Development of Nutrition Intervention Package and It`s Efficacy Assessment in Improving the Iron Status of Rural Adolescent Girls of Bhilwara District in Rajasthan

A Thesis
Submitted for the Award of the Ph.D. Degree of
UNIVERSITY OF KOTA
in the
HOME SCIENCE
(FACULTY OF SOCIAL SCIENCE)
By

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UNIVERSITY OF KOTA,
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2017

CERTIFICATE

I feel great pleasure in certifying that the thesis entitled **"Development of Nutrition Intervention Package and It`s Efficacy Assessment in Improving the Iron Status of Rural Adolescent Girls of Bhilwara District in Rajasthan"** by Jyoti Sachan under my guidance. She has completed the following requirements as per Ph.D. regulation of the university.

(a) Course work as per university rules.
(b) Residential requirements of the university (200 days).
(c) Regularly submitted annual progress report.
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I hereby certify that the work, which is being presented in the thesis, entitled **"Development of Nutrition Intervention Package and It`s Efficacy Assessment in Improving the Iron Status of Rural Adolescent Girls of Bhilwara District in Rajasthan"** in partial fulfillment of the requirement for the award of the Degree of Doctor of Philosophy, carried under the supervision of Dr. Deepa Swamy and submitted to the (Department of Home-Science, JDB Govt. Girls P.G. College, Kota) University of Kota, Kota represents my ideas in my own words and where others ideas and words have been included. I have adequately cited and referenced the original sources. The work presented in this thesis has not been submitted elsewhere for the award of any other degree or diploma from any institutions. I also declare that I have adhered to all principles of academic honesty and integrity and not misrepresented or fabricated any ideas/data/facts/sources in my submission. I understand that any violation of the above will be cause for disciplinary action by the University and can also evoke panel action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Date:

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Acknowledgement

It gives me immense pleasure and sense of honour to be able to express my feeling to gratitude to one and all who have contributed to the successful completion of my present investigation. Firstly I express my heartiest devotion to '**The Almighty God'** for his graceful blessing at every step of the research work.

In an ecstasy of delight, I express my profound sense of gratitude and indebtedness to my revered guide Dr (Mrs) Deepa Swamy, Senior Lecturer in Home-science, JDB Govt. Girls College, Kota for her scholarly, painstaking, incessant efforts, invaluable guidance, constant stimulating criticism and encouragement throughout the research work.

I pay my respectful thanks to Dr Sunil Kumar, Assistant Professor (Soil Scientist), Dry land Farming Research Station, Arjia, Bhilwara for giving permission to conduct nutritional analysis in Soil Science Laboratory of this research station.

I owe my thanks to Dr. Chitra Bhargava, Principal, SMM Govt Girls College, Bhilwara for her graceful blessing at every moment.

I express my cordial thanks to Mrs.Sudha Nuwal (Head, Dept. of Home Science), Mrs. Sunita Bhargava, Mrs Meenakshi Jain and Dr. (Mrs.) Seema Gaur and all the staff members of SMM Govt. Girls College, Bhilwara, for their generous help and valuable suggestion during the investigation.

I express my sincere thanks to Dr. Bhim Singh, Assoc. prof. Dept. of Agricultur Statistic and computer Application, Horticultur College, Jhalawar for his scholarly guidance, inducement and valuable suggestion in statistical analysis of the research.

I express my sincere gratitude to Dr. Prakesh Panwar, Associate Prof. Agriculture College, Bhilwara for her encouragement and constant caring and sharing during the study period.

Words are the poor substitute to express my deep sense of gratitude to my father Mr. Ram Avtar Sachan and mother Mrs Shanti Devi Sachan for supporting and applauding my academic efforts constantly. I take this opportunity to dedicate this work to my parents who have made me what I am.

My heartfelt thanks to my husband Mr. Dilip Katiyar for his moral support, propitious assistance and paramount eagerness during the course of work.

And above all its very difficult for me to restrict the feeling and expression, arising from the cedes come of my heart for my loving kids **Master Akshat** and Baby **Divyanshi**, who spared me, from their genuine demand and responsibilities, for achieving my goal.

I owe my deep sense of gratitude to my elder sister Dr. Madhu Dhaker and her husband D. Rajesh Dhaker and my brother Mr. Vipin Sachan and His wife Mrs. Mala Sachan. My very affectionate thanks to younger sister Mrs. Nidhi Gangwar and her husband Mr. Amit Gangwar who were also great source of motivation for me during this work.

I will not forget to thanks all the students of BSc. (Home-science) I, II and III year and Home-science lab assistant for helping me in laboratory work.

Last but not the least, I am also thankful to all my respondent whose response, participation and cooperation made this study possible.

Jyoti Sacahn

(Research scholar)

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Abbreviation

ACRIP	All India Coordinated Research Project
ANOVA	Analysis of variance
AOAC	Association of Analytical Communities
APHA	American public health association
AWC	Anganwadi Center
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CDPO	Child Development Project Officer
DLHS	District Level Household Survey
FAO	Food and Agriculture Organization
GLV	Green Leafy Vegetable
Hb	Hemoglobin
HDPE	High Density Polyethylene
IAP	Indian Academy of Pediatrics
ICDS	Integrated Child Development Services
ICMR	Indian Council of Medical Research
IDA	Iron deficiency anemia
IFA	Iron Folic Acid

IIPS	International Institute for Population Sciences
MPS	Mean Percent Scores
NFHS	National Family Health Survey
NHANES	National Health and Nutrition Examination Survey
NIN	National Institute of Nutrition
NNMB	National Nutrition Monitoring Bureau
RCH	Reproductive & Child Health
RDA	Recommended Dietary Allowance
RDI	Recommended Dietary Intake
SD	Standard deviation
SEAR	South East Asian Region
SES	Socio-economic Status
STH	Soil-transmitted helminthes
TVC	Total Vibal Count
UN	United Nations
UNDP	United Nations Development Program
UNCF	United Nations Children's Fund
VMNIS	Vitamin and mineral nutrition information system
WHO	World Health Organization
WIFS	Weekly iron-folic acid supplementation

CHAPTER-1

INTRODUCTION

Introduction

"Adolescent is an age when foundation for better life can be laid. Let us help youngsters to lay such foundation through sound health and nutrition education"
(**Abraham, 2015**)

In the Millennium Declaration, adopted in 2000, world leaders made a promise to children to help them fulfill their human potential. The children born in that milestone year are now adolescents. It is time to review whether the promise is being kept for these 'Millennium children' and for all adolescents (UNICEF, 2012).

The word adolescence is derived from the Latin word, 'adolescere' meaning "to grow, to mature". WHO has defined adolescence as the age period between 10 to 19 years of age both the sexes (married and unmarried). Adolescence is a transitional period from childhood to adulthood and is the period when a growing child experiences a linear growth 'spurt' to attain his or her fullest potential of adult height, shape, body composition, physical and sexual function(Nayar et al., 2007).

There are about 1.2 billion adolescents in the world, which is equal to $1/5^{th}$ of the world's population and forming 18 percent of world population. Out of these, 5 million adolescents are living in developing countries. The proportion of adolescents in the global population peaked around 1980 and is now on the decline almost everywhere, a trend expected to rise during the same period(Figure-1.1)(UNICEF, 2012). More than half of the world's adolescents live in either of the South Asia or the East Asia and Pacific region, each of which contains roughly 330 million adolescents. India's population reached the 1 billion mark, out of which 21% are adolescents. India has largest national population of adolescents, nearly 243 million (UNDP, 2010) (Figure-1.2).

Figure: 1.1 Adolescents share of a growing world Population

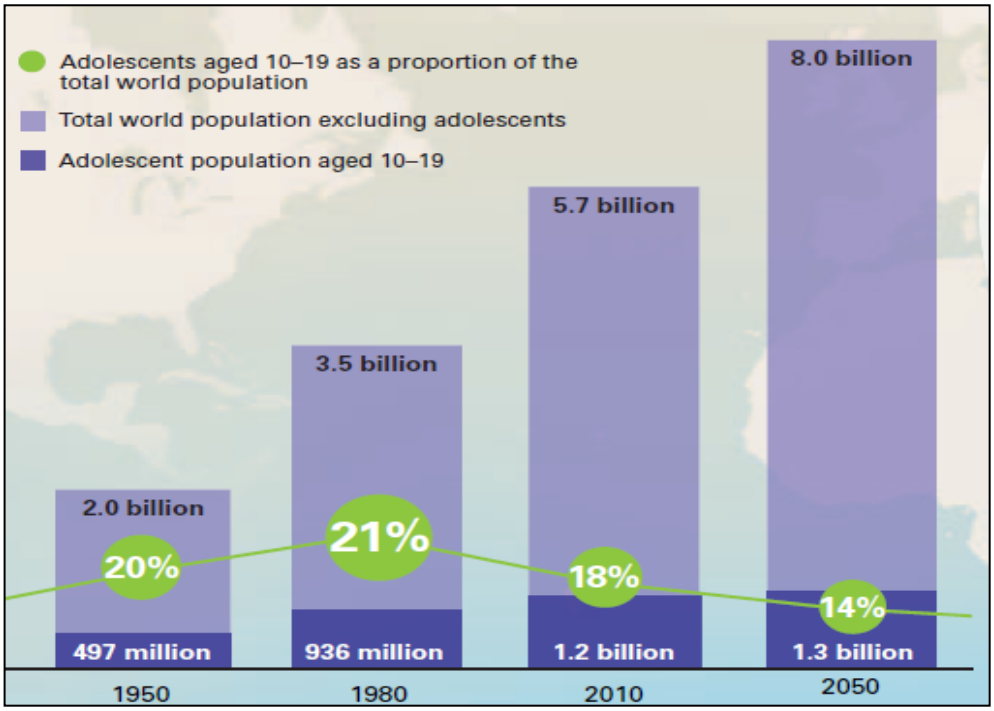
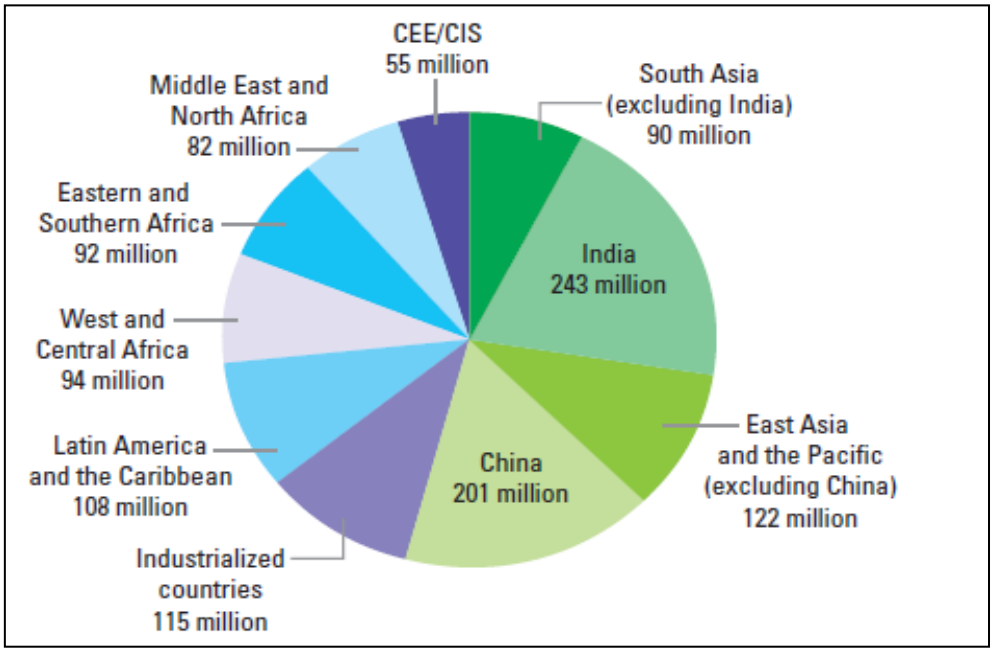


Figure: 1.2 Population of Adolescents 10-19 years old by region



(Source: UNICEF, 2012 and UNDP, 2010)

The world's adolescent population is facing a series of serious nutritional challenges, which are not only affecting their growth and development but also their livelihood as adults. Yet, adolescents remain a largely neglected, difficult-to-measure and hard-to-reach population, in which the needs of adolescent girls in particular, are often ignored. This period is very crucial, since these are the formative years in the life of an individual, when major physical, psychological and behavioral changes take place. The nutritional and the health need of the adolescents are also more because of the growth spurt and the increase in the physical activity in them (Chatterjee, 2008).

Anemia is currently one of the most common and intractable nutritional problem globally. It is a global public health problem that affects both developing and developed countries with major consequence of for human health as well as social and economic development. WHO estimates the number of anemic people worldwide to be a staggering two billion with approximately 50% of all anemia attributable iron deficiency (WHO, 2011).

Iron deficiency anemia occurs at all stages of life cycle, but is more prevalent in pregnant women and young children. Adolescent, particularly girls are vulnerable to iron deficiency. The World Health Report (2002) identified iron deficiency among the 10 most serious risks in countries with high infant mortality coupled with high adult mortality and reported that measures to address iron deficiency anemia are the most cost effective public health intervention.

Public health significance of anemia

At the national level, anemia is considered a severe public health problem when its prevalence is equal to or greater than 40 percent. By the measure given in Table-1.1, Anemia is a severe public health problem in nearly all developing countries. Anemia prevalence rate in industrialized countries are typically in the normal to mild range (WHO, 2001).

Table: 1.1 Public health significance of anemia

Prevalence of anemia (%)	Category of public health significance
<4.9	No public health problem
5.0-19.9	Mild public health problem
20.0-39.9	Moderate public health problem
>40	Severe public health problem

Source: WHO, 2001

Iron Deficiency Anemia

Iron deficiency is the most prevalent nutritional deficiency and the most common cause of anemia in the world. Iron deficiency anemia is characterized by a defect in hemoglobin synthesis, resulting in red blood cell that are abnormally small (microcytic) and contain a decreased amount of hemoglobin (hypochromic). The capacity of the blood to deliver oxygen to body cell and tissue is thus reduced (CDC, 1998). Anemia is an indicator of both poor nutrition and poor health.

Iron is essential to all cells. Function of iron include involvement in energy metabolism, gene regulation, cell growth and differentiation, oxygen binding and transport, muscle oxygen use and storage, enzyme reactions, neurotransmitter synthesis and protein synthesis (Beard, 2001).

Hemoglobin

Most of the iron in our body is found as a part of proteins called hemoglobin. Each hemoglobin molecule is composed of four protein chains. Each chain, called a globin is bound to a red pigment, identified in figure 1.3 as a heam molecule. Each heam molecule contains one iron atom. Therefore one hemoglobin molecule contains four iron atoms. Hemoglobin play a crucial role in the transport of oxygen. It carries oxygen to the cell of the body. The body's cell needs oxygen to function and enable a person to perform all physical and mental activities.

With moderate IDA, there is a compensatory mechanism by biochemical changes to compensate for the reduced oxygen carrying capacity of blood. In contrast, in sever IDA, the markedly reduced hemoglobin content decreases the oxygen carrying capacity, leading to chronic tissue hypoxia. In normal individuals, 2/3 of total body iron is available for hemoglobin formation and the remaining gets deposited as hemosiderin and ferritin atoms. In normal individuals, 2/3 of total body iron is available for hemoglobin formation. The remaining 1/3 gets deposited as hemosiderin and ferritin. (Agarwal, et al., 1983).

