed oil and meal. (de Carvalho et al., 2001), sesame seeds are used in culinary as well as in traditional medicines for their nutritive, preventive, and curative properties. Its oil seeds are sources for some phyto-nutrients such as omega-6 fatty acids, flavonoid phenolic anti-oxidants, vitamins and dietary fiber with potent anti-cancer as well as health promoting properties.

Sesame plant is a tall annual herb of the Pedaliaceae family, which grows extensively in Asia, particularly in Burma, China, and India. It is also one of the chief commercial crops in Nigeria, Sudan and Ethiopia. Its scientific name: Sesamum indicum L, compotion of sesame seeds (Sesamum indicum L) as follow:

- Handreat grams (100 g) of seeds provide 573 calories. Although, much of its calorie comes from fats, sesame contains several notable health-benefiting nutrients, minerals, antioxidants and vitamins that are essential for wellness.
The seeds are especially rich in mono-unsaturated fatty acid oleic acid, which comprise up to 50% fatty acids in them. Oleic acid helps to lower bad cholesterol (low density lipoprotein, LDL) and increases good cholesterol (high density lipoprotein, HDL) in the blood. Research studies suggest that Mediterranean diet which is rich in mono-unsaturated fats help to prevent coronary artery disease and stroke by favoring healthy lipid profile (Sirato-Yasumoto et al., 2001).

The seeds are an also very valuable source of dietary proteins with fine quality amino acids that are essential for growth, especially in children. Just 100 g of seeds provide about 18 g of protein (32% of daily-recommended values).

In addition, sesame seeds contain health benefiting compounds such as sesamol (3, 4-methylene-dioxyphenol), sesaminol, furyl-methanithiol, guajacol (2-methoxyphenol), phenylethanthiol and furaneol, vinylguacol and decadienal. *Sesamol* and *sesaminol* are phenolic anti-oxidants. Together, these compounds help stave off harmful free radicals from the human body (Ajay et al., 2010)

Sesame is among the seeds rich in quality vitamins and minerals. They are very good sources of B-complex vitamins such as niacin, folic acid, thiamin (vitamin B1), pyridoxine (vitamin B6), and riboflavin.

A Handreat gram (100 g) of sesame contains 97 µg of folic acid, about 25% of recommended daily intake. Folic acid is essential for DNA synthesis. When given to expectant mothers during the peri-conception period, it may prevent neural tube defects in the baby.

Niacinis another B-complex vitamin found abundantly in sesame. About 4.5 mg or 28% of daily-required levels of niacin is provided by just 100 g of seeds. Niacin helps reduce LDL-cholesterol levels in the blood. In addition, it enhances GABA activity inside the brain, which in turn helps reduce anxiety and neurosis.

The seeds are incredibly rich sources of many essential minerals. Calcium, iron, manganese, zinc, magnesium, selenium, and copper are especially concentrated in sesame seeds. Many of these minerals have a vital role in bone mineralization, red blood cell production, enzyme synthesis, hormone production, as well as
regulation of cardiac and skeletal muscle activities (USDA, 2014). See the table (2.6) below for in depth analysis of nutrients

**Table (2-6). Sesame seeds (Sesamum indicum L), whole, dried,**

**Nutritional value per 100 g.**

<table>
<thead>
<tr>
<th>Principle</th>
<th>Nutrient Value</th>
<th>Percentage of RDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>573 Kcal</td>
<td>29</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>23.45 g</td>
<td>18</td>
</tr>
<tr>
<td>Protein</td>
<td>17.73 g</td>
<td>32</td>
</tr>
<tr>
<td>Total Fat</td>
<td>49.67 g</td>
<td>166</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0 mg</td>
<td>0</td>
</tr>
<tr>
<td>Dietary Fiber</td>
<td>11.8 g</td>
<td>31</td>
</tr>
<tr>
<td><strong>Vitamins mg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folates</td>
<td>97</td>
<td>25</td>
</tr>
<tr>
<td>Niacin</td>
<td>4.515</td>
<td>28</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>0.050</td>
<td>1</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>0.790</td>
<td>61</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.247</td>
<td>19</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.791</td>
<td>66</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>9 IU</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td><strong>Electrolytes mg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Potassium</td>
<td>468</td>
<td>10</td>
</tr>
<tr>
<td><strong>Minerals mg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>975</td>
<td>98</td>
</tr>
<tr>
<td>Copper</td>
<td>4.082</td>
<td>453</td>
</tr>
<tr>
<td>Iron</td>
<td>14.55</td>
<td>182</td>
</tr>
<tr>
<td>Magnesium</td>
<td>351</td>
<td>88</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.460</td>
<td>107</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>629</td>
<td>90</td>
</tr>
<tr>
<td>Selenium</td>
<td>34.4</td>
<td>62.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>7.75</td>
<td>70</td>
</tr>
<tr>
<td><strong>Phyto-nutrients ug</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotene-β</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>Crypto-xanthin-β</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>Lutein-zeaxanthin</td>
<td>0</td>
<td>--</td>
</tr>
</tbody>
</table>

USDA National Nutrient data base (2014)
2.13.1. Food and industrial uses of sesame seeds (Sesamum indicum L)

Sesame seeds are delicious, crunchy and widely considered healthful foods. There are many foods with sesame as an ingredient. Sesame seeds have a delicate nutty flavor. Their flavor indeed becomes more pronounced once they are gently roasted under low flame just for few minutes. Sesame seeds are used liberally in cooking. The seeds ground with olive or any other vegetable oil to make a semi-solid, flavorful paste, which is then added to different cuisine.

- Dry, roasted sesame seeds and vegetable oil are ground into a thin light brown color paste known as tahini. Tahini is one of the main ingredients in famous middle-eastern dip, hummus.
- Dry fried seeds sprinkled over toasts, biscuits, breads, cakes, salads, stir fries etc., (USDA, 2014).
- The seeds are largely used in the manufacture of several industrial uses have been compiled for sesame (Appendix, 2). African people use sesame to prepare perfumes and cologne has been made from sesame flowers. Myristic acid from sesame oil is used as an ingredient in cosmetics. Sesamin has bactericide and insecticide activities plus it also acts as an antioxidant that can inhibit the absorption of cholesterol and the production of cholesterol in the liver. Sesamolin also has insecticidal properties and is used as a synergist for pyrethrum insecticides (Morris, 2002). Sesame oil is used as a solvent, oleaginous vehicle for drugs, skin softener and used in the manufacture of margarine and soap. Chlorosesamone, obtained from roots of sesame, has antifungal activity (Begum et al., 2000).
- Today, energy demand is increasing while world fossil energy resources are increasingly depleted. The vegetable oil is potentially able to replace mineral oil in future. In the early days of diesel engines, vegetable oils were tested (their original compositions unchanged) as a possible motor fuel but the idea never took hold owing to incompatibility problems such as deterioration of the oil with time, high viscosity, and fouling of the engine. Recently, Ahmad et al. (2010) has prepared biodiesel from sesame oil by its transesterification with methanol in the
presence of NaOH as catalyst and maximum yield of 92\% was achieved at 60\°C. It was also observed that the environmental performance of sesame biodiesel was superior to that of mineral diesel.

2.13.2. Medicinal properties of sesame seeds (*Sesamum indicum*L) and health issues

Sesame oil is mildly laxative, emollient and demulcent. The seeds and fresh leaves are also used as a poultice. The oil has wide medical and pharmaceutical application. Sesamin has been found to protect the liver from oxidative damage. The oil has been used for healing wounds for thousands of years. It is naturally antibacterial for common skin pathogens such as *Staphylococcus* and *Streptococcus* as well as common skin fungi such as athlete’s foot fungus. It is anti-viral and anti-inflammatory. In recent experiments in Holland by Ayurvedic physicians, the oil has been used in the treatment of several chronic diseases including hepatitis, diabetes and migraines. Analgesic activity of the ethanolic extract of *Sesamum indicum* has been tested by acetic acid-induced writhing model in mice by Nahar and Rokonuzzaman (2009).

A study done by Sankar et al., (2011), showed that sesame oil improved the effectiveness of the oral antidiabetic drug glibenclamide in type 2 diabetic patients. Another study showed that the substitution of sesame seed oil as the sole edible oil lowers blood pressure and glucose in hypertensive diabetics. (Sankar et al., 2006), Sesame oil has been found to inhibit the growth of malignant melanoma *in vitro* and the proliferation of human colon cancer cells (Smith and Salerno, 1992). In the tissues beneath the skin, this oil neutralizes oxygen radicals. It penetrates into the skin quickly and enters the blood stream through the capillaries. Molecules of sesame seed oil maintain good cholesterol (high density lipoprotein, HDL) and lower bad cholesterol (low density lipoprotein, LDL) (Sirato-Yasumoto et al., 2001). In an experiment at the Maharishi International College in Fairfield, Iowa, students rinsed their mouths with sesame oil, resulting in an 85\% reduction in the bacteria which causes gingivitis. As nose drops, sniffed back into the sinuses, sesame oil has cured chronic sinusitis. As a throat gargle, it kills *Streptococcus* and other common cold bacteria. It has been successfully used in the children’s hair to kill lice infestations. It protects the skin from the effects of chlorine in swimming poolwater. Used before and after radiation treatments, sesame oil
helps neutralize the flood of oxygen radicals, which such treatment inevitably causes (Cooney et al., 2001). On the skin, oil soluble toxins are attracted to sesame oil molecules that can then be washed away with hot water and a mild soap. Internally, the oil molecules attract oil soluble toxins and carry them into the blood stream and then out of the body as waste. Used as a douche mixed with warm water, the oil controls vaginal yeast infections. Sesame oil absorbs quickly and penetrates through the tissues to the very marrow of the bone. It enters into the blood stream through the capillaries and circulates. The liver does not sweep sesame oil molecules from the blood, accepting those molecules as friendly (Chakraborthy et al., 2008).

Sesame oil helps joints keep their flexibility. It keeps the skin supple and soft. It heals and protects areas of mild scrapes, cuts and abrasions. It helps tighten facial skin, particularly around the nose and controls the usual enlargement of pores as skin ages. Sesame oil helps control eruptions and neutralizes the poisons that develop both on the surface and in the pores. Used on baby skin, particularly in the area covered by a diaper, sesame seed oil protects the tender skin against rash caused by the acidity of body wastes. In the nose and ears, it protects against common skin pathogens. For school going children, who are in the presence of other children with colds and sniffles, the oil swabbed in the nose protects against air borne viruses and bacteria (Johnson et al., 2001; Morris, 2002).

Older men make zinc-rich foods such as sesame seeds as a regular part of their healthy way of eating in order to contribute towards their bone mineral density. Although osteoporosis is often thought to be a disease for which postmenopausal women are at highest risk, it is also a potential problem for older men. Almost 30% of hip fractures occur in men, and one in eight men over age 50 will have an osteoporotic fracture. A study of 396 men ranging in age from 45-92 found a clear correlation between low dietary intake of zinc, low blood levels of the trace mineral, and osteoporosis at the hip and spine (Hyun et al., 2004). The beneficial effects of phytosterols are so dramatic that they have been extracted from soybean, corn and pine tree oil and added to processed foods, such as “butter”-replacement spreads, which are then touted as cholesterol-lowering foods (Takashi et al., 2003). It is not necessary to settle for an imitation “butter” when sesame seeds are a naturally rich source of phytosterols and cardio-protective fiber,
minerals and healthy fats as well. Sesame seeds have the highest total phytosterol content. Phytosterols are believed to reduce blood levels of cholesterol, enhance the immune response and decrease risk of certain cancers. Many health benefits of sesame may be attributed to its lignin especially sesamin (Jeng and Hou, 2005). Sesamin binds to and activates a receptor in the body called Peroxisome Proliferator- Activator Receptor Alpha (PPARalpha). PPARalpha is highly expressed in muscle, liver, kidneys and heart and is involved in the regulation of lipid metabolism, specifically the transcription of genes involved in the a-oxidation of fatty acids and lipogenesis. Activation of PPARalpha increases gene expression of the fatty acid oxidation enzymes and decreases gene expression of lipogenic enzymes. In other words, sesamin increases the fat burning process and decreases the storage of fat in the body (Penalvo et al., 2006)
Chapter Three

Methodology

3.1. Ethical consideration

The ethical approval was obtained from the Ethical Committee for Health Sciences of Gezira University and director of Health Services administration of Um-Alqura Locality. Also, permission from director of Um- Alqura Hospital was obtained. The principal investigator had a meeting with pregnant women and explained the objective of the study. The participation was completely voluntary. An approval was obtained from pregnant women to intervention, blood testing pre and post intervention and interviewing. Cases with severe anemia (hemoglobin level ≤7g/dl) were excluded and referred to the consultant at the hospital for treatment and follow-up. The sesame used was tested to be free of pesticide (see Appendix 1).

3.2. Study design

This is a experimental community based study carried out over a period of six months from October 2005 to May 2014, to study the effect of sesame seed as a natural source of iron on certain hematological parameters in pregnant women in Um Elgura town Gezira State-Sudan.

3.3. Study area

Um-Alqura locality was established in October 1996 and divided into three unit north, central and south Um Alqura. Area of 211000 KM2. It is located between latitude 33_34 east surrounded in north by east Gezira unit, south by Sinner State ,west by Wad Medina locality and in east by Elgadarf State. The study was carried out in Um- Alqura town and some village around it (Eltadamon, village 39, Elsaadonab and village 35). Um- Alqura town is the capital of Um- Alqura locality in Gezira state in Sudan. Total population of Um- Alqura town is 40000 ,people living there belong to different tribes most of them belong to Elshukria, Elashraf, Elgaaleen and Elbataheen tribes. Some people belong to west and south Sudan tribes. Public services include 18 pre-school 16 primary school, two scendary schools and one private school, there are 12 mosques, one
general hospital, one health center and 7 pharmacies, and 9 clubs (Um-Alqura locality, 2014).

3.4. Study subjects

The total number of pregnant women was 311 in Um Alqura – town - Gezira State, Sudan.

3.5. Sampling techniques

Simple random sampling was used.

3.5.1. Selection criteria

All pregnant women at the time when the study was carried were included in the study.

3.5.2. Inclusion criteria

All healthy pregnant women in second and third trimester in Um Alqura town-Gezira state-Sudan were included in the study.

3.5.3. Exclusion criteria

Anemic pregnant women were excluded for ethical issue, also pregnant women in first trimester were excluded to avoid any loss in sample size because some of them were develop upper gastrointestinal symptom in this trimester, classically, these symptoms are worse in the morning (morning sickness).

3.5.4. Sample size

The sample size was (100) pregnant women represents (32%) of total study population (311). The sample size was determined by using the following formula:
\[ n = \frac{N}{1+Nd^2} \]

\( n \) = sample size (104)

\( N \) = total study population size. (311)

\( d \) = is normal score according to normal distribution value at 0.5 level of confidence

Equation 2

\[ n = \frac{n_0}{1+(n_0 - 1) \frac{N}{n_0}} \]

\( n_0 \) = The sample size primary (155)

\( n \) = The final sample size (104)

3.6. **Method of data collection**

Data was collected from pregnant women whose came to antenatal visits in Um-elgura general hospital and health center in some village around, blood samples was taken and data for questionnaire was collected there.

3.6.1. **Hematological measurement.**

Two laboratory (pre and re) tests were done by qualified laboratory technicians for hematological measurement;

a. Complete Blood Count (CBC) Test

b. Serum iron (SI)

c. Total Iron Binding Capacity (TIBC).

e. Transferring Saturation (TS).

- **Materials:**

5 ml of blood were collected using 5 ml disposable syringes from each subject. The blood was divided into 2 ml and 3 ml for examination of whole blood and serum respectively.

3.6.1.1. **Whole blood:**

2 ml of blood collected in E.D.T. container was used for estimation of Complete Blood Count (CBC) included:
- Red Blood Count (RBC).
- Hemoglobin concentration (HB).
- Haematocrit (HCT).
- Mean Corpuscular Volume (MCV).
- Mean Corpuscular Hemoglobin Concentration (MCHC).
- Mean Corpuscular Hemoglobin (MCH).

**a. Method of Complete Blood Count (CBC) Test:**

Full blood count was performed using Analyzer (Sysmex,), able to test some parameters per sample including Hb concentration, PCV, RBC concentration, MCH, MCV, MCHC, WBC count, and PLT count. Standardization, calibration of the instrument, and processing of the samples were done according to the manufacturer’s instructions.

- **Procedures**

  Each blood sample was mixed well and then approximately 20 μL was aspirated by allowing the analyzer’s sampling probe into the blood sample and depressing the start button. Results of the analysis were displayed after about 30 seconds, after which the analyzer generated a paper copy of the results on thermal printing paper.