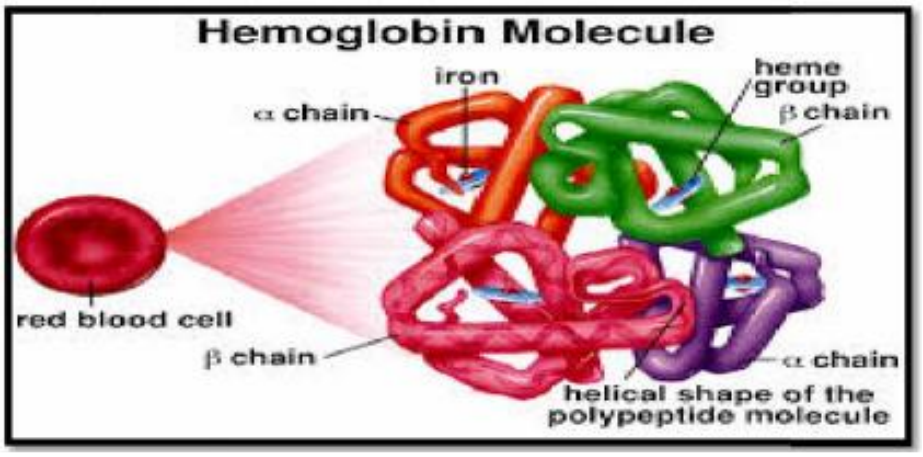


Figure: 1.3 Hemoglobin Molecule

Stages of iron deficiency anemia

Deviation from normal iron status to iron deficiency have been summarized by Herbert (1999) and Adaman and Dan, (2005) as follows:

Stage –I and II negative iron balance (i.e. iron depletion): This stage initially begins with depletion, where a fall in storage iron is observed as a decrease in serum ferritin which in turn reflects low iron in liver/spleen/bone marrow and there is no dysfunction. In stage I negative iron balance, reduced iron absorption and moderately depleted iron stores.

This is followed by the second stage where there is a decrease in transport iron, hence low serum iron is observed with an increased total iron binding capacity and decreased transferring saturation. Both these two stages are preanemic-Latent iron deficiency. When person in these two stages are treated with iron, they never developed dysfunction and disease.

Stage –III and IV negative iron balance (i.e. iron deficiency): In the third stage, there is significant fall in supply of transport iron, thus restricting hemoglobin synthesis with increase in erythrocyte-porphyrin. As a result microcytosis appears, which is accompanied with a fall in hemoglobin, this fulfills the laboratory definition of iron deficiency anemia. Iron deficiency is characterized by inadequate body iron, causing dysfunction and disease. In stage III negative iron balance, dysfunction is not accompanied by anemia; however, anemia does occur in stage IV negative iron balance (Mahan and Sylvia, 2008).

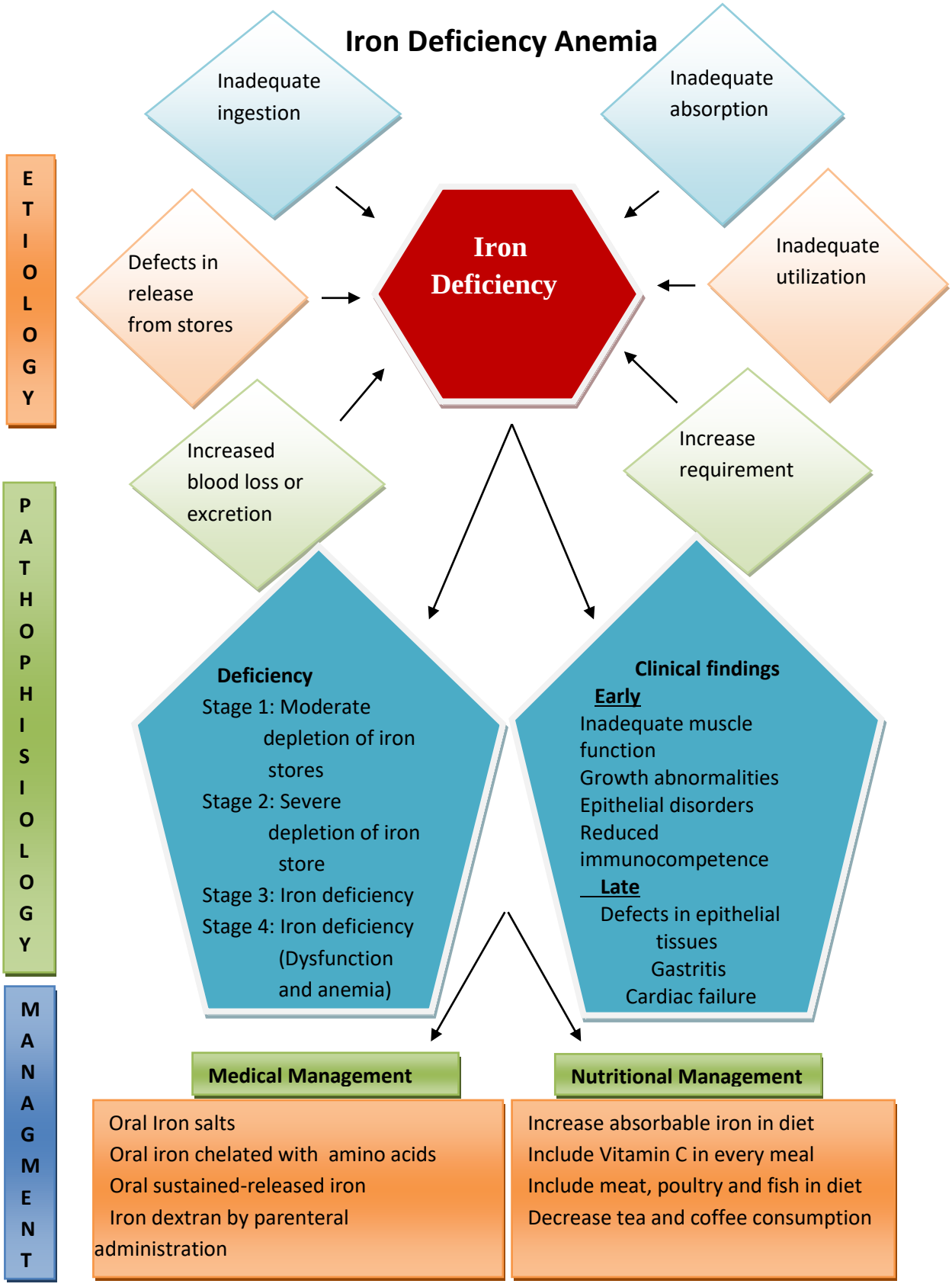
The cut-off values suggested for different physiological groups by the WHO (2001), for diagnosis of anemia. If the level falls below these values, then the person is diagnosed as having anemia.

Table: 1.2 Cut off levels of hemoglobin for diagnosis of anemia

Age/Sex	Hemoglobin g/dl
Children 6 month to 6 years	<11
Children 6-14 years	<12
Adolescent 15-19 years	<12
Adult male	<13
Adult female	<12
Adult female pregnant	<11

Source: Iron deficiency anemia: assessment, prevention and control. A guide for programme managers; WHO 2001- WHO/NHD/01.3

Figure: 1.4 Pathophysiology and care management algorithm



Source: John, J.B. Anderson and Sanford, C. Garner , 2002

In most population anemia is primarily due to iron deficiency and is in fact the late stage of a relatively long process of deterioration in iron stores. UNICEF/UNU/WHO/MI report indicates that there are approximately 2.5 cases of iron deficiency for each case of anemia. The functional consequences are known to occur prior to onset of clinical stage of iron deficiency. Many more adolescents are in fact suffering from iron deficiency with its adverse effects on health and physical stamina, than are frankly anemic. Iron deficiency and iron deficiency anemia (IDA) in adolescence is a major public health problem. Studies indicate that the incidence of anemia in adolescents tends to increase with age and corresponds with the highest acceleration of growth during adolescence. The highest prevalence is between the ages of 12-15 years when the requirement are at peak. More than 50% in this age group have been reported to be anemic.

Etiology of iron deficiency anemia in adolescent

Adolescents (10-19 years) are at high risk of iron deficiency and anemia due to accelerated increase in requirement for iron, poor dietary intake of iron, high rate of infection and worm infestation as well as the social norm of early marriage and adolescent pregnancy.

a) Accelerated increase in requirements for iron

Iron requirement peaks during adolescent due to rapid pubertal growth with sharp increase in lean body mass, blood volume and red cell mass, which increase iron need for myoglobin in muscles and hemoglobin in blood. The continuous increase in the median requirement for absorbed iron for both boys and girls during adolescence peaks between the age of 14-15 years for girls and one to two years later for boys. The requirement of iron in fact doubles during adolescence as compared to younger age group. The overall iron requirement increases two to three folds from preadolescent level of approximately 0.7-0.9 mg iron per day to as much as 1.37-1.88 mg per day in adolescent boys and 1.40-3.27 mg per day in adolescent girls(Beard,2000). Additional iron is therefore required by both for the expanding red cell mass and growing body tissues.

Table: 1.3 Risk factors of iron deficiency anemia

Inadequate iron intake/absorption/stores	Increased iron requirement
• Poor dietary intake of iron rich food	• Heavy/lengthy menstrual periods
• Vegetarian eating style	• Rapid growth
• Low intake of meat, fish poultry	• Teenage marriage and early pregnancy
• Low bio-availability of iron:	• Hemorrhage from injury, bleeding ulcer, bleeding hemorrhoids
• Presence of inhibitors: phytates/tannins	• Frequent blood donation
• Poor consumption of enhancers: Vitamin C	• Parasitic infection
• Frequent dieting or restricted eating	• Chronic inflammation or other chronic disorders
• Chronic or significant weight loss	• Participation in endurance sports
• Meal skipping	• intensive physical training
• Faulty dietary habits: fast foods and junk food	
• Substance abuse	
• History of iron deficiency	
• Special health care needs	

Source: Alton (2005) Iron deficiency anemia. Stang J, Story M. eds. Guidelines for adolescent nutrition services. Minneapolis.

After sexual maturation, there is a rapid decrease in growth spurt and need of iron. As a result, there is an opportunity to recover from an iron deficiency that might have developed during this peak growth especially for boys. In girls, however, the growth spurt is not as great, but menstruation typically starts about one year after peak growth and requirement for iron remain high through the reproductive life to replace iron that is lost during menstruation. There is a regular loss of 12.5-15 mg iron per month or 0.4-0.5 mg iron per day in menstrual blood. Therefore in girls,

following the growth spurt, the risk of iron deficiency continue to be public health concern through the entire reproductive age but this risk subside for boys after completion of pubertal growth spurt (Passi and Vir, 2000).

b) Low dietary intake by adolescents and bio-availability of iron

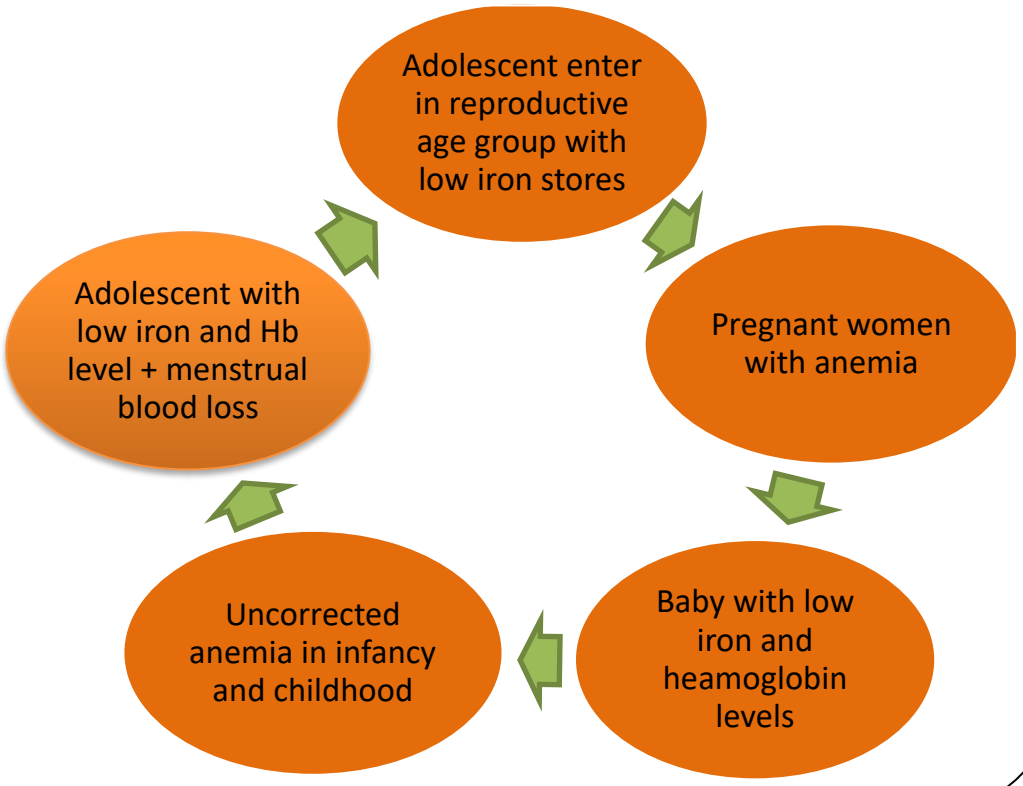
Another cause of IDA in adolescence is low dietary intake and poor bio-availability of iron consumed against the significant increase in requirements. The data from India indicates that the diets of girls aged between 13-18 years provide much lower level of iron than the diets of boys in the same age group. Low consumption of nutrients by adolescents reported from India indicates that over 50% adolescent girls consumed less than 50%RDA for energy while over 70% girls consumed less than 50% RDA of iron.

In south-east Asia region, the low iron intake is further worsened by the fact that the bio-availability of iron consumed is low since the diet is primarily cereal-based with little meat or vegetables. Such diet has high concentration of inhibitors and low concentration of enhancers and lowers the bio-availability of dietary iron.

c) Adolescent pregnancy

Added to the problem of poor dietary iron intake is the traditional practice of early marriage in many countries of the SEA Region. Social pressure often results in not delaying the first pregnancy and majority of young married women conceive soon after marriage. Onset of pregnancy during adolescence further increases demands for iron and contributes to aggravating iron deficiency and IDA. In India 47 % of girls and in Bangladesh and Nepal over 50% girls are married by the time they are 18 year of age (IIPS, 2007). Early marriage is frequently associated with early pregnancy. This indicates that risks and outcomes of pregnancy increases in adolescent mothers who have higher prevalence of anemia.

Figure: 1.5 Intergenerational cycle of anemia



An adolescent girl who enters the reproductive age with low iron stores and becomes pregnant during adolescence or later is at greater risk of giving birth to a low birth weight and preterm baby. The baby is also born with low iron stores and due to poor infant feeding practices is more likely than ever to enter adolescence with low iron stores in the body. Thus this vicious cycle of iron deficiency anemia continues.

d) Frequent infectious disease and parasitic infections

The frequent occurrence of infectious diseases and parasitic infestation among developing countries further increases requirement for iron and increases the chances of negative iron status and IDA. In the study in India, one third of had a history of infestation. The prevalence of anemia was double in these girls (53.6%) compared to those who were not reported to be infected (Rawat, 2000).

Infections interfere with food intake, absorption, storage and use of many nutrients such as iron, vitamin B, folic acid, vitamin C, vitamin A etc which contribute to anemia.

Clinical features of iron deficiency anemia

Anemia is the last manifestation of chronic, long term iron deficiency; the symptoms reflect a malfunction of variety of body systems. Inadequate muscles function is reflected in decreased work performance and exercise tolerance. Neurological involvement is manifested by behavioral changes, such as fatigue, anorexia and pica. Growth abnormalities, epithelial disorders and a reduction in gastric acidity are the common. A possible sign of early deficiency is reduced immunocompetence, particularly defect in cell-mediated immunity and the phagocytic activity of neutrophils, which may lead to an increased propensity of infection.As iron deficiency anemia becomes more severs, defects arise in the structure and function of the epithelial tissue, especially of the tongue, nail, mouth and stomach. The skin may appear pale and the inside of the lower eyelids be light pink instead of red.