**3.6.1.2. Serum:**

3 ml of blood using centrifuge tube was allowed to clot and serum was separated in a polyethylene tube (Iron free) and kept in refrigerator (– 20°C) until analyzed for:

- Serum iron (SI)
- Total Iron Binding Capacity (TIBC).
- Transferring Saturation (TS).

**a. Method of estimation of serum iron**

Colorimetric method

- **Reagent composition**

R1. Buffer/Reductant. Guanidine chloride 1.0 mol/L, hydroxylamine 0.6 mol/L, acetate buffer 400 mmol/L pH 4.0, Teepol.

R2. Chromogen. FerroZine 8 mmol/L, sodium acetate 400 mmol/L.

Iron standard. Ferric ion 100 μg/dL (17.9 μmol/L).
• **Reagent preparation**

Working reagent. 4 volumes of R1 mixed with 1 volume of R2. Reagents and samples were brought to room temperature

• **Procedure**

Tubes were prepared as follows

<table>
<thead>
<tr>
<th>Tubes</th>
<th>Reagent Blank</th>
<th>Sample Blank</th>
<th>Sample</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>200 μL</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sample</td>
<td>–</td>
<td>200 μL</td>
<td>200 μL</td>
<td>–</td>
</tr>
<tr>
<td>Standard</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>200 μL</td>
</tr>
<tr>
<td>R1</td>
<td>–</td>
<td>1.0 mL</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Working reagent</td>
<td>1.0 mL</td>
<td>–</td>
<td>1.0 mL</td>
<td>1.0 mL</td>
</tr>
</tbody>
</table>

Tubes were mixed and let to stand for 5 minutes at room temperature and absorbance (A) of the sample blank was read at 560 nm against distilled water then absorbance (A) of the samples and the standard was read at 560 nm against the reagent blank.

**Calculation**

\[
A_{\text{Sample}} - A_{\text{Sample blank}} = \frac{X}{C_{\text{Standard}}} = \mu g/dL \text{ iron}
\]

A Standard

**b. Method of estimation of total iron binding capacity (TIBC)**

Colorimetric method.

• **Principles**
Serum iron is bound to transferrin, but only about one third of the iron binding sites are saturated with iron. The unsaturated iron-binding capacity of transferrin (UIBC) denotes the available iron-binding sites of serum. The amount of iron that serum transferrin can bind when completely saturated with an excess of Fe$^{+3}$ is the total iron-binding capacity (TIBC). When the serum iron (SI) determination is performed concurrently with the TIBC and the result subtracted from the TIBC value, the difference yields the unsaturated iron-binding capacity (UIBC).

Total iron binding capacity (TIBC) - serum iron = unsaturated iron binding capacity (UIBC). (TIBC - SI = UIBC) TIBC and iron may also be used to determine "transferrin" saturation. Serum iron divided by TIBC gives the saturation.

- **Reagent composition**
  
  R1. Iron solution. 500 μg/dL Fe+3 (89.5 μmol/L)
  
  R2. Carbonate. Magnesium hydroxide carbonate (powder).

- **Procedure**
  
  Photometer capable of measuring absorbance at 560 nm. Adsorption sample and reagent were pipetted into disposable centrifuge tubes as follows:

<table>
<thead>
<tr>
<th>Sample</th>
<th>0.5 mL</th>
<th>R1</th>
<th>1.0 mL</th>
</tr>
</thead>
</table>

Ratio of $\frac{\text{Sample}}{\text{R1}} = 1 \quad \frac{\text{Ratio of}}{2}$

Dilution factor $= 3$

Tubes were mixed and allowed to stand for 5-20 minutes at room temperature, one scoop (aprox. 100 mg) of R2 was added to each tube and allowed to stand for 30 minutes, and mixed vigorously at 5-minute intervals, Centrifuged for 10 minutes at 3000
r.p.m, then samples (aliquot of the supernate) and reagents were brought to room temperature and then read at 560 nm.

**Calculations**

Once performed the serum iron (SI) test as described in the technical insert of the kit, figured out the results as follows: The total iron-binding capacity (TIBC) was measured 

\[ \text{TIBC} = \mu g/dL \times \text{supernat x 3 (Dilution Factor)}. \]

Unbound iron-binding capacity (UIBC) 

\[ \text{UIBC} = \text{TIBC} - \text{SI}. \]

**3.6.2. Intervention:**

**3.6.2.1. Processing methods for the home made Supplement diet**

Two samples of sesame seeds (*Sesamum indicum L*) red and white were collected from Rehad Alberde, Southern Darfor State and Algadarif State respectively, were washed and dried by sun light, the dried seeds were categorized in two groups.

- Group one raw sesame.
- Group two roasted for 10-15 minutes.

Then determination of Fe**++** by used following method:

**a. Method of determination of Fe**++**in sesame seeds (*Sesamum indicum L*)**

The element was determined by flame photometry method described by AOAC (1983). To determine; the ash of 5g of sesame prepared at 550°C overnight, was transferred a 250 ml digestion flask. Five ml conc. HN₃O were added to crucible to dissolve ash traces and taken in digestion flask, boiled and evaporated nearly to dryness at 350°C redisolved with 20 ml HNO₃, heated for just boiling. Filtered through glass, residue thoroughly washed with deionised water and filtrate volume completed to 100 ml, the mineral content was then determined.

- **Apparatus:**
  - Colorimeter, burette, pipettes, beaker and flask.

- **Reagents:**
  - Iron stock solution 10% NH₄ SCN in distilled water. Preparation of stock solution, the salt weight required was determined using the following equation:
Weight of mineral salt required (g/1) =

\[
\text{Required mineral concentration (g/1) x molecular wt of the salt} \\
\text{Atomic weight of mineral}
\]

**Procedure**

To prepare stock solution of $F^{3+}$ contain 100 ppm $F^{3+}$ in 1 liter flask from $Fe_3(SO_4)$ dissolved and diluted to 1 liter to get a 100 ppm $Fe^{3+}$ solution standard solution of $F^{3+}$.

Standard solution of $F^{3+}$ was prepared in range (0 – 10 ppm $F^{3+}$) in 100 ml flask. From stock solution to each flask 10 ml NH$_4$SCN were taken 10% was than added, all the flask become red colour except B (Blank). Completed to the mark with distilled water, 0.5 ml from sample were taken 2 drops of HNO$_3$ were added, then 10 ml from NH$_4$ SCN 10% was added then completed previously to mark with distilled water.

Then a series of standard solution containing 2, 4, 6, 8, 10 ppm were prepared. The absorbance for both sample and standard solution read using colorimeter at 650 nm. The calibration curve (AV$^2$C) were plotted. From the curve the quantity of Fe in the sample was calculated according the following equation:

\[
\text{Fe mineral % (mg/g) =} \\
\text{Concentration from curve x dilution factor x 100} \times \frac{100}{\text{Weight of sample}}
\]

**b. Method of Intervention**

According to the result white roasted sesame was used, because it contains high percentage of iron compared with red roasted sesame, results showed that 100gm of white roasted sesame contain 14mg of iron these amount equivalent to iron amount in "Pregnacare Tablets". an iron supplementation drug usually used in pregnant women there for daily 100 gm for each pregnant women were determined and white sesame roasted was distributed to all participants for month. Weekly visit, were done to give the supplement and to check the proper usage of the recommended dose. The post-test was done by the end of month to determine the effects of sesame in previous parameter.
3.7. Questionnaire:

A questionnaire was designed in Arabic language and was tested in small group of pregnant women. It was then revised and finalized according to the test feedback a formal from the questionnaire was designed, the questionnaire included the following:

- Socio – economic status.
- Obstetrical history.
- Health education knowledge and antenatal care follow up.
- Nutrition and nutritional habits about certain type of food.
- Intake of sesame (food intervention).
- Intake of iron supplement and folic acid before study.

3.8. Statistical analysis

Data were analyzed using SPSS (v 16) T test were used for analytic assessment and the differences were considered statistically significant when the $P$ value obtained was, 0.05.
Map (3.1) showing study area
Chapter Four
Results and Discussion

4.1. Change in hematological parameters after intervention.

Figure (4.1.1): Change in HB for pregnant women after using sesame in UmAlqura town in Gezira state

The result presented on (Fig., 4.1.1) revealed that Hb level increased significantly after intervention in (58%) of participants (P = 0.000), hence the sesame had a positive effect on increase of iron and it's a good material as iron supplement from natural. The mean hemoglobin concentration falls from 13.3g/dl in the non-pregnant state to 10.9g/dl at the 36th week of normal pregnancy. This physiological change may be mistaken for the development of pathological anemia, most commonly due to iron deficiency (Philip, 2006; Hoffbrand, 2010) Pregnant women require increase amounts of iron and absorption of dietary iron from the gut is increase. This finding demonstrates that sesame can satisfy the pregnancy daily need of iron. This result is in agreement with the findings
obtained by (Ahmed et al., 2012) In Darfur State, Western Sudan, who stated that, Guiddaim (Grewia Tenax) supplementation improve nutritional status significantly (P. value = .000) as measured by MUAC as well an increase in HGB, HCT, and MCV, levels (P. value = 000). On other support is a study done by Gebauer et al., (2007) who concluded that, fruits of Grewia Ten ax are often used in special diet for pregnant women and anemic children because of its high iron contents, the fruits considered as simple safeguard against iron deficiency. Also Gebauer et al., (2005) stated that, the Grecian tenax fruit was reported to contain large amounts of iron and as such is used for treatment of anemia and malaria. Because of its high iron contents, fruits of G. tenax are often used in special diets for pregnant women and anemic children

In the Sudan Grewia tenax fruits are used as fresh or dry food and the fruit juice is used as refreshing beverage to increase hemoglobin level for curing anemia and malaria as well as it is used as a thin porridge (Nasha) by lactating mothers to improve lactation and health. Pulp is used in making jams and Giddied slices (Gamardein) and the remnants of the processed fruit are used as animal and bovine chicks feed (Elamin, 1995)

Also the result is in consistent with the findings obtained by (Abdellmutti, 1991) who said that, a wide range of nutrients in the Grewia fruits (common name Guddeim), the high iron content (7.4 mg per 100 g pulp) which attracted more attention.
Figure (4.1.2): Change in RBC count of pregnant women after using sesame in Um Alqura town in Gezira state.
Figure (4.1. 3): Change in HCT for pregnant women after using sesame
in Um Alqura town in Gezira state

The result on (Fig., 4.1.2 and 4.1.3) reflected that majority of participants (62%) were significant decrease of (RBCs) after taking sesame (P= 0.023). However, (74%) of participants were no significant decrease of (HCT) after taking sesame (P= 0. 245), but, this decreased considered normal physiological change during pregnancy and within the range referred to in the studies. This result is in agreement with the results obtained by (Philip, 2006) who found that, although pregnancy is associated with an increase in the production of erythrocytes, this increase is outstripped by relative increase in plasma volume. Thus hematological indices, which depend upon the proportion of plasma in measured blood sample, tend to decrease. Such indices red cell count, hematomacrit and hemoglobin concentration.
Figure (4.1.4): Change in MCV of pregnant women after using sesame in UmAlqura town in Gezira state.

The finding on (Fig., 4.1.4) revealed that majority of participants were high statistically significant increased (47%) of MCV after taking sesame (p = 0.000). This means that intervention of sesame intake had significant affect on this parameters. Cause of a high MCV include cobalamin (B12) deficiency due to strict vegetarianism, folate deficiency from alcoholism, lack of vegetable, celiac disease and mild macrocytosis can be seen during normal pregnancy in woman who are not iron or folate deficiency (Fischbach et al., 2004; Abbassi et al., 2009).

In study done in Lagos, Nigeria for hematological profile of normal pregnant woman by (Akinami et al., 2013) found that, during pregnancy the MCV for the first, second and third-trimester was decreased (79.7 ± 0.966, 78.38 ± 5.72 and 70.02 ±5.4 fL respectively)
Figure (4.1.5): Change in MCH for pregnant women after using sesame in Um Alqura town in Gezira state
The findings on (Fig., 4.1.5 and 4.1.6)) revealed that (65% and 67%) of participants were statistically significant decrease of both MCH and MCHC after taking sesame respectively (\( p = 0.050 \) and \( 0.060 \)), this results in agree with the finding reported by (Kratz et al., 2004 Abbasi et al., 2009 and Akinami et al., 2013) who stated that, there was gradual decrease in MCH and MCHC reaching the lowest values in the late pregnancy.
Figure (4.1.7): Change in Serum Iron (SI) of pregnant women after using sesame in Um Alqura town in Gezira state
Figure (4.1.8): Total Iron Binding Capacity (TIBC) of pregnant women after using sesame in Um Alqura town in Gezira state

The results on (Fig., 4.1.7 and 4.1.8) showed that most of participants (64%) had increase in serum iron and (61.0%) were decreased in total iron binding capacity. There was statistically significant association between serum iron before and after taking sesame (P = 0.001), and significant decreased in total iron binding capacity after using sesame (P = 0.001), this is good indicator showing that, sesame has high iron content because the serum iron is decreased and total iron binding capacity was increased during normal pregnancy. Serum iron was not change in first trimester, after that, is a gradually decrease in the mean, reading the lowest values in the late pregnancy. Total Iron Binding Capacity, the values during the first 20 weeks were found to be within normal limits, during the second half of pregnancy the total iron binding capacity increased, the highest values were found in the last trimester and within eight weeks after delivery, normal values were again attained. It may be noted that the total iron binding capacity increased at the time the serum iron diminished and the total iron binding capacity curve is the reciprocal of the serum iron curve (Kratz et al., 2004 and Abbassi et al.,2009). However there was statistically significant negative association between increase of SI and decreased in total iron binding capacity before and after taking sesame (P= 0.000)
Figure (4.1.9): Change in Transferrin Saturation (TS) of pregnant women after using sesame in Um Alqura town in Gezira.

The finding on (Fig., 4.1.9) revealed that most of participants (62%) had increased of transfrein saturation. There was statistically significant association between transfrein saturation before and after taking sesame (P = 0.000), This is a good indicator illustrates that, the role of sesame is increasing the proportion of iron. During pregnancy transfrein saturation was decreased in pregnant women (15_30%) compared with non pregnant (25_35%) Abbassi et al., (2009).
4.2. Take supplement diet

![Bar chart showing types of sesame supplement intake by pregnant students in Um Alqura town in Gezira state]

Figure (4.2.1): Types of sesame supplement intake by pregnant students in Um Alqura town in Gezira state

Regarding the participant's distribution according to sesame intake the study in (Fig. 4.2.1) showed that (32%) taking plane sesame; while majority of them (61%) add sugar, this means that most of participant prefer to add sugar, it does not affect the content of iron in the sesame seeds, but cannot be used in cases of pregnant women with diabetes mellitus.
4.3. Side effect sesame

The side effect of taking sesame of pregnant women in UmAlqura town in Gezira state

Figure (4.3.1): The side effect of taking sesame of pregnant women in UmAlqura town in Gezira state

The result in (Fig., 4.3.1) showed that majority of participants (81%) had no side effects. This indicated that sesame is a good material during pregnancy and should be used without any side effect except for some few cases that may be associated with individual differences or because the sesame contains a high percentage of oil (49.67mg per 100 g) may cause diarrhea.
4.4. Effect on Gastro-Intestinal Tract (GIT).

![Bar chart showing effect on GIT](image)

Figure (4.4.1): The effect on Gastro-Intestinal Tract (GIT) of taking sesame of pregnant women in UmAlqura town in Gezira state.

With regard to the distribution of participants according to effects of sesame intake on Gastro-Intestinal Tract (GIT) symptoms Fig (4.4.1) sowed that, (58%) of participants had no effects. Quarter of participants were relieved from heartburn. This means that sesame is a good material during pregnancy and should be used to treatment of some symptoms of indigestion and other complication e.g. constipation which are common gastrointestinal tract symptoms during pregnancy. Heartburn was relieved by usage of sesame, perhaps it contains alkaline material which neutralizes to the increasing acidity. This is supported by the result obtained by Neilson, (2008) who found that there were a range of interventions have been used to relieve symptoms including advice on diet and lifestyle, antacids, antihistamines, and proton pump inhibitors. On the other hand the sesame was treated constipation may be due to, it's highly oil content and being a good sources' of fiber. This is in agreement with the finding reported by Jewell and Young (2001) who stated that dietary supplement of fiber in the form of bran or wheat fiber are likely to help women experiencing constipation in pregnancy. Also to minimize this, women should be advised to eat plenty of dietary fiber as whole meal bread or bran products as well as the fruit and vegetable.
4.5. Nutritional data

Figure (4.5.1): Meals intake /per day of studied pregnant women in UmAlqura town in Gezira state.

The findings in (Fig., 4.5.1) revealed that, participants were taking three meals / day (45%) and, were taking two meals / day (27%), this result reflected that, the majority of participants had poor knowledge about the importance of nutritional status during pregnancy, this may be due to low education level of participants and their husbands or due to economic aspects of the family and both factors greatly influenced the food habits and food selected and consumed during pregnancy.