Finger nail can become rough and rough and eventually koilonychias (spoon-shaped) nail may be noted. Mouth changes include atrophy of the lingual papilla, burning, redness and in severe cases completely smooth, waxy and glistening appearance to the tongue (glossitis). Angular stomatitis may also occur as may a form of dysphagia. Aggressive and untreated anemia result in cardiovascular and respiratory changes which can eventually lead to cardiac failure (Mahan and Sylvia 2008).

Iron deficiency anemia develops after normal stores of iron have been depleted in the body. Thus the signs of anemia may not be clinically visible until the anemia is severe (Hb less than 7-8 gm/dl) (Nelson, 1993). However, adverse impact on health occurs even before this stage is reached.

Potential consequences of iron deficiency anemia, which occur in relation to its severity, are summarized in Table-1.4, while symptoms associated with anemia are listed in Table-1.5.

Table: 1.4 Potential consequences of anemia	
Decreased maximum aerobic capacity	Impaired cognitive function and memory
Decreased athletic performance	Decreased school performance
Lowered endurance	Compromised growth and development
Impaired temperature regulation	Increased risk of pregnancy complication
Depressed immune function	including prematurity and fetal growth retardation
Increased rate of infection	

Table: 1.5 Signs and symptoms associated with iron deficiency anemia

Symptoms of IDA	Signs of IDA
• Dizziness, tiredness, fatigue and low energy	• Whiteness or light pink in the inner rims of the eyelid,
• Unusually rapid heartbeat, particularly with exercise	• Whiteness or pallor in overall skin, nails,, tongue and palms
• Shortness of breath	• Flattened, brittle nail(spoon nail)
• Lack of interest in play and studies	• Angular stomatitis (crack at mouth corners)
• Difficulty/inability to concentrate	• Glossitis
• Leg cramps	• Pale conjunctivae
• Lowered resistance to infections	• Swelling (oedema) of feet
• Ringing in ears	
• Taste disturbances	
• Loss of appetite	
• Pica	

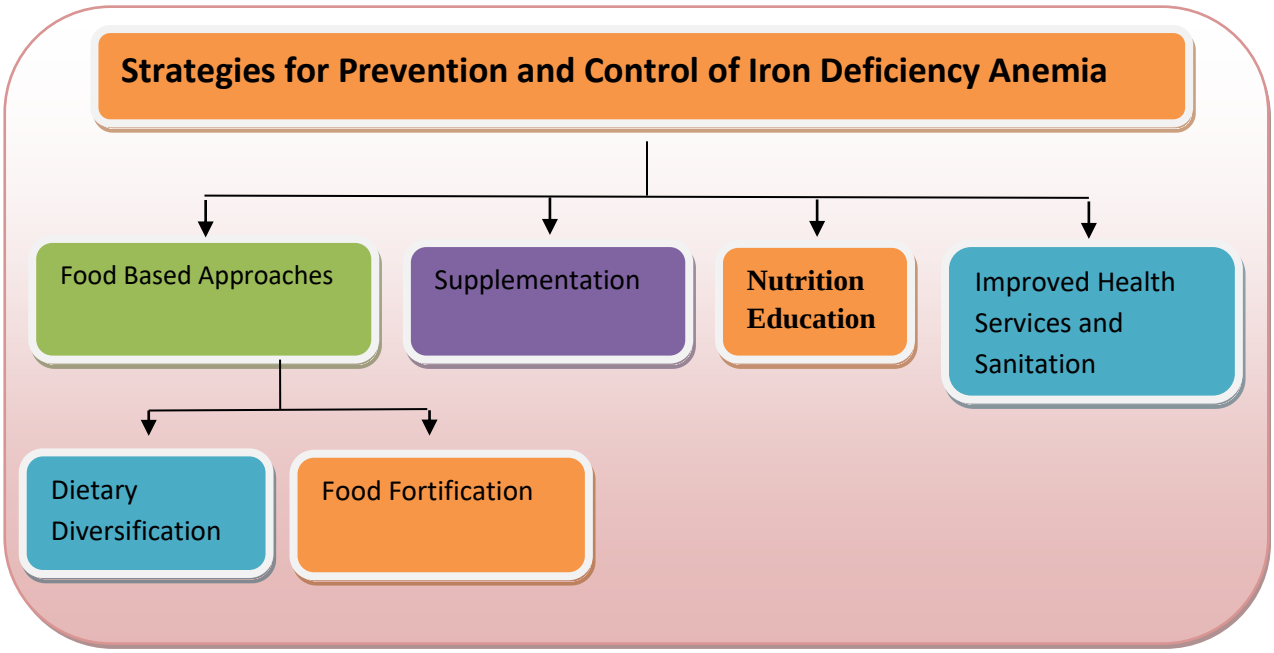
Source: Alton (2005) Iron deficiency anemia. Stang and Story. eds. Guidelines for adolescent nutrition services. Minneapolis.

Strategies for prevention and control of iron deficiency anemia

Anemia is a multi-factorial disorder that requires a multi-pronged approach for it prevention and treatment. Iron deficiency and infections are the most prevalent etiological factors. However, other conditions may have a contributory role. Adolescence is an opportune time for intervention to address anemia. Not only is there a need (growth, preparation of pregnancy), but large numbers of both boys and girls can be reached easily if school attendance or participation in other group activities is high. Also adolescents are open to new information and new practices since they are often striving for physical or academic excellence.

Strategies focus on prevention of IDA among adolescents is more important from the point of view of productivity gain from improved physical capacity; productivity gains from increase cognitive ability; and improved pregnancy outcomes and intergenerational benefits.

Figure: 1.6 Strategies for prevention and control of iron deficiency anemia



Source: Iron deficiency anemia: assessment, prevention and control. A guide for programme managers; WHO 2001- WHO/NHD/01.3

Prevention of iron deficiency anemia requires approaches that address all the potential causative factors. Interventions to prevent and correct IDA therefore must includes measures to increase iron intake through food based approaches, namely dietary diversification and food fortification with iron; iron supplementation and by improved health services and sanitation.

Food Based approaches

Food based intervention programs, dietary enhancement and diversification, and food fortification including bio-fortification play a critical role in alleviating micronutrient malnutrition.

Food based strategies focus on improving the availability of, access to, and consumption of vitamin and mineral rich food. Benefit of food based strategies includes not only improved intakes of specific nutrients but also improved overall diets and health status. Food based approaches to increase iron intake through food fortification and dietary diversification are important sustainable strategies for preventing IDA in general population

Increasing overall food intakes

Micronutrient deficiencies are closely associated with poverty, food insecurity and under-nutrition and are common in those groups whose overall food intakes are not sufficient to meet nutritional requirements. Consequently, intervention programs need to as a first priority to ensure that overall food supplies are adequate through increasing the production, availability, access to, and consumption of an adequate and nutritious diet, especially by those who are hungry and food insecure and most vulnerable to deficiency.

Increasing consumption of micronutrient rich food

Most traditional diets and food habits provide a range of nutrients that are able to meet the nutritional requirement of most groups. However, those physiologically challenged such as the sick, young children, adolescent and pregnant and lactating women may require larger amounts of micronutrient rich foods to meet their

increased needs. Where iron deficiency is widely prevalent, the usual diet often does not provide enough bio available iron. Under such circumstances, promoting the increased consumption of micronutrient rich foods is key to good health and nutrition.

The promotion of dietary improvement/diversification with a focus on improving the intake of bio-available iron through greater consumption of animal products, fruit and vegetable, especially those rich in vitamin C, is the only intervention that can lead to self sustained success in improving iron status. Neither supplementation nor fortification can be effective on its own. Promoting consumption of micronutrient rich foods foster better overall health.

Management and control of inhibitors and enhancers

Improved food preparation and cooking methods and the modification of consumption practices to increase dietary enhancers and eliminate inhibitors of absorption can safeguard the amounts of micronutrients that are available and maximize their uptake by the body. The bio-availability of dietary iron is the proportion of iron that is actually available for absorption and utilization by the body. As seen in Table-1.6, the bioavailability of food and dietary iron is influenced by certain factors, some of which are briefly described below:

Heam and non-heam iron: Food iron is classified as either heam iron (the iron from meat, poultry and fish) or non--heam iron (from cereals, pulses, legumes, fruits and vegetables). In human, heam iron is well absorbed and its absorption varies little with the composition of the meal. Absorption in inversely related to the quantity of iron stores in the body, i.e. absorption range from 15 to 25 percent in normal subjects and 25 to 40 percent in iron deficient subjects. The absorption of non-heam iron ranges from 2 to 20 percent. The specific rate of absorption of non-heam iron from plant food is highly dependent on the concomitantly ingested dietary components (reducing substances such as ascorbic acid keep iron in the reduced ferrous form)

and the amount of body iron stores. Severely iron deficient individuals absorb non-heam iron at higher rate than those with normal iron levels (Kraus, 2008).

Phytates and polyphenols: The iron in Indian diets is mainly non-heam, the absorption of which is inhibited by food component, primarily phytate in grains, legumes, nuts, vegetable, roots and fruits, and polyphenols (tannates) in tea, coffee, vegetable, herbs and spices. Phytates can decrease non-heam iron absorption by 51-82 percent, and are found in higher concentration in unrefined,non and under- milled cereals than in refined, milled cereals. Fermentation and germination can degrade the phytate and increase the bio-availability of iron in body (Thompson, 2005). Polyphenols in tea are strong inhibitor of iron absorption. For example, one large cup of (250 ml) of black tea can inhibit non-heam iron absorption by approximately 50 percent. To overcome the inhibitory effects, therefore, tea or coffee should not consume with the main iron-containing meals.

Calcium: Calcium from dietary products interferes significantly with iron absorption of both heam and non-heam iron. Because calcium is also a important nutrient, it should be included in the diet for optimum health. Practical solutions for the competition of calcium with iron is to increase iron intake, increase its bio-availability or avoid taking calcium and iron rich foods at the same time.

Ascorbic acid: Ascorbic acid (vitamin C) is the most potent enhancer of non-heam iron absorption even in the presence of inhibitors such as phytates, tannates and calcium. It can reduce food ferric iron to the better absorbed ferrous iron by 75-98 percent. In Indian studies, the addition of ascorbic acid to cereals and pulses enhanced the available iron (NIN, 1992). Ascorbic acid also improves the availability of iron from fortified foods. The bio-availability of non-heam iron rises to a level similar to that of meat products when consumed with a significant source (25 mg) of vitamin C in the same meal.

Meat, fish and poultry

Meat and fish taken even in small amounts markedly improve the bio-availability of non-heam iron. The addition of 90-100g of meat, fish or poultry to the daily diet improves the bio-availability of iron significantly (Johnson and Walker, 1992), but because these foods are costly and culturally unacceptable, their use is uncertain.

Table: 1.6 Dietary factors that enhance and inhibit Iron Absorption

Enhancing factors	Inhibiting Factors
• Meat, Fish, poultry • Seafood • Gastric acid • Ascorbic acid • citric acid • certain fruits and vegetables • Fermented food • Sprouts	• Phytates • calcium(e.g. milk, cheese) • iron binding phinolic compounds (e.g. tea(tannic acid), coffee, cocoa, certain spices) • Carbonated beverages(e.g. colas) • Soy protein • High dose of minerals • Bran /fibers(e.g. bran product, breakfast cereals High-extraction flour bread, unpolished rice • Pasta products

Source: Alton (2005) Iron deficiency anemia. Stang J, Story M. eds. Guidelines for adolescent nutrition services. Minneapolis.

Processing and preservation

Processing, preservation and preparation to maintain micronutrient availability by improving methods or processing and preservation of surplus food produced during the peak season, further losses may be reduced leading to greater year-round availability of these foods, improving nutritive value, acceptability and shelf life, and thereby improving consumption. Local food preservation and processing facilities should therefore be strongly promoted. At the household level, the promotion of effective cooking methods and practical ways of preserving foods (solar drying of seasonal micronutrient rich foods such as papaya, grapes, mangoes, peaches,

tomatoes, lotus stems, green leafy vegetable etc.) may significantly increase the access to bio-available micronutrient rich foods.

Cast iron pots and cookware can also be a source of significant quantities of dietary iron. Encouraging the use of cooking in iron pots has been shown to improve iron status.

Food fortification

Food fortification is the addition of nutrients at levels higher than those found in the original food. Food fortification has a role in meeting iron, folate, iodine and zinc needs and is recommended when dietary iron is insufficient or dietary iron is of poor bioavailability, which is the reality of most people in the developing world and for vulnerable population groups in the developed world. Because staple foods around the world provide predominantly non-heam sources of low bio-availability, the traditionally eaten staple foods represent an excellent vehicle for iron fortification. Examples of foods which can be fortified are wheat flour, corn flour, rice, salt, sugar, cookies, curry powder, fish sauce and soy sauce.

Nutrition education for behavioral change

Communication techniques can be used to help bring about changes in eating practices at the household level. As income rise, people often reduce breastfeeding, stop gathering wild foods, and eat fewer green leafy vegetables. Such nutritionally beneficial traditional practices are under threat of erosion from factors related to urbanization and modernization and need to be protected and supported by education campaigns and communication strategies that aim to preserve such positive traditional practices. This is especially in case for those foods which may be available but are not consumed in sufficient quantities to prevent disease.

Intervention programs should always be accompanied by a public nutrition education and promotion program to encourage improved food consumption. Advice for a healthy diet should provide both a quantitative and qualitative description of the diet for it to be understood by individuals, and information on both side and number of serving per day should be provided. Quantitative aspects include the estimation of the amount of nutrient in foods and their bio-availability in the form they are actually consumed. Qualitative aspects related to the biological utilization of nutrient in the food as consumed and the potential for modifying the balance between food enhancers and inhibitors. Nutritional status can be improved significantly by educating households on food preparation practices which minimize the consumption of inhibitors of iron absorption. In addition, education detailing the appropriate storage and processing of foods to prevent micronutrient losses at the household levels is important.

Iron supplementation

Supplementation refers to periodic administration of pharmacological preparation of nutrients as capsules, tablets or by injection. Supplementation is necessary as a short term emergency measure to reverse clinical signs or for prevention in groups at risk. Nutritional supplementation should be restricted to vulnerable group which cannot meet their nutrient need through food (women of child bearing age, infants and young children, elderly people, low socioeconomic group, displaced people, refugees and population experiencing other emergency situations (Thompson 2005).

Since it is difficult to influence dietary behavior due to social reasons and poverty, it is proposed jointly by UNICEF/UNU/WHO/MI (1998) that in countries where anemia prevalence exceeds 40 % in pregnant women, provision of universal iron supplements for adolescent girls and women of child bearing age is necessary. Iron-folic acid supplements are cost effective and positive results are evident in a short period of a few months.

It has been suggested that adolescence may be an optimal time to deliver iron supplements to build iron stores in the body before pregnancy. Physiological needs are high at this stage of life because of increased requirements. Since menarche often sets in by 12 years of age, it is critical to ensure that adolescents regularly consume iron- folic acid tablets to prevent iron deficiency anemia. Intervention to address anemia at a younger age, 10-14 years, as compared to 15-18 years has been demonstrated to give a better response in weight gain and body mass index (BMI) and in regularization of the menstrual cycle (Scholl and Hediger, 1994).

Significance of the study

Anemia is a worldwide problem in persons of all ages; it is not a diagnosis but rather a sign or symptoms of an underlying disorder. The rate of prevalence is higher in the developing countries. In India the prevalence of anemia among adolescent, non pregnant and pregnant women, and children under 6 years of age is seen in higher percentage. Iron deficiency and anemia reduce work capacity of individuals and entire population and obstacles to national development. Adolescent growth and development is closely linked to the diet they receive during childhood and adolescence. Adolescent may represent a window of opportunity to prepare nutritionally for a healthy adult life. It may also be a timely period to shape and consolidate healthy eating and life style behavior, thereby preventing or postponing the onset of nutrition related chronic disease in adulthood. However, eating patterns are frequently erratic in adolescents, and this may be a common factor of nutritional risk. Eating disturbances and disorders have become a leading chronic illness among adolescent girls. Number of adolescent in India particularly girls live under suboptimal conditions marked by poor nutritional status and high level of morbidity and mortality. The next generation of our country will be effected if adolescent girls who would be mother would have ill health and nutritional status.

Adolescent girls under-nutrition still remains our major public health problem. Therefore it is essential to provide nutritional education to change knowledge, attitudes and household dietary practices may be required to adolescent girls especially in rural areas and to the weaker sections of the society and to implement adolescent friendly health services at primary health care level with emphasis on nutritional counseling component. This will decrease the poorly nourished mothers in future, who are more likely to give low birth-weight babies, perpetuating a cycle of health problems which pass from one generation to another. There is a need to provide scientific information to rural as well as urban adolescent girls regarding to health, nutrition, and anemia as they are the major portion of Indian population. So there is a need to create overall awareness regarding anemia and its prevention. This will help in attaining good health, providing good information and decrease the myth about anemia, as it is necessary for healthy living and good economy of the country. The measurement of knowledge of selected communities towards anemia and nutrition is useful to health worker for researching and designing approaches in right direction. This study will also be helpful to student, researchers, people of NGO's and government and all those engaged in the field of health and nutrition to implement and create awareness through education programs.

Since iron supplementation programmes have had little reported success in reducing anemia, interest is turning to food based approaches that have higher potential for achieving far-reaching and long lasting benefit for the control of iron deficiency. Food-based approaches aim at improving nutrition by increasing the availability and consumption of a nutritionally adequate and micronutrient rich diet made up from a variety of available local and indigenous foods. Food-based approaches are recognized as an essential part of an urgently needed more comprehensive strategy to combat iron and other micronutrient deficiencies. Tondon (2002) opines that from "pill" to natural food is a difficult challenge but should be considered as the best and most natural solution to the problem of iron deficiency in India.

Food-based approaches to combat deficiencies of micronutrients deserve great attention because they are likely to be sustainable in the long term and intake of all the micronutrients will increase simultaneously.

New thinking is emerging concerning fortification and enrichment. Fortification of a micronutrient-poor staple with a concentrated micronutrient-rich food is an under explored strategy with household/community-level income generating and gender-empowering potential. Some traditional household food preservation and preparation practices, such as fermentation (e.g. of fish, soy, and milk products), favour micronutrient retention or enhance bioavailability, particularly of iron, and are important components of a household food-to-food fortification. There is a need for additional research to confirm the aforementioned observations, to explore on the manifestations of IDA in adolescent girls, to evaluate the impact of alternative methods for delivering iron and to establish the feasibility and effectiveness of food-based iron supplementation on hematological profile.

The present study emphasizes the management of iron deficiency among adolescent girls by appropriate supplement to daily diet and nutrition education. The global prevalence of micronutrient deficiency can be controlled by food supplementation, fortification and nutrition education which are the cost effective interventions, reaching a greater proportion of the population at risk than any other feasible intervention. Adequate intake of macro and micro nutrient improve the nutritional status of the vulnerable population like adolescent girls. They form a significant part of our population and the assessment of their nutritional status is relevant as healthy adolescence is a pre-requisite of healthy adult life. We all know adolescence is a phase of dynamic growth with increased demand. All these factors put the adolescent girls at high risk for deficiency state like iron and other nutrients. The major contributory factors of iron deficiency anemia are poor absorption and insufficient intake of iron.

Nutrition education and food based approach is desirable for eradicating the chronic iron deficiency. Thus, there is a need to develop nutrition intervention package including nutrition education and iron rich food supplement but at the same time it is essential to assess the efficacy of nutrition intervention package before it is suggested for public use. This study will help in the formulation of health and nutrition intervention and promotion program to reduce the prevalence of iron deficiency anemia among adolescent girls.

Keeping in view, the importance of adolescent period in human life and nutritional problem of adolescent girls, the present investigation has been planned to assess the prevalence of anemia among adolescent girls who belong to rural community. To combat iron deficiency anemia among rural adolescent girls, nutrition education material and food products rich in iron using food-to-food fortification was developed. The study also attempted to assess the efficacy of nutrition education package and iron rich food supplement in affecting the hematological parameters and nutritional status of rural adolescent girls.

Objective of the Study

1. To assess the nutritional status of adolescent girls (10 -19 yr.)

2. To estimate the prevalence of anemia among adolescent girls.

3. To study the socio-economic factors associated with anemia among adolescent girls.

4. To assess the nutrition knowledge of adolescent girls.

5. To develop nutrition intervention package including development of iron rich food supplement powder and nutrition education package.

6. To assess the efficacy of the nutrition intervention package in improving the iron status of adolescent girls.

CHAPTER-2

REVIEW OF LITERATURE

The comprehensive review of literature is an essential part of any scientific investigation. The review of literature leads the researcher to conclude the findings with references to past studies. The review gives a clear perspective of the overall field of research and allows comparing the results of the past studies in the particular field with the present research. It also provides the investigator with an opportunity to gain insight into the methods and approaches employed by other researchers and helping in formulating the research design. The available literature related to the present study has been organized systematically and presented under the following sections:

2.1. Prevalence of anemia in adolescent girls

2.1.1. Global prevalence of anemia

2.1.2. National prevalence of anemia

2.1.3. Prevalence of anemia in Rajasthan

2.2. Nutritional status of adolescent girls

2.3. Strategies for Prevention and Control of Iron Deficiency Anemia

2.3.1. Food Based Approaches

2.3.2. Supplementation

2.3.3. Nutrition Education

2.3.4. Improved Health Services and Sanitation

2.1. Prevalence of anemia in adolescent girls

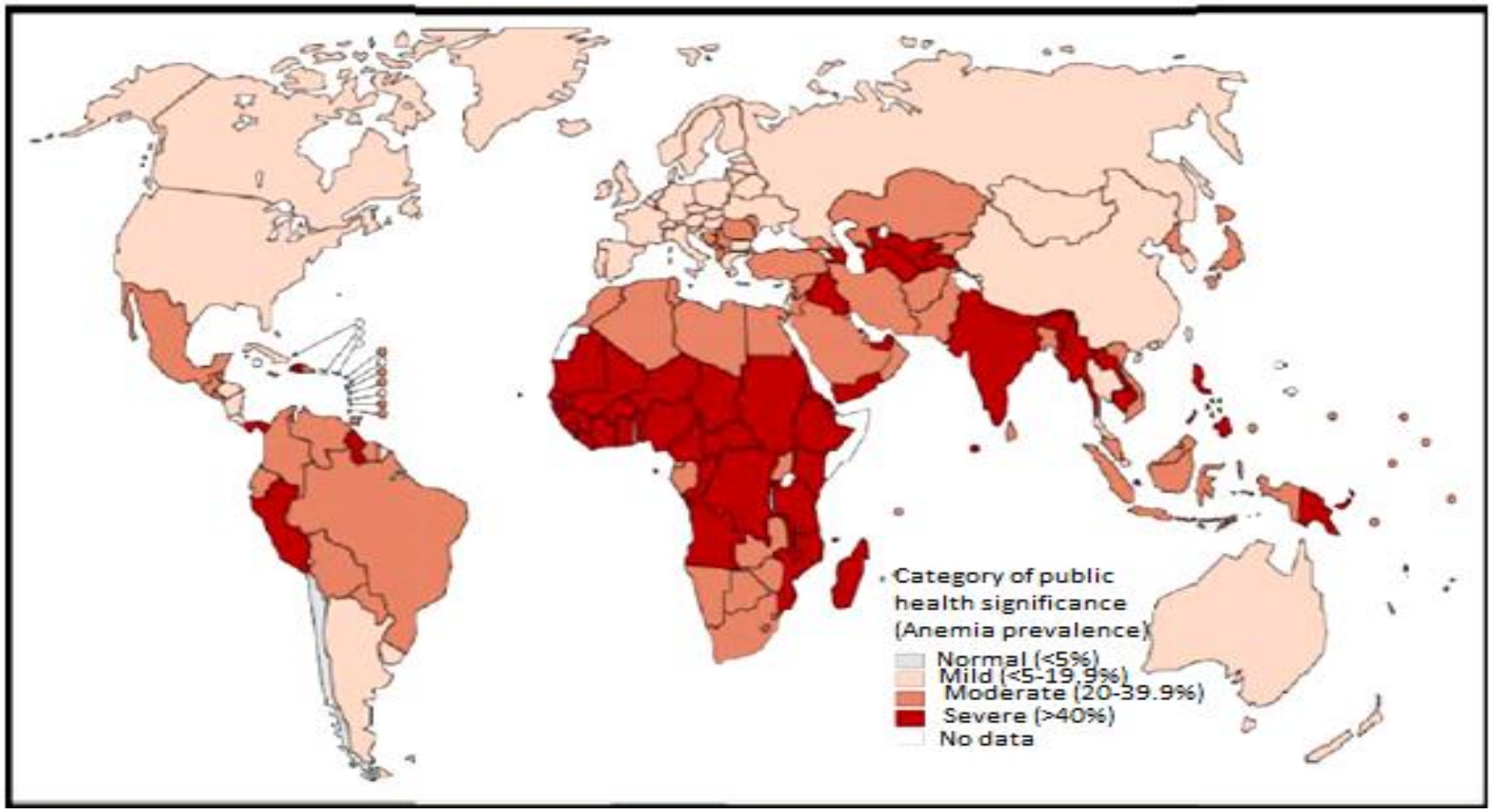
2.1.1. Global prevalence of anemia

Anemia affects 1.62 billion people in the world, which corresponds to 24.8% of the world population. The highest prevalence is in preschool-age children (47.4%). In women, anemia may become the underlying cause of maternal mortality and prenatal mortality. Nearly 50 percent of women of reproductive age are anemic. In non-pregnant women, the prevalence of anemia is slightly lower than in pregnant women. Overall, 468.4 million non pregnant women are anemic (30.2% prevalence globally). The highest prevalence is found in Africa (47.5%) and in South East Asia (35.7%). In the eastern Mediterranean region, the prevalence is 32.4%, 20.5% in the western pacific region, 19% in the European region and 17.8% in America (WHO, 2008).

Nine out of ten anemia sufferers' lives in developing countries, about 2 billion people suffer from anemia and an even large number of people present iron deficiency anemia. An alarming 600 million people in South-East Asia are suffering from iron deficiency anemia, predominantly affecting adolescent girls, women of reproductive age and young children.

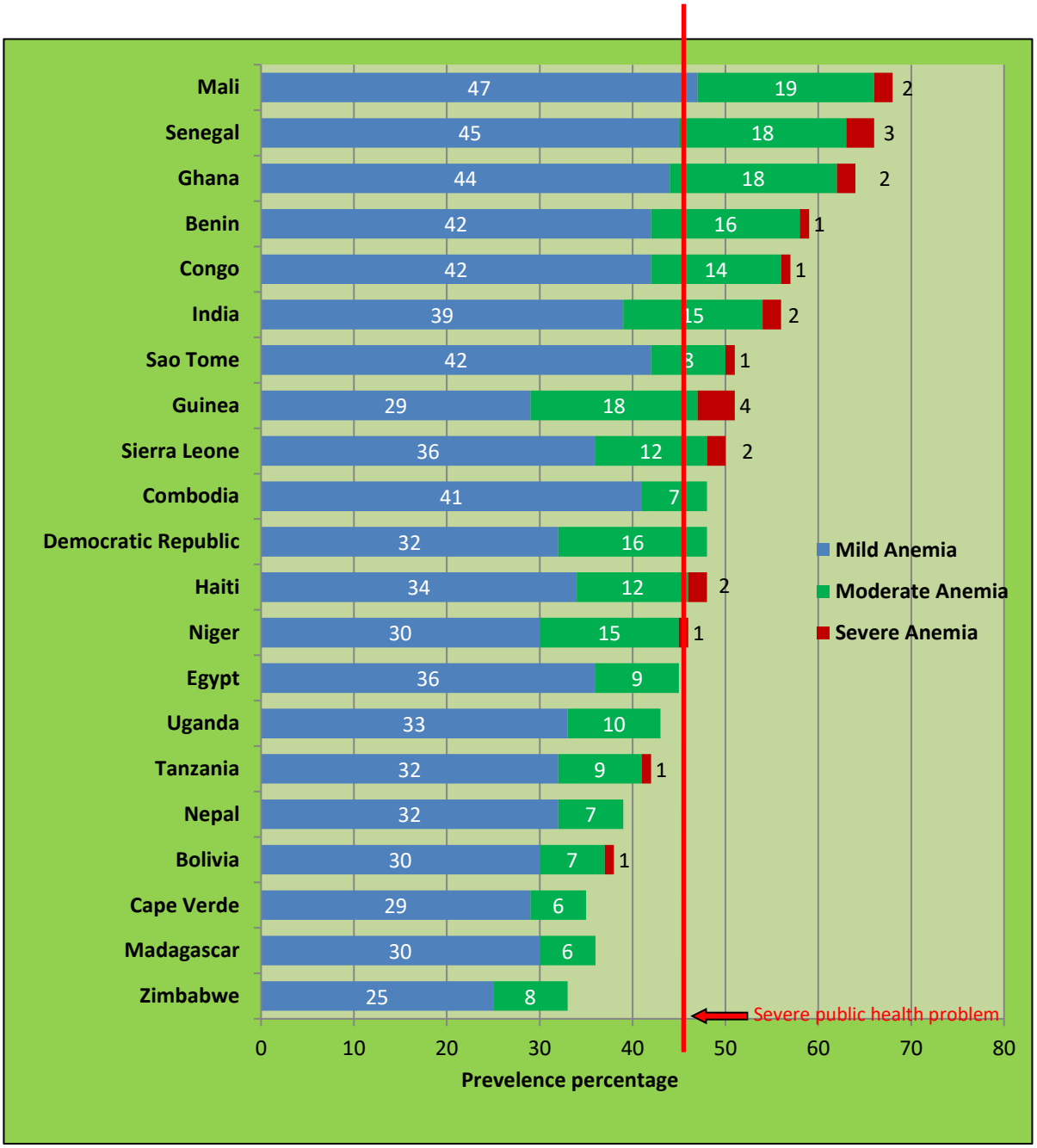
Adolescents (10-19 years) constitute about 20% of the population in South-East Asian countries. While national data on anemia among adolescent girls for all the countries of the region are not available, data from studies,(Figure 2.1) shows that in all South-East Asian countries, Thailand, more than a quarter of girls are anemic, though there is a great disparity within the region. Irrespective of the severity, the anemia prevalence among adolescent girls ranges between 17%-90% within the region. The national data from India, Nepal and Myanmar also show that adolescent anemia is a moderate to severe public health problem.