One of the indicators of malnutrition is underweight, which significantly contributes towards mothers’ poor health and consequently passed on as low birth weight babies. This association of low weight mothers and newborns, it is prudent to note that malnourished mothers are at the verge of increased risk for complications and death during pregnancy and childbirth. Northstone et al.,(2008) This result could be explained by Nielsen (2006) who stated that, high risk of malnutrition in pregnancy is found among women from very poor families and women who have very little weight gain during
pregnancy. Pregnant women need more food than adults. Appropriate nutrient intake and weight gain during pregnancy are considered two of the most important modifiable behaviors for improved maternal and infant outcomes. Saleem and McClure (2010) reported that, poor educational, nutritional and other health indicators during pregnancy and postnatal period in women of lower socioeconomic status as compared to those with upper socioeconomic status. Consequently, the more preterm deliveries were seen in this economically deprived population. Anwar (2012) concluded that, nutritional of mother is very basic and important determinant of maternal health and child health, shortage of proteins, energy foods, minerals, particularly iron and vitamins leads to poor health of the mother, chronic sub-standard nutrition of mother, under stress, result of the mother
Table (4.5.1): Rate of different food intake (%) through one month during pregnancy

<table>
<thead>
<tr>
<th>Intake</th>
<th>No</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>16</td>
<td>5</td>
<td>47</td>
<td>32</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Meat</td>
<td>6</td>
<td>65</td>
<td>24</td>
<td>5</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Dates</td>
<td>30</td>
<td>27</td>
<td>26</td>
<td>17</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>5</td>
<td>81</td>
<td>11</td>
<td>3</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>45</td>
<td>8</td>
<td>29</td>
<td>18</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>15</td>
<td>24</td>
<td>53</td>
<td>8</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Milk</td>
<td>16</td>
<td>69</td>
<td>12</td>
<td>3</td>
<td>100(100%)</td>
</tr>
<tr>
<td>Fruits</td>
<td>8</td>
<td>16</td>
<td>45</td>
<td>31</td>
<td>100(100%)</td>
</tr>
</tbody>
</table>

With regard to the distribution of participant by consummation of food items the study showed that participants daily intake vegetable (81%), milk (69%), meat (65%) and fruits (16%), table (4.5.1). this may reflect that pregnant women had inadequate knowledge about nutrition during pregnancy, because all these items are considered major sources of protein, vitamin and minerals. These results are in agreement with the finding obtained by (Sussi et al., 2003) who found that meat is a good source of protein and hem-iron, small amounts of meat (≥50 g) significantly increase nonheme-iron absorption from a phytate-rich meal low in vitamin C, and green leafy vegetable are good sources of non-hem, and vitamin C. On the other hand Barker (1991); Rossender et al., (1996) and Sandrine et al., 2008) who mentioned that, dietary fruits and vegetables may enhance iron status because of their high vitamin C content. The potential association between iron status and intakes of specific fruits and vegetables, vitamins C found in fruits; fruit juice and vegetable, enhance iron absorption by reducing the ferric iron to the more readily absorbed ferrous form. In addition, it also protects ferrous form from being oxidized back to the ferric form, pregnant woman should eat meals of good quality contain mixture of different food e.g. meat, plenty of green, fresh fruit and milk.
The monthly intake of food items shown in table (4.5.1) revealed that (32%) of participants took liver and (31%) took fruits. This reflects negative attitude of pregnant woman toward the importance of nutritive value of liver and fruit during pregnancy or may be due to economic status of family, because it is most important factor affecting nutrition. This result is similar to the finding obtained by Milkhail, (1982) who found that in the urban sector, small families had higher income and better nutrition. Also Fallah et al., (2013) reported that, a nutritional education intervention will have a positive effect on nutritional awareness of pregnant women. pregnant women require dietary advice about how to modify their usual diet so as to supply extra needs for nutrients.

Regarding the food restriction during pregnancy in table (4.5.1) revealed that some of participant avoid dates (30%), fenugreek (45%), because they believe that, these food items cause abortion, other avoid pigeopea (15%) fruits (8%) because they believe that those items cause hearburn, and some avoid milk (16%) liver (16%) meat (6%) because they believe that these food cause nausea while small group dislike fat, okra, kisra and Aseeda. Despite the fact, these foods are useful during pregnancy and major sources of iron which is important in preventing anemia but most woman change their diet during pregnancy they avoid certain types of food due to taboos. In a hospital based Pakistani study of women’s beliefs about food in pregnancy,12% believed in restricting some food item during pregnancy (Ali et al., 2004)

Ebomoyi (1988) in Nigerian found that, specific foods of protein rich meat group, particularly rabbit oryctologus capensis was avoided during pregnancy because sociocultural believes, energy- giving starch rich food items most frequently regarded as good for the body. Also Melku et al.(2014) found the prevalence of anemia among those who had a habit of eating animal products in their food stuff, not having a habit of eating vegetable, and who take tea/coffee after meal was 17.8%, 22.4%, and 15.3%, respectively.

Another study done in Pondicherry by Rajkumar and Anuj ( 2010) concluded that, most of the illiterates (91.3%) told that Papaya should not be eaten during pregnancy in comparison to 83.9% of literates. 62.8% participants believed that consumption of saffron by pregnant woman results in a fairer skin child. Most common reason for restriction of specified fruit/vegetable was abortion (86.1%). Overall more than half of
the participants lack awareness; they still believe in old unscientific tales. Illiteracy is an important factor responsible for this.

United Nation Children's Fund and World Health Organization (2002) reported that, pregnant women should be advised to have a realistic, easily digestible and affordable, balanced diet rich in iron and protein. Although red meat and liver are excellent sources of hem iron which promotes erythropoiesis, many women especially in Asia, are vegetarians. Vegetarians should be advised to increase the intake of iron rich food sources such as lentils, green peas, green vegetables, figs etc. and also to include an iron absorption enhancer such as a vitamin C rich food source e.g., orange juice. They should also be advised to avoid coffee and especially tea which inhibits iron absorption soon after a meal.
4. 6. Demographic data

The study in figure (4.6.1) showed that, one fifth of pregnant women (29%) were under 20 years. Hence most of them were adolescent and they may be at high risk of adverse pregnancy outcome. A study conducted by Vienne et al.,( 2009) and Alon et al.,( 2011) who found that seventy thousand adolescent die annually from obstetrical complication and one million infant born to adolescent mothers die before the age of one years and teenage mothers carry a greater risk of adverse pregnancy outcome, mainly due to preterm birth. These results is in agreement with the result reported by Gilbert et al.,( 2004) and Adeginka et al.,( 2010) who found that, the majority of teenage pregnancies occur in developing countries. On the other hand the study should that (43%) of pregnant women in age group (20-30) years this is good indicator. The most of participants in suitable age of childbirth

Figure (4.6.1): Age distribution of studied pregnant women in UmAlqur town in Gezira state.
Figure (4.6.2): Educational level of studied pregnant women in Um Alqura town in Gezira state.
The educational level of both pregnant women and their husbands was low (35% and 39% respectively) in level illiterates and khalw in (Fig., 4.6.2 and 4.6.3); that may be effects their health aspects negatively. This is supported by what was reported by (UNICEF, 2007) that education level plays an important role in perception and response of individual about the problem and how to deal with them. Educated women are less likely to die in pregnancy or childbirth and more likely to send their children to school. If mothers have a primary school education, the mortality rate for their children under 5 is halved: Each additional year of schooling for girls reduces infant mortality for their offspring by up to 10%. Also, mothers provide better nutrition and health care and spend more on their children: girls and women spend 90% of their earned income on their families, while men only spend 30-40%. Children of uneducated mothers are half as likely to attend primary school as those whose mothers attended primary school themselves.
Also study done in Iran by Fallah,(2013) stated that The awareness level of pregnant women about healthy nutrition was significantly increased from 3% before intervention to 31% after the nutritional education intervention (P < 0.001). This significant difference was independent of maternal characteristics of age and levels of literacy. Educations is important in nutrition selection, change of attitude towards antenatal care, child-spacing, practice and help the mother to get more information through reading and discussion with other or form mass-media. In Nepal, Khanal, et al., (2014), found that, education of mother has been found to be a significant determinant of low birth weight (LBW), similar studies from India by (Sreeramareddy et al 2011) and other study done in Pakistan by Badshah et al.,(2008) who mentioned that, the association of the education status of mothers has great effect on birth weight and this can be interpreted in a number of ways. Education is closely related to delayed marriage and child birth thus avoiding adolescent pregnancy. Educated mothers are more likely to be aware of the importance of use of pregnancy care and nutrition care and are more likely to understand health message and more likely to be concerned about their health and nutritional status.
Table (4.6.1): Pregnant Occupation in Um Alqura town in Gezira state.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housewife</td>
<td>92</td>
<td>92.0%</td>
</tr>
<tr>
<td>Occupational</td>
<td>8</td>
<td>8.0%</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure (4.6.4): The Distribution of occupation of studied pregnant women’s husband in UmAlqura town in Gezira state.
With regard to occupation of pregnant woman and their husband, the study revealed that the majority of participants were housewife (92%) and majority of their husband were drives(59%) in Table (4.6.1) and Fig., (4.6.4) respectively. This occupation reflected in family income, this mean that the economic status of the family was low. This result is the same when compared with finding obtained by Kim , (2014) in Korean adolescent girls, who found that, girls with higher income had lower anemia prevalence and consumed more iron and vitamins. Correlation analysis demonstrated that there is a relationship between household income and serum hemoglobin and ferritin levels (P=0.003 and P=0.026, respectively). Higher socioeconomic status leads to lower prevalence of anemia and iron deficiency anemia; this may be due to the fact that higher socioeconomic status individuals consume more iron and vitamin C. The economic status of the family is one of the most important factors affecting nutrition and reflected in women Hb. Education is another important factor depending on family's economic status. This may support the idea that the participants of the study were those who were in need of iron supplement will support use of sesame if the results are good.
4.7. Sosiouecnomic chractrestic