Figure: 2.1 Anemia as a public health problem by country: Non-pregnant women of reproductive age



Source: worldwide prevalence of anemia 1993–2005

Figure: 2.2 Proportion of anemic adolescent girls 15-19 years old

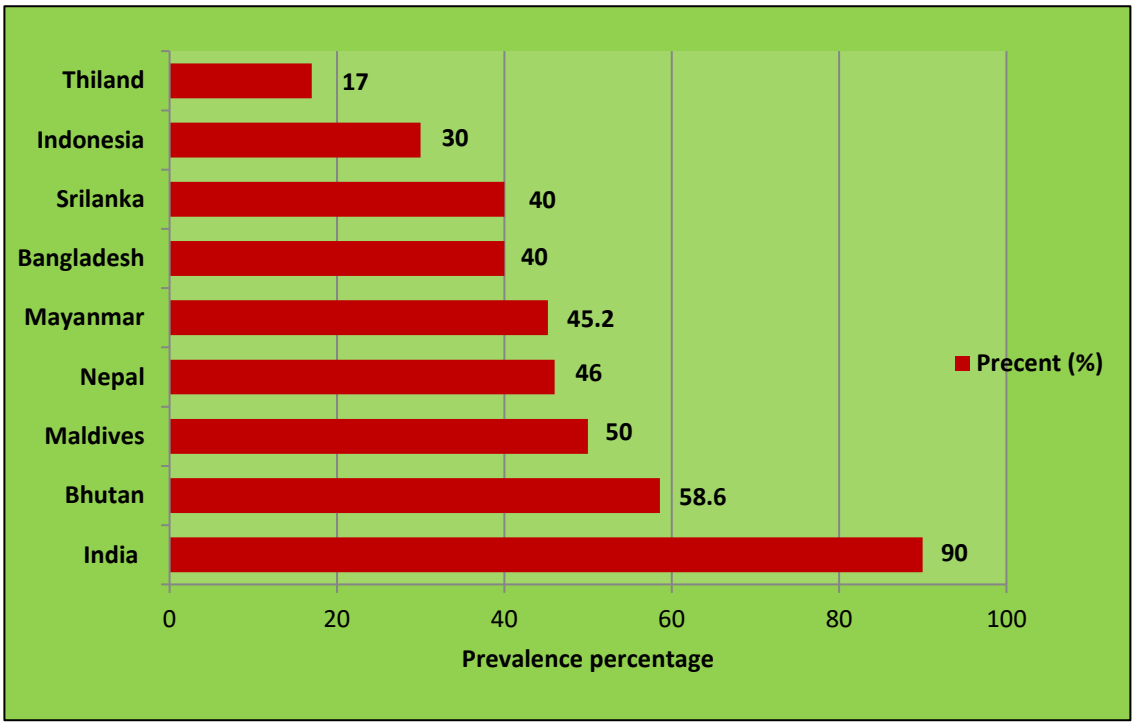


Note: Analysis based on 41 countries with available data. The vertical line at the 40% mark represent the threshold at which anemia is considered a severe national public health problem.

Source: UNICEF global databases, 2011, based on DHS, MICS and other surveys, 2005–2011.

In 21 out of 41 countries with data, more than one third of girls aged 15-19 years are anemic (Figure-2.2). Anemia prevalence is highest in Mali, where more than two third of girls aged 15-19 years are anemic. Anemic is a severe public health problem in 16 countries, the largest number of cases being found in India, where more than half of girls aged 15-19 years are anemic (UNICEF, 2011).

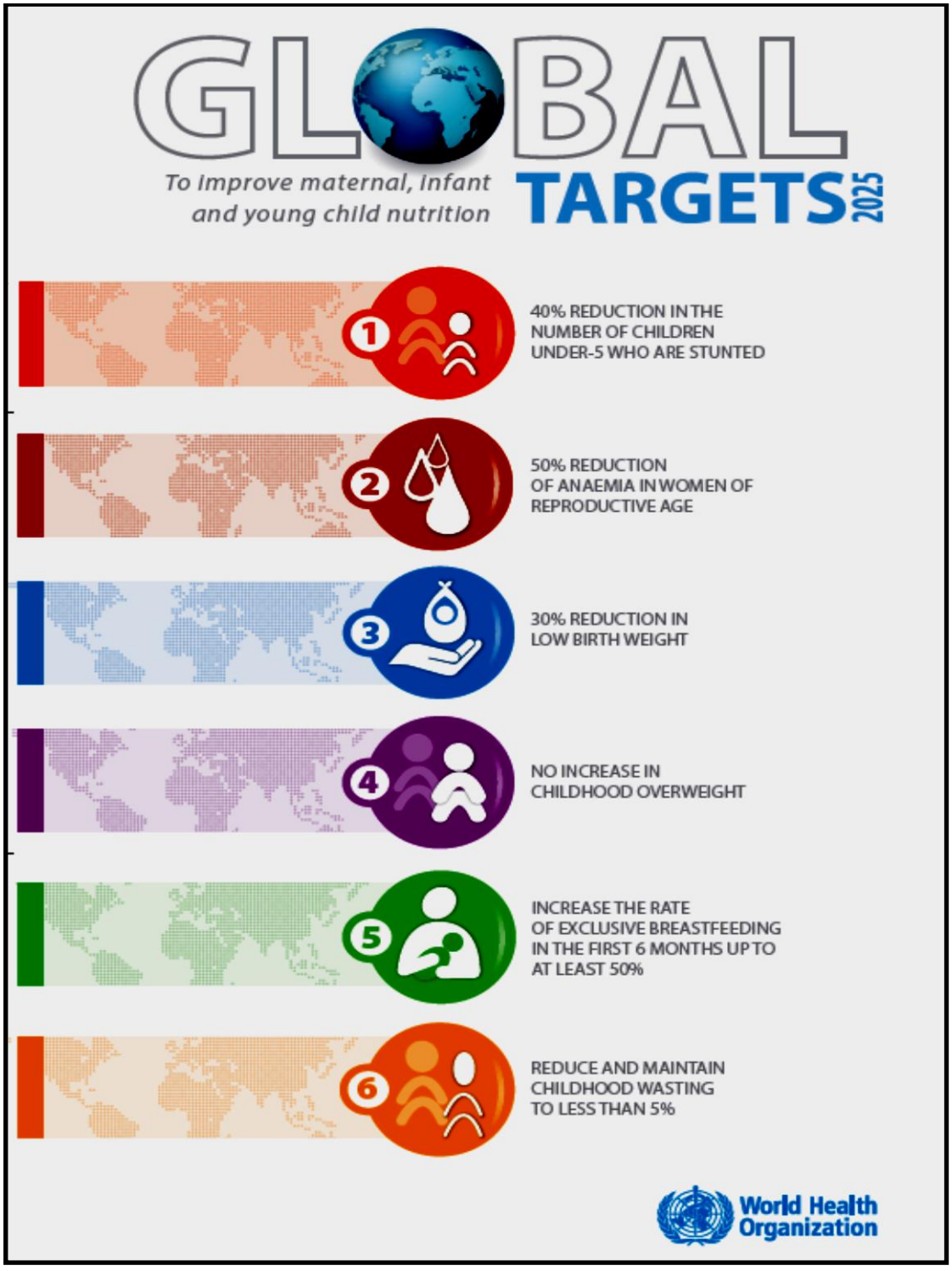
Figure: 2.3 Anemia prevalence in adolescent girls in SEAR (WHO, 2011)



Global nutrition target for 2025

In 2012, the world Health Assembly Resolution 65.6 endorsed comprehensive implementation plan on maternal, infant and young child nutrition, which specified six global nutrition targets for 2025(Figure-2.4). This policy brief cover the second target: a 50% reduction of anemia in women of reproductive age. The purpose of this policy brief is to increase attention, to investment in, and action for a set of cost effective interventions and policies that can help Member states and their partners in reducing the rates of anemia among women of reproductive age (WHO, 2013).

Figure: 2.4 Global target 2025



Source: WHO, Global targets 2025

Achieving a 50% reduction in the prevalence of anemia among women of reproductive age by 2025 will require a relative reduction in the prevalence of anemia in this group of 6.1% per year. Recognizing the complexity of anemia can lead to the establishment of effective strategies, an integrated, multi-factorial and multi-sectoral approach is required to achieve this global target (WHO, 2004).

2.1.2. National prevalence of anemia

Prevalence of anemia among adolescent is very high, according to WHO (2007) report it is ranging from 50% to more than 90%. In 2006 survey data from 16 districts in four regions of India reveal that the overall prevalence of anemia was extremely high at 90.1% in adolescent girls (11-18 years). The earlier study from western India reports, that in low income group 80-90% had hemoglobin less than 12%. In a study of adolescent girls 10-19 years in urban slum of Southern India Andhra Pradesh, anemia prevalence is reported to be 67.9%, while another study from Ranga Reddy district of Andhra Pradesh reports anemia prevalence in girls 13-18 years to be 83%. A similar high prevalence of anemia has been reported in rural Rajasthan between 73.3% to 83.4 % (NNMB, 2006), Rajvanshi et al., 2012 and Mandot and Bhanawat, 2015). About 62% of urban adolescent girls from the lower socio economic group are estimated to be anemic. Along with other population groups such as young children and pregnant women, anemia in adolescent girls is now recognized to be a public health problem.

Data from National Nutrition Monitoring Bureau (NNMB III), Indian Council of Medical Research (ICMR) and District Level Household Survey (DLHS) (Figure-2.5), have shown that prevalence of anemia is very high (ranging between 80 - 90%) in preschool children, pregnant and lactating women and adolescent girls. That way anemia begins in childhood, worsens during adolescence in girls and gets aggravated during pregnancy.

Table: 2.1 Prevalence of iron deficiency anemia in adolescent girls of India

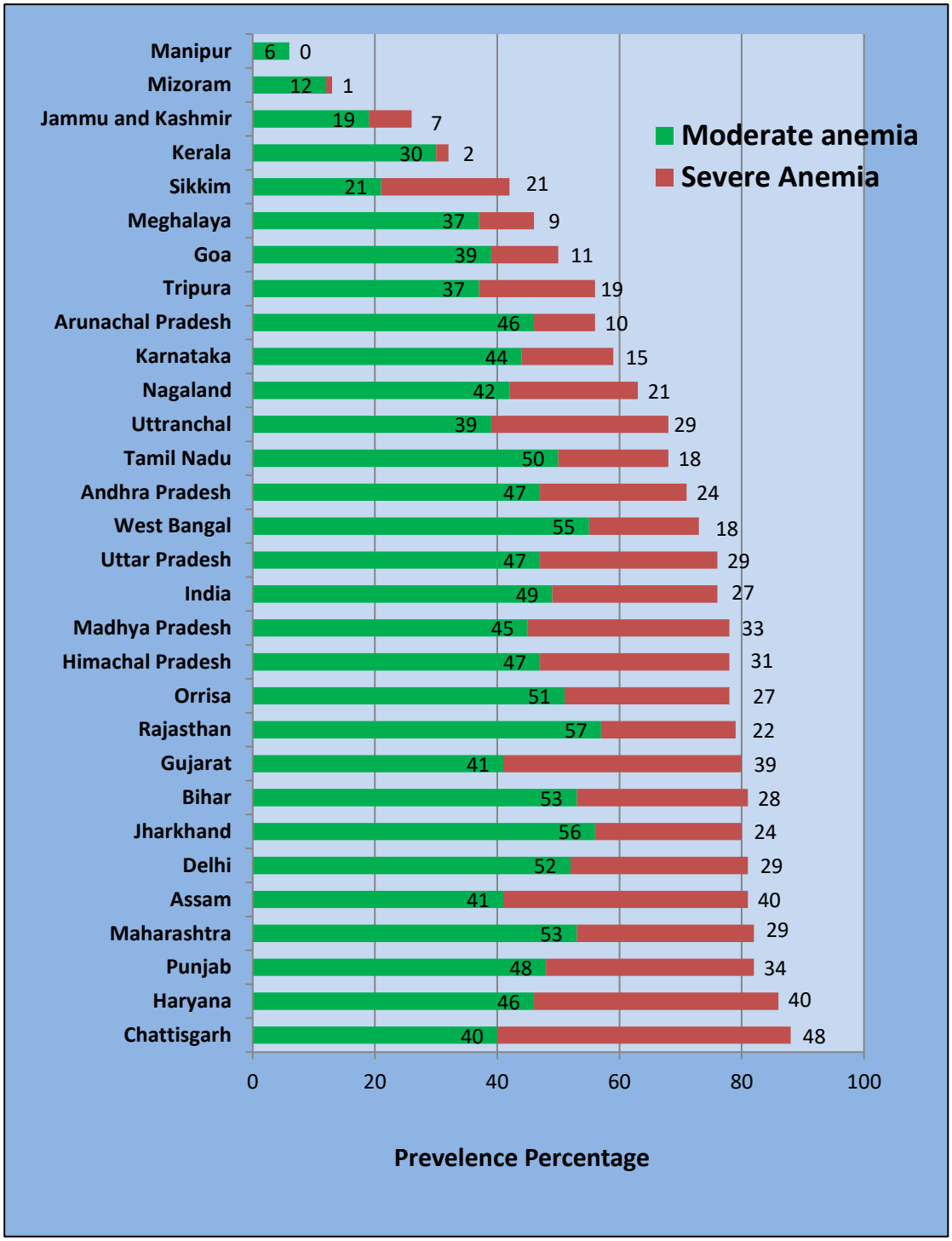
S.No.	State	Author	Year	Place	Age (years)	Total No.	Anemia %
1	Karnataka	Chapparbandi et al.	2016	Kalaburangi	10-19	318	64.15
2	Maharashtra	Jawarker et al.	2015	Amravati	10-18	350	55
3	Rajasthan	Mandot and Bhanawat	2015	Sirohi	5-15	1462	83.6
4	Haryana	Kaur and Kaur	2015	Karnal	13-15	250	88
5	Maharashtra	Gaik and Wagh	2014	Wardha	15-19	385	72.3
6	Haryana	Verma et al.	2014	Lakhanmajra,Rohtak	15-24	187	60.96
7	Maharashtra	Arlappa et al.	2014	Rural	10-19	784	62.7
8	Andhra Pradesh	Kaushik et al	2014	Gantur	10-19	150	77.33
10	Rajasthan	Choudhary et al.	2014	Bikaner	11--16	250	34.5
11	Haryana	Kaur et al.	2013	Kurukshetra	10--19	250	91.3
12	Odisha	Patnik et al.	2013	Kordha	10--19	151	78

S.No.	State	Author	Year	Place	Age (years)	Total No.	Anemic %
13	Karnataka	Birader et al.	2012	Belgaum	10-19	840	41.1
14	Maharashtra	Kulkarni et al.	2012	Nagpur	10-19	296	35.1
15	Rajasthan	Rajvanshi	2012	Bikaner	10-19	345	80
16	Tamil nadu	Premlatha et al.	2012	Chennai	13-17	400	78.75
17	Uttar pradesh	Sachan et al.	2012	Lucknow	10—19	847	57.9
18	Shimla	Geol and Gupta	2007	Shimla	10-19	350	13.3
19	Tamil nadu	Sudhagandhi	2011	Kattankulathur	8-16	900	52.88
20	Uttar pradesh	Dixit et al.	2011	Lucknow	10—19	586	83.33
21	Andhra Pradesh	Chandra shekher	2011	Kadapa	15-18	248	68.95
22	Karnataka	Siddharam et al.	2011	Hasan	10-19	314	45.2
23	Jharkhand	Bharti et al.	2009	Jharkhand	10-18	450	99.9
24	Rajasthan	Gupta and Prakesh	2009	Jaipur	10-15	190	96.3
25	Uttar pradesh	Singh,R.	2008	Meerut	10-18	556	36.5
23	Maharashtra	Choudhary and Dhage	2008	Nagpur	10-19	296	35.1

The state-level data on the prevalence of moderate and severe anemia among adolescent girls (10-19 years) are graphically presented in figure-2.6 (DLSH, 2006). In India, overall, 98 percent of adolescent girls have any anemia. Twenty two percent of them are mildly anemic, 49 percent are moderately anemic and 27 percent are suffering from severe anemia. The state of Chhattisgarh has the highest percentage of adolescent girls who are either moderately or severely anemic (88%) followed by Haryana (86%). In the state of Andhra Pradesh, Bihar, Delhi, Gujarat, Himachal Pradesh, Jharkhand, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttar Pradesh and West Bengal the combined prevalence of either moderate or severe anemia among adolescent girls is in the range of 70-80%. The state where this percentage is between 50-70% included Karnataka, Tamil Nadu, Uttaranchal, Arunachal Pradesh, Tripura and Nagaland. In the rest of the state in India, the percentage of adolescent girls who are either moderately or severely anemic is less than 50%. Among them, the low percentages in Jammu and Kashmir (26%) and Kerala (32%) are noteworthy. In India as whole, only 61 out of 542 district fall in the category of low prevalence on moderately anemic adolescent girls, 186 districts fell in medium prevalence and 295 districts in high prevalence categories. In more than 50% of the district of Uttar Pradesh, Madhya Pradesh, Maharashtra, Punjab, Haryana, Orissa and Assam more than three-fourth of adolescent girls in the age group 10-19 years are either moderately and severely anemic. The state such as Punjab and Haryana, despite being economically and agriculturally more advanced than other states, show relatively high prevalence of moderate and severe anemia among adolescent girls.

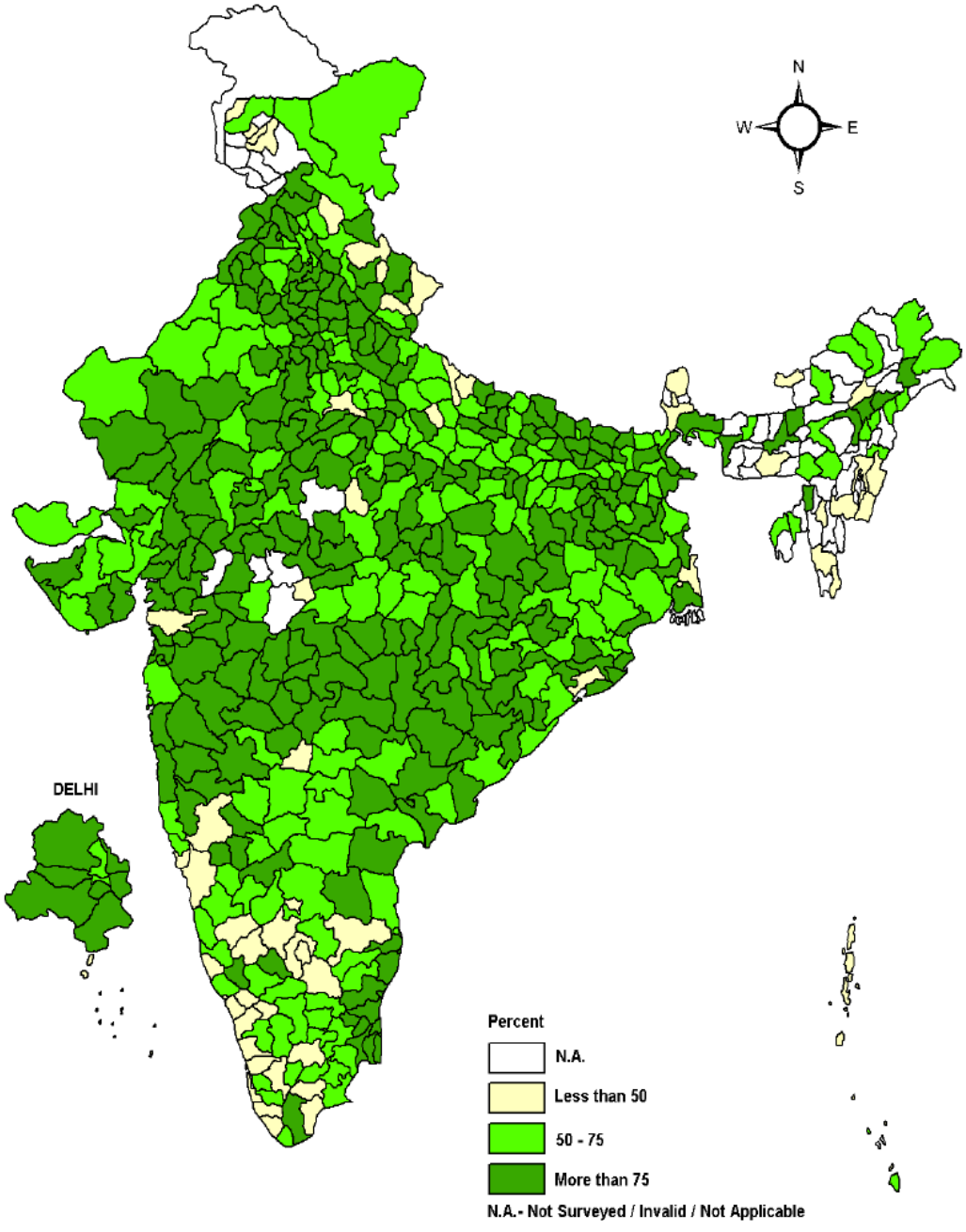
A multistage observational study was conducted by Dixit et al. (2011), to find out the prevalence of anemia in rural, urban and slum living adolescent girls. 586 adolescent girls of age 10-19 years were selected from Lucknow district of Uttar Pradesh (151 from rural, 150 from slum and 286 from urban area). Overall 83.3% of recruited girls were anemic. Almost all of the rural (100%) and slum (99.3%) girls were found anemic. Mean iron intake and blood hemoglobin level was found 20.8mg/day and 10.36g/dl respectively.

Figure: 2.4 Percentage of severely and moderately anemic adolescent girls (10-19 years) by state



Source: DLSH-RHC, India 2006

Figure: 2.5 Percentage of adolescent girls with moderate and severe anemia by district, 2002-2004



Source: Source: DLHS – RCH, India, 2002-04

The mean hemoglobin level of the girls was 10.36 ±1.41g/dl. The picture of iron deficiency anemia seen in rural and the urban girls was alarming. Poor quality of diet consumed from early childhood and early onset of menarche induce depletion of iron stores would occur at faster rate in this age group.

A cross-sectional community based study was conducted among 272 adolescent girls in an urban slum area under Urban Health Training centre, Department of Community Medicine, Nagpur (Kulkarni et al., 2012). Hemoglobin estimation was done by Shalis Hemoglobinometer. Prevalence of anemia was found to be very high (90.1%) among adolescent girls. Majority of the girls (88.6%) were having mild or moderate anemia and only 1.5% girls were severely anemic. Overall mean hemoglobin level was 10.33.±1.34. A significant association was found between adolescent girls education, mothers occupation and anemia.

Premlatha et al. (2012) estimated the prevalence of iron deficiency anemia among adolescent girls in the age group of 13-17 years and its associated factors in Chennai. Socio-demographic details and anthropometric measurements were obtained. Hemoglobin concentration was estimated by the Cyanmethemoglobin method using hemoglobin analyzer. Out of 400 school going adolescent girls, nearly 315 girls which are 78.75% were anemic with varying degrees ranging from mild, moderate and severe which were 37.5%, 35% and 6% respectively. The prevalence was higher in public schools (43.75%) than in private schools (35%). The result of the study shows that the factors such as age, literacy status of mother, type of family, community, weight, diet, frequency of intake of green leafy vegetables and fruits, menstrual discharge and deworming.

A cross-sectional study was conducted by Biradar et al. (2012), to assess the prevalence of anemia among rural adolescent girls of Belgaum. A total of 840 adolescent girls (10-19 years) were included in the study.

The details of socio-demographic variables were obtained by a pre-designed and pre-tested Performa. The blood samples were analyzed by using an automated cell counter. The prevalence of anemia was 41.1% with that of severe anemia being 0.6%, that of moderate anemia being 6.3% and that of mild anemia being 34.6%. It was observed that the prevalence of anemia was high in late adolescents (15-19 years) as compared to that in the early adolescents (10-14 years). The prevalence of anemia was considerably high among the girls who belonged to the low socio-economic status.

Koushik et al. (2014) estimated the prevalence and severity of anemia among the adolescent girls of Guntur district of Andhra Pradesh. The prevalence of anemia among adolescent girls was 77.33%. Among the anemic adolescent girls 12.06% were severe anemic, 50.86% were moderate anemic and 37.06% were mild anemic. A high prevalence of anemia was found among adolescent girls, which was considerably high in the late adolescents. Significant association was found between anemia and socio-economic status.

A community based cross-sectional study adopting multistage stratified random sampling procedure was carried out in rural Maharashtra to assess the prevalence of anemia among different physiological groups (Arllapa et al., 2014). Hemoglobin was eatimated using cyanmethemoglobin method. The overall prevalence of anemia was 59%, 61%, 76%, and 73% among pre-school children, adolescent girls, pregnant women and lactating mothers, respectively. Logistic regression analysis revealed that the risk of anemia was two times higher among pregnant and lactating women and among the subject belongs to scheduled caste and scheduled tribe communities.

Verma et al. (2014) had undertaken a study to assess the prevalence of anemia among 187 college going young women (15-24 years) who belongs to the rural communities of Haryana. The overall prevalence of anemia was 60.96%. 114 out of 187 young women had varying degrees of anemia while 39.04% were non-anemic. Out of the 187 girls, 83 (44.38%) were mildly anemic, 26 (13.9%) were moderately

anemic and 5 (2.67%) were severely anemic. The range of hemoglobin among the girls was 5.6-14.4g//dl with mean hemoglobin level of 9.9±1.09g/dl among anemic and 11.80±0,5g/dl among non-anemic girls.

Prevalence of anemia among adolescent school girls at Amravati city, Maharashtra, was assessed by Jawarkar et al. (2015). Total 350 adolescent girls were selected by random sampling from Sharda Kanya Vidyalaya, in Amravati city. The overall prevalence of anemia in adolescent girls was found to be 55%. Mean and standard deviation of hemoglobin in adolescent girls was 10.57±1.09. The contributing factors of anemia were low socio-economic status, onset of menarche, family size and vegetarian diet.

Kaur and Kaur (2015) highlighted the problem of anemia in adolescent girls of Karnal district, Haryana. Two hundred and fifty rural school going adolescent girls (13-15 years) of low socio-economic background were randomly selected from rural area. Cyanmethemoglobin method was used for hemoglobin estimation. The severity of anemia was categorized as severe (<7g/dl), moderate (7-10g/dl) and mild (10-12g/dl). Very high anemia pervasiveness (88%) with various grades was observed among the selected girls. A positive significant ($P<0.05$) correlation was observed between hemoglobin and various daily dietary intake of blood forming nutrients.

A cross-sectional study was carried out by Chapparbandi and Nigudgi (2016) to assess the prevalence of anemia among adolescent girls (10-19 years) residing in rural area of Kalaburagi, Karnataka, India. Overall all prevalence of anemia was found to be 64.15%. Majority of adolescent girls 176 (55.35%) were moderately anemic, followed by 15 (4.72%) were having severe anemia, 13 (4.09%) were having mild anemia and 114 (35.85%) were having normal hemoglobin level. The study concluded that anemia is one of the health problems, which adolescent girls are facing in rural area. Various studies done over the year in different cities of India showed a similar trend (Table 2.1).

2.1.3. Prevalence of anemia in Rajasthan

Iron status of adolescent girls (10-15 years) attending a government School in Jaipur city, Rajasthan, was assessed by Goyal and Prakash (2009). The iron status of adolescent girls was determined through hemoglobin, serium iron and serum ferritin levels. Prevalence of anemia among adolescent was 96.3%, taking the cut-off point of hemoglobin as <12g/dl. Out of 109 adolescent girls, 31.2% had mild deficiency and 65.1% had moderate deficiency. It was highest in the older age groups. This could be due to onset of menstruation in girls of higher ages and hence a lowering of their iron status. About 31% of the subjects had normal levels while the rest (69%) had low levels of serum iron and about 75% of the subjects had low levels of serum ferritin levels. The mean hemoglobin level of adolescent girls was 9.43± 1.365g/dl.

Rajvanshi (2012) conducted a survey to find out the prevalence of anemia among adolescent girls of Bikaner district, Rajasthan. The surveys finding state that 83.4% adolescent girls were found to be anemic in the district with 2.98% suffering from severe, 22.2% moderate and 58.12% mild anemia. They reported that calorific difference and low intake of iron rich food was the major reason for the problem and called for effective monitoring of the anemia control program.

Mahajan and Bhatnagar (2015) conducted a study to compare the severity and prevalence of anemia between 30 vegetarian and 30 non-vegetarian women of Udaipur city, Rajasthan. Blood hemoglobin levels of respondents were assessed using standardized techniques. Mean hemoglobin level of non-vegetarian was higher (12.07 ± 1.08 g/dl) than the vegetarian group (10.09 ± 0.95 g/dl). Forty percent vegetarians were having moderate anemia, 60 percent were mild anemic whereas 46.66 percent non-vegetarian respondents were in normal category. The prevalence of anemia was higher observed in vegetarian group. A significant difference ($P<0.01$) was found in intake of green leafy vegetable, fats and oil and sugar. As a large proportion on Indians subsist on iron-poor vegetarian diets for religious,

economic and cultural reasons, large scale iron supplementation and fortification of commonly consumed vegetarian food stuffs constitute a feasible, culturally appropriate and cost-effective strategy for addressing this major public health problem.

A prospective cross-sectional study was conducted by Mandot and Bhanawat (2015) in 8 government schools in tribal village of Sirohi district, Rajasthan over a period of 6 months. The prevalence of anemia among rural school children was assessed. Hemoglobin estimation was done using cynmethemoglobin method. Anemia was diagnosed according to the WHO standard for the given age and sex. Overall prevalence of anemia was 83.6%. Girls had a higher prevalence of anemia than boys. Menarcheal age group girls (11 to 15 years) were more anemic than boys and lesser age group girls (<11 years). Girls were at higher risk of developing anemia.

2.2. Nutritional status of adolescent girls

Adolescence is an intense anabolic period when requirements for all nutrients increase. The ultimate intention of nutritional assessment is to improve human health. Malnutrition which refers to an impairment of health from a deficiency or imbalance of nutrients is of public health significance among adolescents all over the world. It creates lasting effect on the growth, development and physical fitness of a person. Assessment of nutritional status is considered as a measure of health and it is necessary for planners to understand the food and nutrition situation among population for up-liftment of these vulnerable groups.

Several recent studies have investigated nutritional status of adolescents from different parts of India

Kokiwar and Shaw (2009) conducted a study to assess the nutritional status of adolescent girls (10-18 years) in a slum community of urban Health Center, Panangal, Andhra Pradesh. Over all prevalence of stunting was found to be 47% and 23% as per NCHS and Indian standards respectively. Prevalence of underweight was

42.6% and 22.9% as per NCHS and Indian standards respectively. Prevalence of thinness was 20.6% as per Indian standards. High prevalence of under nutrition was found among adolescent girls in this slum community.

Maliya et al. (2010) conducted a cross-sectional study on the nutritional status of 430 unmarried adolescent girls (age 10-19 year) in the four adopted villages of the Department of Community Medicine,M.G.I.M.S., Sewagram, Wardha. The mean height of the adolescent girls was 142.9±7.6cm. Overall, 57% of the adolescent were thin and 43% of the adolescent were normal. The average energy intake, which was 1239.6±176.4 kcal/day, was deficient by 39%. The average protein intake was 39.2±7gm/day. It was deficient by 36% and the average iron intake, which was 13.2±2.5mg/day, was deficient by 48%. The prevalence of thinness was significantly higher 67.6% in early adolescence than in late adolescence 54.4%. The finding reiterates the dietary deficiency among adolescent girls which adversely affects the nutritional status

A community based cross sectional study was conducted by Maiti et al. (2012) among the adolescent girls (9-19 years) resides in Paschim Medinipur district of West Bengal. Height and weight of 277 adolescent girls were measured by standard techniques and body mass index (BMI) was calculated using the following equation: BMI=weight (kg)/height (m^2). The indices of under nutrition, such as stunting and thinness were assessed by using the 2007 WHO growth reference. Stunting and thinness was defined as Z-scores below -2.0 SD. Mean BMI of girls was 15.38±3.18. The overall (age combined) rate of stunting and thinness were 50.5% and 45.1% respectively. The present study demonstrated that this vulnerable group tends to high rate of growth retardation and prevalence of under-nutrition. This may be due to inadequate food intake, health care facilities and socioeconomic inconvenience among these population propagate the vicious cycle of under-nitrition.