Table (4.7.1): Family Income Level per/ month of Pregnant women in Um Alqura town in Gezira state.

<table>
<thead>
<tr>
<th>Income Level/per. Month</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 250 Pound</td>
<td>6</td>
<td>6.0%</td>
</tr>
<tr>
<td>(250- 750) Pound</td>
<td>51</td>
<td>51.0%</td>
</tr>
<tr>
<td>&lt; 750 Pound</td>
<td>43</td>
<td>43%</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The finding in Table(4.7.1) showed that half (51%) of families with low income level (250_750 pound), this mean that, the family may be suffering from poor nutritional status because, in general, income served as a source for the way of living. Anemia can be due to inability to buy adequate and good quality food or due to poor eating habits most likely to affect; women and infants with unfavorable health conditions and lower socioeconomic status. (Saleem and McClure, 2010). These results are in consistent with finding reported by (Shazia et al., 2012) who mentioned that, the anemia of pregnancy primary affect women of low socioeconomic status, frequency of certain maternal health conditions like diabetes, hypertension, anemia and obesity were comparable with the findings of other studies done in poor women.( Tanya and Goldenberg, 2009; Shen and Wei, 2008 ; Chimaraokae and David ,2010). If uncontrolled, these conditions can lead to poor infant outcome and can have long-term negative impact on a woman's health. Globally by WHO criteria 52% of pregnant woman from developing countries are compared with 20% from industrialized nation are anemic during pregnancy. The highest prevalence is among pregnant women in India (88%) followed by Africa (50%), Latin America (40%) and Caribbean (30%) Maureen (2012).
4.8. Obstetrical data.

![Family size of studied pregnant women in Um Alqura town in Gezira state.](image)

The data on family size in Fig (4.8.1) indicated that, the majority of study group in the range of three to six persons (44%), in spite of small family size but in the fact anemia is more common in woman with many children and the risk of maternal morbidity and mortality increased with each pregnancy beyond the fifth. High prevalence of anemia was observed in those pregnant women who were living with more than four family members, large family size, underweight and gravidity, were significantly associated with maternal anemia. (Melku et al., 2014) mother who have born many children become anemic due to additional demand of rapid pregnancy and the lost of blood in each delivery. Family having number of children under five >3 were more susceptible to the development of anemia. The iron stores of mothers are usually depleted after repeated pregnancies rendering the mother more susceptible to anemia. Anemia in infancy appears at an earlier age in infants born of anemic mothers Similar findings were reported by (Obse et al., 2013) who stated that, Pregnant women with family size >5 were 2.7 times more anemic than women with family size less than five. This finding is
comparable with a study in Kisumu, Western Kenya in which the prevalence of anemia was higher in women with family size >7 compared to their counterparts (Jemal and Rebecca, 2009). The direct relationship of family size with anemia could be associated with food insecurity for large family size.
Figure (4.8.2): The gestation age distribution of studied pregnant woman in UmAlqura town in Gezira state.

In regard to gestational age, the study in figure (4.8.2) showed that, second and third trimester attained highest gestational age (47% and 50% respectively) . This is suitable time to use the entervention because in this time less nausea and vomiting compared with the first trimester. The majority of pregnant women experience some degree of upper gastrointestinal symptom in the first trimester of pregnancy, classically, these symptoms are worse in the morning (so-called morning sickness). Also this is suitable time because of the increased demand for iron by the mother and fetus, and this is in agreement with Lee and Okam (2011) who stated that a much incidence of anemia in 2nd and 3rd trimester because of increased demand for iron by the mother and fetus. Other study done in Lhasa, Tibet, by Yuan and, Hong , (2009) who found that, hemoglobin level was low and prevalence rate of anemia was high among pregnant women. Gestational age, ethnicity, residence and income were found to be significantly associated with the hemoglobin level and the occurrence of anemia in the study population.
This study in fig (4.8.3) revealed that majority of participants above (90%) had poor antenatal care (ANC) before the study conducted. This may be because of pregnant women had poor knowledge about the importance of ANC during pregnancy which may be due to low education level of participants and their husband or poor knowledge about the complication occurrence during pregnancy and low economic status. Women with poor antenatal care have a greater risk for adverse pregnancy outcome. The current findings are supported by Huetson *et al* (2003) who found that ANC visits were found to be significant protective factors against low birth weight. Also, WHO (2014) reported that, one problem that complicated the issue of anemia during pregnancy is the reluctance of pregnancy woman to seek ANC. This result is in agree with previous study conducted by (White *et al.*, 2006; Panaretto *et al* 2005) who found that, ANC visits are likely to influence in improvements in dietary practices, monitor and encourage recommended weight gain during pregnancy and improve neonatal outcomes.
Another study conducted by (MHP, 2010) in Nepal, reported that, mothers are provided with iron-folic acid (combined) supplementations and deworming medication during ANC, and also provided with the advice on rest, and self-care during illness. All these factors are crucial in improving the mother’s health status as well as adequate weight gain during pregnancy.
Table (4.8.1): History of abortion of studied pregnant women in Um Alqura town in Gezira state.

<table>
<thead>
<tr>
<th>Fallout</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>33</td>
<td>33.0%</td>
</tr>
<tr>
<td>No</td>
<td>67</td>
<td>67.0%</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
The data on history of abortion and anemia shown on table (4.8.1) and fig (4.8.4) respectively, confirmed that, (67%) of pregnant women had no history of abortion and (74%) had no history of anemia. This is a good indicator that most of participants were healthy in previous pregnancy, because there is relation between abortion and anemia. This results confirm the statement of Lone et al., (2004) who stated that, the risk of preterm delivery and low birth weight was 4 and 1.9 times higher, respectively, in anemic woman (Hb <11g/l) than in pregnant woman without anemia, another study done by Ruch (2000) and WHO (2003) reported that anemia during pregnancy has serious derived consequences. It is associated from greater risk of maternal death, in particular from hemorrhage, severely anemic pregnant woman less able to with stand blood loss and may require blood transfusion which is not always available in poor countries and is not without risk. Severe anemia during second and third trimester was reported by Lee and Okam,( 2011) who stated that a much incidence of anemia in 2nd and 3rd trimester because of increased demand for iron by the mother and fetus.
Figure (4.8.5): The diseases incidence during current pregnancy of studied women in Um Alqura town in Gezira state