A community based cross-sectional study was undertaken by Baliga et al. (2014) at a village Peeranwadi of District Belgaum, Karnataka among 400 adolescent girls 10 to

19 years. The study was aimed to assess the nutritional status of adolescent girls. The overall mean weight of the study population was 29.5±8.08 kg with range being 15kg to 55 kg and mean height was 138.60±29.54cm with range minimum being 102.50 cm to maximum 165 cm. Adolescent girls between the age 10 to 14 years were more stunted (63.82%) as compared to 15 to 19 years (40.84%) (p=0.0003). Adolescent girls between the ages 10 to 14 years were more thin (60.79%) as compared to 15 to 19 years (39.43%) (p=0.0009).The average calorie intake of the subject was 1272.2 ±133.38 kcal/day and calorie intake was deficient by 35%. The average protein was 40.99 ±3.32gm/day and the protein intake was deficient by 32%, the average iron intake was 14.42 ±2.58 mg/day and was deficient by 37%. As majority of girls were having dietary intake less than 50% of RDA by ICMR, whatever cooked in home, one extra meal should be advised. The study emphasis on improvement of nutritional status of adolescent girls through counseling and health education is needed.

Gaiki and Wagh (2014) assessed the nutritional status of adolescent girls (15-19 years) in the rural part of Wardha district. Height and weight of 385 adolescent girls were measured by standard techniques. Prevalence of wasting among adolescent girls was found to be 48.05% where as 30.39% adolescent girls were stunted.

2.3 Strategies for Prevention and Control of Iron Deficiency Anemia

Iron deficiency, like most nutritional deficiencies of public health concern, is mainly a consequence of poverty. Even in developed countries, it affects a significant proportion of people in groups which are particularly vulnerable. Prevention strategies must, if they are to be sustainable, involve the input and resources of a wide range of sectors and organizations. This is especially true for iron deficiency. For example, the agriculture, health, commerce, industry, education and communication sectors should be included in any strategy (WHO, 2001). These in turn, should work in concert with communities and with local non-governmental organizations. Strategies for prevention and control of Iron Deficiency Anemia are:

2.3.1. Food Based Approaches

A food based strategy has the goal improving nutrition through increasing the availability and consumption of nutritionally adequate micronutrient rich diet made up of variety of available foods. The most successful approach to increasing consumption of micronutrient rich foods is likely to be a combined strategy that addresses both increased production (supply) and increased consumption (demand) of food. The special needs of particular groups such as children, adolescent girls and women of child bearing age require particular attention. Food based intervention programs, dietary enhancement and diversification, and food fortification including bio-fortification play a critical role in alleviating micronutrient malnutrition. Food-based strategies focus on improving the availability of, access to, and consumption of vitamin and mineral rich foods. Benefits of such food-based strategies include not only improved intakes of specific nutrients but also improved overall diets and health status. Iron therapy, in combination with dietary strategies to increase iron and vitamin C intakes, effectively treats iron deficiency anemia by raising the hemoglobin level and replacing iron stores (Thompson, 2005).

Food-based approaches to addressing IDA in India are being promoted, but information on which and what extent food combinations would improve the bio-availability of dietary iron is fragmentary. Long-term controlled consumption and feeding studies are lacking owing to the difficulty and costs of dealing with several variables in large populations. Several experimental studies on the availability of food iron and related aspects have been reported, which showed the possibility of assessing how to improve bio-availability of iron in plant foods (Allen and Ahluwalia, 1997), which should reduce the prevalence of IDA in the long run. A comprehensive review was carried out that attempted to high light how food-based approaches could improve the availability and bio-availability of iron from Indian diets.

Green leafy vegetables are good source of micronutrients. There are many varieties of green leafy vegetables, which are richest source of iron and β- carotene but they are discarded and not used properly for human consumption. Cauliflower greens are also come in this category of waste products which are often neglected. Cauliflower (Brassica oleraceae var. Botrytis) is one of the most popular cole vegetable grown extensively in India. It is belongs to family Brassicaceae. It is rich in nutrients but has highest waste index that is the ratio of non-edible to edible portion after harvesting.

The edible portion of cauliflower is curd (head), whereas, its leaves which are generally thrown away and become a part of animal feed, are also rich source of iron and β- carotene. (Kowsalya and Sangheetha, 1999). Cauliflower leaves are rich source of vitamin C, Vitamin K, vitamin A and B vitamins, including B6 (pyridoxine), B5(Pantothenic acid), B2 (Riboflavin), B3 (Niacin), and vitamin B1 (Thiamin), folate and fiber and minerals such as potassium, phosphorus, manganese, magnesium, iron and calcium. These leaves contain phytonutrients and antioxidant (Ambroson and Tang, 2009).

Thus, it can be utilized in various value added products. The leaves contribute about 50% of the total production of cauliflower. The leaves of cauliflower are available only for a short period but this can be dried and stored for use during lean season. Dehydrated leaves are also rich source of iron and β- carotene (Singh et al., 2005).

Mundra and Mathur (2000) studies the influence of incorporation of leaf concentrate(LC) prepared from a variety of green leaves to alleviate the anemic conditions of twenty adolescent girls (20-23 years) the control group was provided plain diet (without LC), while the experimental group was daily supplemented with 6g LC for three months. A significant increase ($P<0.05$) in the Hb values from 11.5g/dl (13%) was observed for the experimental group. While that of control was 2.2% indicating a tremendous potential for overcoming anemia through consumption of natural food sources.

Mohan and Bhavani (2004) assessed the efficiency of cauliflower green in improving blood hemoglobin level of adolescent girls. Cauliflower leaves were looked in the traditional South Indian poriyal form. Twenty girls in the group of 20-22 years selected and grouped into control and experimental group for the feeding trial. In the feeding trial, the standard recipe of cauliflower leaves containing 15g of iron was given to those adolescent girls whose hemoglobin level were below 12g/dl for 100 days. Mean blood hemoglobin level before feeding trial in both the control and experimental group were found to be 10.32+0.93g/dl and 10.6+1.32g/dl and after feeding trial in the respective group it was 10.3+0.89g/dl and 13.56+0.35g/dl respectively. There was significant ($t=9.4$, $p<0.05$) rise in the hemoglobin level of the experiment group. The study suggests that it can be effectively used in improving the hemoglobin level of blood by incorporating into food preparation.

Singh and Kawatra (2006) prepared cake, biscuits, pakora, vada, namakpara and kurmura using fresh and dried powder of amaranthus leaves and analyzed for various nutrients. Protein content of all the products ranged from 7.4g/100g in biscuits and 17.9g/100g in vada. β-carotene content in products prepared from ameranthus was observed to be maximum in namakpara(3.7mg/100g) and minimum in cake(1.1mg/100g) prepared from dried leaves. Total iron content ranged from 5.1mg/100g in biscuits (dried leaves) to 12.4mg/100g in vada (fresh leaves). Ionizable iron content of amaranthus products ranged from 1.3mg/100g in kurmura to 2.9mg/100g in biscuits prepared from dried leaves. Copper, manganese and zinc content of amaranthus products ranged from 0.20 to 1.10mg/100g, 0.80 to 2.43mg/100g and 0.40 to 2.38mg/100g respectively. Biscuits contained maximum manganese prepared from dried leaves. Results revealed that products developed from fresh and dried amaranthus leaves contained appreciable amount of iron and β-carotene. It can be concluded that these products are incorporated in the diet of people and it can improve the health status of vulnerable group.

Banga and Mogra (2008) developed cauliflower leaves powder (CLP) by drying cauliflower leaves for 22 hours at 40°C in mechanical dryers. Varying amount of leaf powder was incorporated in food snacks like sandwich, tikki, khaman, chowmein and burger and evaluated for sensory characteristics on nine point hedonic scale. Incorporation of CLP at 10 percent level scored highest in comparison to 5 and 7 percent. The mean overall acceptability scores at 5, 7 and 10 percent were 7.6, 7.7 and 7.9 for chowmein, 7.5, 7.7 and 8.0 for burger, 7.7, 7.8 and 8.0 for khaman, 7.3, 7.5 and 7.7 for sandwich and 7.8, 7.9 and 8.0 for tikki respectively. CLP contain 17.67% protein, 15.32% ash, 8.2% fiber, 3600 mg calcium, 368mg phosphorus and 36mg iron per 100g. It was concluded that CLP can serve as a source of micronutrients in diet.

Nutritional composition of cauliflower (Brassica oleracea) leaf powder and its acceptability in fast food snacks was examined by Mogra et al. (2012). The process of drying of leaves in mechanical dryer was standardized after taking trials for different temperature and time period. On the basis of organoleptic characteristics of powder, the leaves dried at 40°C temperature for 22 hrs were finalized. Cauliflower leaf powder (CLP) was then analyzed for their nutritional and anti nutritional composition. On dry weight basis CLP contained 12.55g moisture, 17.67g protein, 1.76g fat, 8.20g fiber, 15.32g ash per 100g. Energy was found to be 256kcal. Calcium, phosphorus and iron were 3600mg, 368mg and 36mg, respectively. CLP developed from cauliflower leaves serve as a source of micronutrients. Thus, CLP need to be popularized which will be helpful in overcoming micronutrient deficiency diseases.

Wani et al. (2011) examined the effect of cauliflower leaf powder on proximate composition of noodles during storage. The alterations in the chemical constituents (moisture, protein, fat, ash and fibre) of noodles were examined by adding cauliflower leaf powder to the noodle formation at the level of 0, 10, 15 and 20% flour weight basis. The sample of cauliflower leaf powder added noodles, for all addition levels, contained more protein, fibre and ash as compared to control sample.

Cauliflower leaf powder added acceptable noodles in term of physico- chemical and sensory properties could be produced by incorporating cauliflower leaf powder into roasted wheat flour up to the level of 10 percent flour weight basis. They concluded that the incorporation of cauliflower leaf powder in noodles up to 10 percent along with roasted wheat flour not only improves the texture, taste and overall acceptability but also improves the nutritive value of these products without adding much to the cost of the products and cauliflower leaves, which are generally thrown away, can be utilized in a better way thus reducing wastage. Thus, cauliflower leaf powder could be successfully used to enrich noodles, giving alternative utilization opportunity to producers and healthy choice option to the consumers

Proximate analysis and sensory qualities of cookies developed from Moringa leaf powder with wheat flour were evaluated by Muluken et al. (2014). Moringa stenopetalla leaves powder (MLP) and wheat flour were blended in the ratio of 0:100, 5:95, 10:90, 15:85 and 20:80 by using mixture simplex lattice design. Crude fibre (2.72-7.15%), ash (0.94-3.02%) and crude protein (6.57-9.59%) contents were significantly increased ($P<0.05$) while crude fat (20.96-18.73%), moisture (7.98-6.84%), carbohydrate (63.56-61.83%) and gross energy (469.12-454.23KJ/100g) of the cookies were decreased ($P<0.05$) as the ratio MLP increased in the blend ratio. The sensory acceptability of cookies decreased significantly with increasing in MLP ratio. The overall acceptability results confirmed that the 5% MLP blended (T2) cookies was more accepted than the others.

Chouhan and Intelli (2014) developed low cost fiber rich product suffering from micronutrient deficiency and assessed the sensory quality of developed products. The fresh collected cauliflower leaves were washed and sun dried for 5-7 days to dry them. Three recipes (pancake, dhokla and idli) were supplemented with 2g and 5g DCGLP per serving and sensory evaluation was done with the help of 9 point hedonic scale in reference to appearance, taste, texture and flavour by 9 panels of semi trained judges. Biochemical analysis of DCGLP revealed moisture 3.4 percent,

protein 21.6 percent, crude fibre 10.23g and iron 62mg/100g. The prepared recipes were found to be acceptable at 2g incorporation. It was concluded that increase in the incorporation of DCGLP in recipes was decreasing acceptability. DCGLP, due to its high iron content can be used as supplement to make low cost iron rich recipes.

Bhvaneshwari and Ramya (2014) incorporated the dried form of Brassica oleracea leaves (cauliflower greens) powder in the common recipes to increase the nutrients. The fresh cauliflower leaves were washed and shadow dried at 27-37°C and the leaves were made into powder. In order to estimated the nutrient analysis by using AOAC procedure cauliflower leaves was found have high vitamin C (54.27mg/100g), Beta-carotene(42.58mg/100g) and iron(60.78mg/100g). The sensory evaluation was done using five point hedonic scales. Three recipes were prepared with and without incorporation of the developed cauliflower leaves powder. The powder was incorporated in 5%, 10% and 15% level in chocolate, cookies and green gram. Only 5% cauliflower leaves powder incorporated recipes were highly acceptable. The effectiveness of the cauliflower leaves for the acceptability of the recipes has been found to be good.

Micronutrient rich composite powder using under-exploited Panicumsumatrense (Samai), Brassica oleracea(Cauliflower leaves) and Phyllanthusacidus(Star gooseberry) was formulated by Murugesan and Arjunan (2015). The dehydrated powder were found to be energy dense with cauliflower leaves being highest (455.94 kcal) followed by samai (452.30 kcal) and star gooseberry (350.22 kcal) respectively when compared to its fresh form. Among the micronutrient composition, the iron content of samai extract powder was 100mg percent which was ten-fold higher than in its whole form (9.3mg). Composite powder at 10% (samai 6.25%, cauliflower leaves 2.5% and star gooseberry 1.25%) and 20% level (samai 12.5%, cauliflower leaves 5% and star gooseberry 2.5%) was incorporated in commonly consumed Indian recipes such as chapatti, idiyappam, paniyaram, dosa, idly, upma and cake and evaluated for its sensory attributes (appearance, color, texture, flavor and taste) over standard (control) recipes using five point hedonic scale by semi-trained (N=25)

panel members. The recipes were highly acceptable till 20% of composite powder incorporation. All the recipes had huge increase in the iron (over ten-fold) and vitamin C content (16 times) upon 20% incorporation of processed composite powder. The under-utilized plant foods such as samai, cauliflower leaves and star gooseberry, upon processing had significant amount of micronutrient which could be used extensively daily diet as a concentrated source of micronutrients to tackle micronutrient malnutrition especially iron deficiency anemia.

Basic food mix was formulated and evaluated for acceptability, nutrient content, antinutritional factor and shelf life by Usharani and Lakshmi (2015), using foods like bengal gram, black gram, carrot, tomato and cauliflower leaves. Among the food mixes developed, basic health mix and variation 1(Amla) provided 384 and 333kcal of energy per 100 g , 69.10 and 59.81g per 100g of carbohydrate, 12.8 and 15.57g per 100g of protein , 3.07and 3.43g per 100 g of moisture respectively. Dietary fiber content of variation 1 was the maximum with 8.16g/100g followed by basic health mix had 8g/100g. Among the minerals, variation 1 contained a higher amount of calcium 419mg/100 whereas basic health had 180mg/100g. Iron content of basic health mix was only 2mg whereas variation 1 had 3.9mg/100g. Functional food mixes can be effective for treating patients with chronic disease like hypertension, diabetes mellitus, arthritis and cardiovascular disease etc.