With regard to incidence of disease during current pregnancy, the study in figure (4.8.5) showed that majority of participants developed malaria (47%), vaginal bleeding (23%) and constipation (15%). Malaria is a serious problem in Sudan; it may be later the course of pregnancy by affecting both the health of the mother and newborn. Dunn and Nour, (2009) stated that, pregnant women infected with malaria usually have more severe symptoms and outcomes, with higher rates of miscarriage, intrauterine demise, premature delivery, low-birth-weight neonates, and neonatal death. They are also at a higher risk for severe anemia and maternal death. Pregnant women suffer disproportionately from severe anemia as a result of malarial infection. Women with severe anemia are at higher risk for congestive heart failure, fetal demise, and mortality associated with hemorrhage at the time of delivery.
Many studies reported that malaria during pregnancy can result in low birth weight (LBW), an important risk factor for infant mortality that stated by Helen and Rosert (2004) revealed that around 19% of infant LBW due to malaria and 6% of infant death are due to low birth weight caused by malaria. These estimated imply that around $10^5$ of infant deaths each year's could be due LBW caused by malaria during pregnancy in areas of malaria endemic in Africa. These findings are in consistent with the result obtained by Menedez et al 2000; Elsanousi et al., (2007) who stated that malaria is one of the most important indirect causes of maternal mortality. A recent study from Mozambique that assigned cause of maternal death via autopsy examination found that up to 10% of maternal deaths were directly attributed to malarial infection and 13% were secondary to human immunodeficiency virus (HIV)/AIDS, which can be exacerbated by coexisting malarial infection Menéndez et al., (2008)
Table (4.8.2): Distribution of participants according to intake of tonics before using sesame of pregnant women in Um Alqura town in Gezira state

<table>
<thead>
<tr>
<th>Used tonics</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularly</td>
<td>34</td>
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</tr>
<tr>
<td>Irregularly</td>
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</tr>
<tr>
<td>No</td>
<td>41</td>
<td>41.0%</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure (4.8.6): The effect of different attribute for irregular and non – use of tonics among participants in Um Alqura town in Gezira state
Before taking sesame while supplement show in table (4.8.2), participants of this study were either not taking iron and folic acid tablets or taking it irregular. The reasons behind that show in Figure (4.8.6), in 38% of participants were not prescribe to them (20%) believed that iron and folic acid were causing heartburn, (17%) causing nausea and vomiting,(14%) causing constipation,. This result is in consistent with results obtained by (Philip, 2006) who stated that, oral iron can casus unpleasant side effect including nausea and constipation.

Iron supplementation is probably the best available option to effectively address iron deficiency in pregnant women and young children. In Iran Yekta et al. (2008) reported that, eighty seven percent of participants took iron supplements for at least 4 months. Training during pregnancy was associated with longer duration of iron use. Knowledge of participants on anemia was obviously poor. Health care stuffs were the main source of information. Information, education and communication programs are the best approach to improve the effectiveness of iron intervention.

Results from various studies show consumer knowledge about anemia is low. However, when consumers are informed, the compliance rate for taking iron tablets increases (Emamghorashi and Heidari, 2004). In Thailand Mora (2002) reported that anemia prevalence decreased when village health volunteers made more effort to encourage pregnant women to attend antenatal care services. One of the difficulties in program management for anemia reduction was the low level of awareness among the target population and perhaps the negative perception towards iron supplementation among general population (Aikawa et al., 2006). Unfortunately, consumer ignorance is caused in part by health providers’ limitations, including lack of knowledge about anemia and iron tablets and insufficient communication and counseling skills. Therefore, improving health providers’ knowledge and communicational skills has been effective in promoting program content and counseling strategies (Emamghorashi and Heidari, 2004). Nordeng et al. has reported demographic factors as associated with non-compliance to guideline on iron supplementation during pregnancy (Wulff and Ekstrom, 2003). In this study, no impact was identified by any socio – demographic characteristics on taking iron tablets for longer period except parity. Nulliparous women took iron longer time, perhaps
because of focused training or their reception to accept health workers recommendation as reported by Aikawa et al. (2006). The study in Jakarta concluded compliance of supplementation program was low and the supplementation strategies need reliable monitoring and evaluation system Hyder, et al., (2002).

Galloway et al., (2002) showed a high compliance (88%) and low side effects (4%) in their study. Another study revealed only one – third of women reported that they experienced negative side effects (Aziz zadeh et al., 2002). In Sweden, side effects of supplements, perceived need and advice from midwives influenced on their use (Yip and Ramakrishnan, 2002). Another study revealed that gastrointestinal side effects were not significantly associated with compliance (Winichagoon, 2002). There is no doubt that supplementation is required for pregnant women, however the challenge remains to improve the effectiveness of supplementation strategies in many developing countries (Aguayo, et al., 2005).
Chapter Five

Conclusion and Recommendations

5.1. Conclusion

The current study indicated that the roasted sesame seeds are good natural source of iron and there was significant effect on certain hematological parameters in pregnant women in Um Elgura Town, Gezira State-Sudan, as follows,

- Hemoglobin Concentration (Hb) level increased significantly after intervention in most of participants (P = 0.000).
- The study showed that most of participants had increase of serum iron (64%).
- Transferrin saturation had increased on (62%) of participants.
- There was no significant decrease in haematocrit (HCT) level (P= 0.245).
- Significant decreased in Total iron Binding Capacity (TIBC) after intervention (P = 0.001).
- The majority of participants were significant decrease of both Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) after taking sesame (p = 0.050 and 0.060, respectively).
- The study showed that most of participants had no effects on Gastro-Intestinal Tract (58%)
- Quarter of participants was relieved from heartburn and constipation.
- Eighty one percent of participants had no side effects.
- Majority of participants (90%) had poor antenatal care (ANC) before the study conducted.
- The educational level of both pregnant women and their husbands was low.
- Before study most of participants were not taking iron and folic acid tablets or taking it irregular.

In our knowledge this is the first research on that particular issue in Sudan. Anemia can be prevented by the intervention of low cost iron supplement. Therefore, the etiological factors associated with maternal anemia during pregnancy in Sudan should deserve more attention.
5.2. Recommendations

- Sesame seeds are a good natural source of iron, an available alternative to the iron supplement and with low side effects pills, further studies are recommended to investigate the sesame seeds potentials also study recommend introduction of nutrition education programme to raise awareness of the benefits of sesame.

- Women should be offered education free of cost, so they can be aware about their health as well as their children health. Health education implementation at all (ANC) clinics.

- Improve the awareness of women about the importance of regular ante-natal care (ANC) visits since conception, regular intake of supplements, emphasis on the use of contraceptive and encourage child - spacing.

- Develop, implement and evaluate nutritional teaching programmes in pregnancy and reproductive age regarding iron rich food items and encourage intake of enhancers.
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Medicine, 31(4):


http://www.who.int/topics/pregnancy/en/


APPENDIX (1)

Bism Allah al-Rahman al-Rahim

Hejra el-Jamhuriya al-Dabi

Morkaz Jarouh wa Qayda al-Musadiq

التاريخ 2/4/2013

السيد/عميد المعهد القومي لبحوث تصنيع الحبوب الزيتية

د/ عاطف عبد المنعم أحمد ياسين

السلام عليكم ورحمة الله وبركاته

الموضوع: نتيجة تحليل عينة سمسم

بناءً على الطلب المقدم من سيادكم لتحليل عينة سمسم تعرض النتائج من خلالها من منتجات المبيدات بخطاب رقم ج/ تبري 1/3 بتاريخ 20/3/2013.

تم تحليل العينة بحسب البروتوكول المعولم به في مثل هذه الحالات.

( MDQ = 100 – 50 =

ب/ جمال عبد الوهاب البكري

مدير المركز

اسمه الحنون

رئيس العمل

قائم بالتحليل

151
APPENDIX (2)

بسم الله الرحمن الرحيم

جامعة الجزيرة
كلية العلوم الصحية والبيئية

استبيان لدراسة تأثيربذور السمسم كمصدر طبيعي للحديد على بعض مكونات الدم لدى النساء الحوامل في مدينة أم القرى - ولاية الجزيرة - السودان

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<td>خلوة</td>
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<td>فوق الجامعي</td>
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<td>أ) أقل من 250 جنيه</td>
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<td>ب) 250-750 جنيه</td>
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<td>ج) أكثر من 750 جنيه</td>
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<tbody>
<tr>
<td>أ) 2 فرد</td>
</tr>
<tr>
<td>ب) 3-4 أفراد</td>
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<tr>
<td>ج) 5-6 أفراد</td>
</tr>
<tr>
<td>د) أكثر من 7 أفراد</td>
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136
8) عمر الحمل:
أ) 1-3 شهور (ب) 4-6 شهور (ج) 7-9 شهور
9) هل حدث اجهاض في الفترة السابقة:
أ) نعم (ب) لا
10/ هل هناك مضاعفات سابقة:
أ) الاصابة بالملاريا (ب) الاصابة بالديدان (ج) الاصابة بالنزيف
(د) الاصابة بارفان (ه) الإصابة بارتفاع ضغط الدم (و) الإصابة بتسمم الحمل
11/ هل اصبت بفقد الدم في أي حمل سابق:
أ) نعم (ب) لا
12/ هل تتبعي مع العيادة المحولة:
أ) نعم بصورة دورية (ب) نعم بصورة غير دورية (ج) لا اتبع.
13-14) إذا كانت الإجابة (ب) أو (ج) ما هو السبب
14) ما هو عدد الوجبات المتناولة في اليوم؟
أ) واحدة (ب) اثنين (ج) ثلاث (د) أربعة (ه) أكثر من أربعة
15/ كيف تتناولين هذا الإعذبة؟
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<th>إسبوعياً</th>
<th>يومياً</th>
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16/ هل تناولت السمسم؟
أ) نعم بصورة منتظمة
ب) بصورة غير منتظمة

17/ ما هي التغيرات التي ظهرت أثناء تناولك السمسم؟
أ) لم يحدث تغيير
ب) زوال الحموضة
ج) حدوث إسهال
د) زوال الإمساك
ه) مغص

18/ هل تناولت السمسم بنفس المواصفات التي قدمت لكي من حيث المواصفات والكمية؟
أ) نعم (1-18)
ب) لا

19/ إذا كانت الإجابة بلا ما، ما هي الأشياء التي اضفتيها لها؟
أ) تقلل الكمية في اليوم
ب) تحميصه
ج) إضافة سكر

20/ هل هنالك أغذية تمتعي عن تناولها أثناء فترة الحمل؟

21/ هل تتناول حبوب الفايتمينات أثناء فترة الحمل؟
أ) نعم بصورة منتظمة
ب) بصورة غير منتظمة
ج) لا أتناول

22/ إذا كانت الإجابة (ب) أو (ج) ما هو السبب؟
أ) الشعور بالغري أو العطش
ب) لا استطيع شرائها
ج) الإمساك
د) لا أتذكر استعمالها
ه) عدم المعرفة باهميتها

23/ تحليل الدم

a) Complete Blood Count (CBC) Test
b) Serum iron (SI)
c) Total Iron Binding Capacity (TIBC).
d) Transferring Saturation (TS).
APPENDIX (3)
PRINCIPLE OF THE METHOD

Transfer-aided ferrous ions in the sample are released by guanidine and reduced to ferrous by means of hydrazine. Ferric ions react with ferrozine forming a colored complex that can be measured by spectrophotometry.

CONTENTS AND COMPOSITION
A. Reagent: 4 x 40 mL, Guanidine chloride 1.0 mol, hydrazine hydrate 0.2 mol, acetic buffer @ pH 4.4.
B. Reagent: 4 x 10 mL, Ferrazole II solution.
C. Iron Standard: 1 x 5 mL, Iron 300 µg/mL (35.8 µmols/L). Acetate primary standard.

STORAGE
Store at 2-8°C.

Reagents and Standards are stable until the expiry date shown on the label when stored tightly closed and if temperature is maintained during their use.

Methods of determination:
- Reagent. Presence of particulate material, turbidity, absorbance of the blank over 0.030 at 560 nm.
- Standard. Presence of particulate material, turbidity.

REAGENT PREPARATION
Standard B is provided ready to use.
- Working Reagent: Transfer the contents of one Reagent B vial into a Reagent A bottle. Mix thoroughly. Other volumes can be prepared in the proportion 1 ml Reagent B + 4 ml Reagent A.

ADDITIONAL EQUIPMENT
- Analyser, spectrophotometer or photometer able to read at 560 ± 5 nm.

SAMPLES
- Serum or heparinized plasma collected by standard procedures.
- Urine in serum or heparinized plasma is stable for 7 days at 2-8°C.

PROCEDURE
1. Bring the Reagent to room temperature.
2. Pipette into labelled test tubes (Tables 1, 2).

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Sample</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted Water</td>
<td>200 µL</td>
<td>200 µL</td>
</tr>
<tr>
<td>Standard B</td>
<td>200 µL</td>
<td>200 µL</td>
</tr>
<tr>
<td>Reagent A</td>
<td>1.9 mL</td>
<td>1.9 mL</td>
</tr>
<tr>
<td>Working Reagent</td>
<td>1.6 mL</td>
<td>1.6 mL</td>
</tr>
<tr>
<td>Blank</td>
<td>1.0 mL</td>
<td>1.0 mL</td>
</tr>
</tbody>
</table>

3. Incubate and let stand the tubes for 5 minutes at room temperature.
4. Read the absorbance (A) of the Samples / Bland at 560 nm against distilled water.
5. Read the absorbance (4) of the Samples and of the Standard at 560 nm against the Reagent Blank.

CALCULATIONS
The iron concentration in the sample is calculated using the following general formula:

- A sample / A standard = C sample / C standard

REFERENCE VALUES
- Mean: 65 - 175 µg/dl, 11.8 - 31.5 µmols/L.
- Woman: 50-170 µg/dl, 9.0 - 30.4 µmols/L.

These ranges are given for orientation only; each laboratory should establish its own reference ranges.

QUALITY CONTROL
It is recommended to use the Biochemistry Control Barran level I (cod. 18005 and 18006) and II (cod. 18007 and 18008) to verify the performance of the measurement procedure.

Each laboratory should establish its own internal Quality Control scheme and procedures for corrective action if control do not remain within the acceptable tolerance.

METROLOGICAL CHARACTERISTICS
- Detection limit 4 µg/dl, iron 0.01 µmols/L.
- Linearity limits 1000 µg/dl, iron 170 µmols/L. For higher values dilute sample 1:2 with distilled water and repeat measurement.
- Repeatability (within run):
  - 100 µg/dl = 18.4 µmols/L: 2.1% 20
  - 300 µg/dl = 54.4 µmols/L: 3.2% 20
- Reproducibility (between run):
  - 100 µg/dl = 18.4 µmols/L: 2.1% 20
  - 300 µg/dl = 54.4 µmols/L: 2.2% 15

Sensitivity: 180 nA (0.5 µg) = 0.06 nA/L µmols/L.

To reduce results obtained with this method do not show systematic differences when compared with reference reagents (Note 3). Details of the comparison experiments are available on request.

Interferences: Bilirubin does not interfere. Do not use hemolysed or lipemic sera (triglycerides > 160 mg/dl). Other drugs and substances may interfere.

These methodological characteristics have been established using an analyser. Results may vary if a different instrument or a manual procedure is used.

DIAGNOSTIC CHARACTERISTICS
Iron is distributed in the body in a number of different compartments: haemoglobin, myoglobin, tissue (mainly in liver, spleen, bone marrow). Only 0.1% of total body iron is present in plasma. Serum iron concentration is affected by many physiological or pathological conditions: Day-to-day variation is quite marked in healthy people.

Iron deficiency and iron overload are the main disorders of iron metabolism. However, altered iron metabolism is also related to a number of other diseases.

Serum iron is increased in hemorrhage, in acute iron poisoning, in active cirrhosis or acute hepatitis and as a result of increased transferrin levels.

Serum iron concentration is decreased in many but not all patients with iron deficiency anemia and in chronic inflammatory disorders. Measurement of serum iron should not be used as a test for identification of men deficiency.

Clinical diagnosis should not be made on the findings of a single test result, but should integrate both clinical and laboratory data.

NOTES
1. These reagents may be used in several automated analyzers. Instruction for many of them are available on request.
2. Contamination of glassware with iron will affect the test. Use well-washed glassware or plastic tubes.
3. Calibration of the provided zero-corrected standard may cause a matrix related bias, especially in some analyzers. In these cases, it is recommended to calibrate, using a serum based standard (Biochemistry Calibrator, cod. 18011).

BIBLIOGRAPHY
APPENDIX (5)
4.1.1. Iron content of sesame (*Sesamum indicum* L) seeds

Table (4.1.1.1): Iron content of white sesame from Algaraf state in (100g)

<table>
<thead>
<tr>
<th>Kind</th>
<th>Iron content mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row</td>
<td>10.6</td>
</tr>
<tr>
<td>Roasted</td>
<td>14</td>
</tr>
</tbody>
</table>

Table (4.1.1.1): shows that, iron content of row white sesame from Algaraf state was 10.6mg/100g and 14mg/100g for the roasted sesame.

Table (4.1.1.2): Iron content in red sesame from Darfur state in (100g)
<table>
<thead>
<tr>
<th>Kind</th>
<th>Iron content mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row</td>
<td>8.5</td>
</tr>
<tr>
<td>Rusted</td>
<td>12</td>
</tr>
</tbody>
</table>

Table (4.1.1. 2): shows that, iron content of row red sesame from Darfoor state, was 8.6mg/100g and 12mg/100g for the roasted sesame.