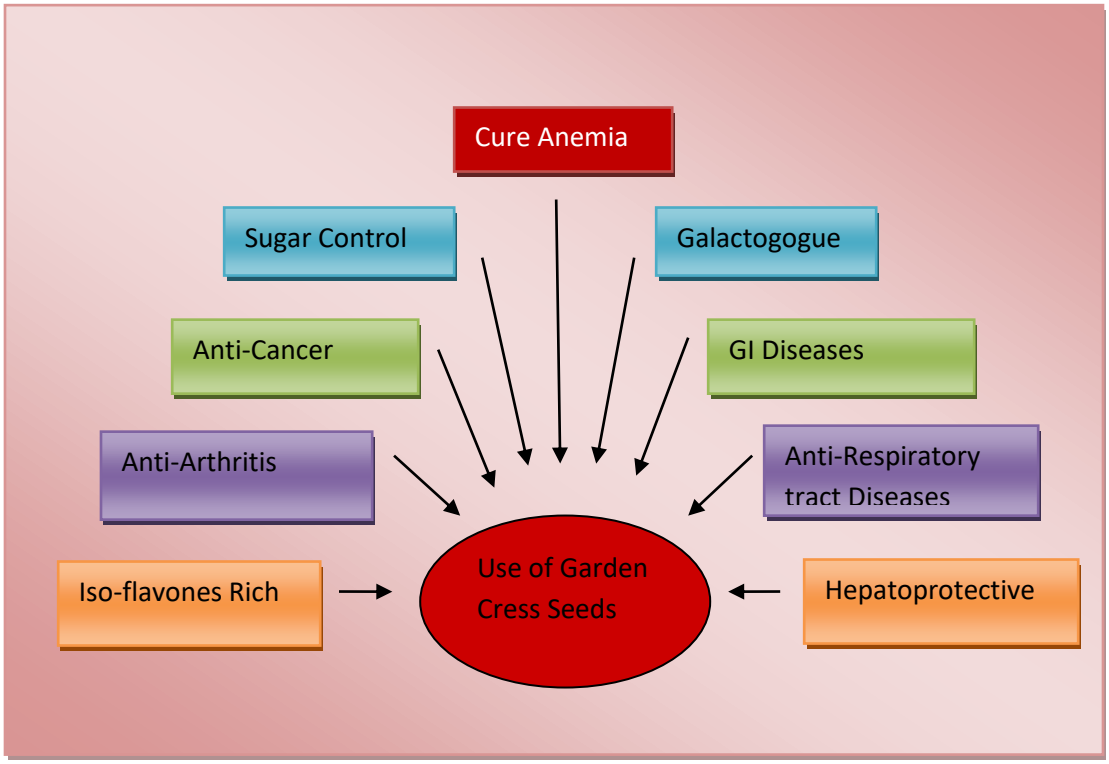
The nutritional potential and acceptability of leaf mixtures(LM) prepared from the less-utilized leaves of beet root (Beta vulgaris), carrot (Daucus carota), cauliflower (Brassica oleracea) and turnip(Brassica rapa) which are usually discarded or are used as animal fodder were analyzed by Mathur (2015). The LM was prepared by mixing the powders of above mentioned greens in a definite ratio (1:2:1:1). The LM was analyzed for the proximate, mineral composition (Ca, P, Fe, Cu, Zn, Mn and Mg) and antinutritional factors (oxalate and phenols). In total, 20 different recipes with different levels (0, 5, 10, 15 and 20 percent) of LM incorporation were prepared and were assessed for quality on the basis of sensory attributes. All the product were

well accepted to the level of 10 percent. Protein, iron and calcium content was significantly ($p<0.05$) higher in the LM-incorporated recipes.

Garden cress seeds

Lepidium sativum (Garden cress seed) belonging to Cruciferae family, widely grown in India, Europe and US. It has considered as an important medicinal plant since the Vedic era. Garden cress seeds are used as a medicin in Ayurvedic system of Medicine. Lepidium sativum description is available in the Ayurvedic classical text with the name as Chandrasoor, Chandrika and Vasapushpa. Garden cress seeds are bitter, thermogenic, depurative, rubefacient, galactogogue, tonic, aphrodiasiac, ophthalmic, antiscorbutic, antihistamines, emmenagogu and diuretic (Figure-2.7). Also, it has health promoting properties which can be used as a functional food. It is also useful in the treatment of desentry , pain in the abdomen, blood and skin disorder, injuries, tumors and eye diseases. Garden cress seeds may stimulate the production of breast milk and prevent postnatal complication (Dwivedi et al., 2016).

Figure: 2.7 Therapeutic uses of Garden Cress Seeds



Garden cress seeds are richest source of non-heam iron, which helps to increase the hemoglobin level. When taken regularly, it helps to alleviate anemia. It is advisable to have vitamin C half an hour after consumption of these seeds as it enhance iron absorption (Zanvar and Devi, 2007). Gardes cress seeds have mild oestrogenic properties. It helps to regulate the menstrual cycle. Garden cress seeds help the human body to reduce oxidative damage when the natural mechanism of antioxidant protection becomes unbalanced by factors such as ageing, deterioration of physiological functions may occur resulting in diseases like cancer, cirrhosis, various inflammatory diseases and accelerating ageing. Due to high free radical scavenging potential leads to consumption of mixed or balanced diet may show rich nutritional as well as medicinal value of garden cress seeds.

Zanvar and Devi (2007) developed supplementary food like iron rich biscuits by using locally available iron rich food stuffs i.e. garden cress seeds and rice flakes. Prepared biscuits were tested for its acceptability. Among all the variation of biscuits, variation III was highly accepted for all sensory characters. It contained 29.61g of fat, 0.99g fibre, 2.8g protein and 6.11g minerals. The major minerals such as calcium and phosphorus were low in developed products. However the iron content was 13.16mg/100g and ionisable iron content 3.22mg/100g, whereas percent bioavailability of iron was found to be 12mg/100g.

Agarwal and Sharma (2011) prepared laddo and baal ahar by using garden cress seeds as one of the ingredients were nutritionally better than standard because garden cress seeds were reported to have rich in protein, iron and calcium because endosperm of garden cress seeds were concentrated source of protein and fat. Both the products were accepted as found on the basis of acceptability studies involving sensory evaluation. But ladoo were more acceptable (83.75±12.5), where as baal ahar were less acceptable (58.81±13.17) in comparison to ladoo. Baal ahar and ladoo are nutritionally sound for anemic person as this contains very good amount of iron (7.84mg/100g) and less amount of anti nutrients as tannin, mostly present in seed coat which is significantly reduced during milling.

Gupta and Singhal (2011) assessed the effect of garden cress seeds and amla intervention on hemoglobin level of non-pregnant (18-25 years). Ten gram garden cress seeds per day were given to experimental group I for 3 months which provided 10 mg iron per day while 10 gm garden cress seeds with 10 gm amla chutney were provided to experimental group II for 3 months. It was found that inclusion of garden cress seeds with vitamin C rich food, which have high content of iron, on a daily basis effectively, increased hemoglobin level in those respondents who have low initial hemoglobin level.

Shivkami and Sarojini ((2013) reported that ten different variation of value added biscuits were developed in which of them one variation was developed by using of garden cress seeds powder. Biscuits (100g) contained 492 kcal, 9.14g protein, 26.43g fat, 55.03g carbohydrate and 18.84mg iron.

Sood and Sharda (2013) developed a locally produced supplement food (laddo) composed of jiggery, processed rice flacks, garden cress seeds and amaranth leaves in the preparation of 45:40:10:5. The product was acceptable and each laddo contributing approximately 30mg iron.

Agarwal and Sharma (2013)prepared different form of garden cress seed powder (GCSP) such as whole GCSP, husk removed GCSP, husk GCSP , roasted GCSP and microwave processed GCSP. Mathri was developed by incorporating different forms of GCSP at different level (2.5%, 5% and 7.5%). They found that only 5% incorporation gave the acceptability scores of sensory analysis. Mathri incorporated with 5% husk removed GCSP showed maximum overall acceptability score of 7.66 next to standard (8.46) mathri. Authors reported that GCSP incorporated mathri is more nutritious than standard mathri and has the potential to act as nourishing as well as therapeutic agent due to antioxidant potential of garden cress seeds.

Nathiya (2014) developed cereal based cookies prepared using garden cress seeds which is a rich source of iron. Cookies were prepared using oats, wheat flour, soybean flour and garden cress seeds. Variation in the cookies were brought about by

incorporating three different quantities (10g, 20g and 30g)of garden cress seeds which is rich in iron. The control was prepared excluding the addition of garden cress seeds. It was concluded that the cereals and garden cress seeds cookies were an excellent source of protein and iron. The study also shows that no bitter after taste was sensed in the cookies up to the addition of 30g of garden cress seeds per 100g of cookies dough. Therefore, this amount can be safely added to the cookie dough.

The garden cress biscuits were prepared by incorporation of garden cress seeds powder (Lepidium sativum) in biscuits. Garden cress seeds were used as 05, 10, 15 and 20% level to prepare biscuits. Prepared garden cress seed biscuits were analyzed for physical analysis and chemical analysis. Protein, fat, moisture and ash content were 6.25, 17.76, 1.98 and 2.74g/100g respectively. On the basis of overall sensory attributes, color of sample 100:10% has better appearance as compare to 100:05% and 100:15%. Flavor, aroma, taste, after taste and overall acceptability of sample 100:10% has got higher score than sample 100:05% and 100:15%, because of dark browning color of garden cress seeds biscuits. The overall acceptability of biscuits, the texture and color of garden cress seeds biscuits was significantly affected by increased level of garden cress seeds powder. After chemical analysis it was found that sample 100:15% had high percentage of protein and other nutrients it was concluded that on the basis of sensory evaluation garden cress seeds can be substituted up to 10% in wheat flour to prepare garden cress seed without adversely affecting quality attributes (Patil et al., 2015).

Sheeba and Sabitha (2016) assessed the effect of Garden cress seeds (Lepidium sativum) incorporated chikkies on the selected anemic adolescent of the age group (12-18 years). Screening of anemia was conducted by assessing hemoglobin levels of 500 adolescent girls. From that 100 moderately anemic adolescent girls (each 50 in the experimental and control group) were chosen for further study. Hemoglobin status and RBC count of the selected subjects was assessed both before and after supplementation. Clinical examination was carried out. A chikkie of twenty grams containing garden cress seeds (3g), groundnut (10g) and jaggery(7g) was

supplemented to fifty selected moderately anemic adolescent girls in the experimental group daily for a period of 3 months. The chikkie contained 3.5mg of iron. Control group were given only plain chikkie without incorporation of garden cress seeds. The hematological parameters namely Hb and RBC count gradually increased from 9.624g/dl to 12.14gdl and 3.207 million cells/mm3 to 4.044 million cells/mm3 respectively. There was significant improvement in parameter of experimental group and there was no specific change in control group. It proves that the supplementation of garden cress seeds incorporated chikkies had a significant effect on the hematological parameters of the anemic girls.

Rice flakes

Paddy (Oryza sativa L.) is a semi aquatic, annual grass which can be grown under a board range of climatic conditions. India is a major paddy producer with an annual production of about 159.20 MMT during 2013-14 and contributes to one-fifth of the global rice production (FAOSTAT, 2015). Paddy grain consists of husk, bran and endosperm, the latter used as a rice kernel. Processing of paddy before its consumption is important for the removal of hull to get brown rice. Further milling eliminates bran and germ from the rice kernel forming white or polished rice (Buggenhout et al., 2013). Flaked rice is obtained after processing of paddy and its further processing yields flaked rice of very low thickness with relatively lower weight and whiter color than normal flaked rice. Flaked rice is rich source of carbohydrates, protein, vitamin, minerals, phytochemicals and essential amino acids. The phytochemical content of flaked rice viz. y-oryzanol has many health benefits as it lowers down the total blood cholesterol and decrease risk of heart disease (Bhattacharya, 2011). Flaked rice generally consumed as breakfast item, snacks and savory is specific to particular regions in India. Flaked rice is a precooked product and is consumed with soaking either in milk or in curd (Kumar and Prasad, 2013).

Gupta et al. (2012) developed low calories ready- to- eat snack (rice flakes mix) by incorporating edible dehydrated herbs, high in nutritional value and rich in micronutrient viz. mint (Mentha asiatica), basil (Ocimum basilicum), drumstick leaves (Moringa oligfera), ginger (Zingiber officimale), garlic (Allium longicuspis)

and lotus stem (Nelumbo nucifera). These herbs were analyzed for proximate and mineral content which were then incorporated into rice flakes with one control (T0) and four treatments T1, T2, T3, and T4 at 4, 8, 12 and 16 % incorporation level of herbs using their standard ingredients and method of preparation. The developed rice flakes mix was analyzed for nutrient composition and organoleptic evaluation. Results showed that moisture, fat, Protein, carbohydrate, energy and fibre content of the dehydrated herbs ranged between 5.02- 11.3g, 0.76-5.91g, 4.06-19.85g, 38.1-72.71g, 205-346kcal and 9.86-40.91g, while calcium and iron content of selected herbs ranged between 80-2112.5mg/100g and 2.75-87.4mg/100g respectively. The developed herbal rice flakes mix was highly acceptable by the subjects and notable change in nutritional value of developed rice flakes mix was observed when compared to the control. Except carbohydrate and energy remarkable increase was observed in the nutrients such as protein, fat, fibre, calcium and iron in the developed rice flakes mix compared to control. The rice flakes mix can therefore be recommended for intervention among anemic subjects as well as among others for improving nutritional status of the population.

Lotus stem

Nelumbo nucifera(Family Nymphaeaceae) commonly known as Indian lotus is an aquatic herb with stout creeping yellowish white coloured rhizome. The stem is used in indigenous Ayurvedic medicine as a diuretic, anthelmintic, to treat strangury, vomiting, leprosy, skin disease and nervous exhaustion. Lotus stem is an underwater vegetable whose consumption is confined indigenously to the cuisines of South-east Asia. People familiar with lotus stem consume it because of its mild sweet flavor, for its novelty as a vegetable or as part of their cultural food habits. A large proportion of people also consumed lotus stem in their food (raw or fried) or as lotus stem tea for its therapeutic properties. The health benefits of lotus stem are that it is rich in proteins, iron, calcium, omega-3 and omega-6 and potassium and low in sugars. In addition, alkaloids present in lotus stem have proven nutraceutical properties (Vora and Srinivasan, 2015). Lotus stem encompasses rich amount of polyphenolic

compounds, which exhibit rich antioxidant properties. Lotus stem is beneficial in the treatment of various disorders like anemia, osteoporosis, bowel diseases, fungal and viral infections, various degenerative diseases and fever also. Lotu stem is also known as kamal kakadi, is a rich source of iron and the data on supplementation of lotus stem on iron nutriture of the adolescent girls have shown positive results (Du H et al.,2010 and Kowsalya and Shimpray, 2008).

A study on the impact of lotus stems supplementation on the hemoglobin status of the college students (17-19years). After screening 62 girls were selected for supplementation and their dietary data was gathered (24 hour dietary recall). Majority of the girls had nutrients deficiency of energy, protein and iron but sufficient in vitamin C. During supplementation phase (8 weeks), the food supplements i.e. providing lotus stem biscuits to the experimental group and plain biscuits to the control group. Height, weight and hemoglobin levels were assessed both in the pre supplementation and post supplementation phase. Data indicate a significant impact of supplementation on various parameters. Hemoglobin level of the experimental group was increased from 11.20g/dl± 0.95 to 13.13 g/dl ± 1.25. Thus, food supplementation can be looked upon as effective long term measure to control and prevent iron deficiency anemia (Sehjpal and Gupta, 2007).

Jain et al. (2012) developed ready to cook extruded product using an indigenous composite powder rich in micronutrients. This composite powder named 'Udaipur ACRIP Mix' was developed by foods and nutrition unit of ACRIP on Home Science and is rich in vitamin A and iron. This indigenous powder mix was prepared from dried carrot, spinach, mint lotus stem, rice flacks and niger seeds powder in the ratio of 1:2:1:9:3:4 respectively. The reference extruded products were prepared with wheat, bengal gram and maize flour in the ratio of 30, 25 and 45 percent respectively. Whereas in experimental products, ACRIP Mix powder were added in different ratio i.e. 5, 10, 15 and 20 percent with the replacement of maize flour. Addition of ACRIP Mix up to 10 percent in raw material was found most acceptable at nine point hedonic scale. The mean scores for organoleptic characteristics of sweet

and savory snack developed with composite flour ranged from 7.8 to 8.7 at nine point hedonic scale. The control and experimental product were analyzed for their proximate and iron composition by the standard method. The protein, fat, energy and iron content for reference was 12.25g, 1.45g, 381kcal and 4.58mg, respectively. While with addition of ACRIP mix 10 percent, contain protein 15.31g, fat 4g, energy 410kcal and iron 11.68mg. The extruded product stored for three month for its shelf life evaluation and showed no significant difference in organoleptic quality during the storage of product.

Sensory attributes and nutritional value of lotus stem flour products were evaluated by Gupta and Dubey (2013). Lotus stem were incorporated in wheat flour recipes viz- Ladoo and Noodles with one control (T0) and four treatments for each products T1, T2, T3 and T4 at different percentage incorporation levels with lotus stem flour for all two products using their standard ingredients and method of preparation. Sensory evaluation of the prepared products was done by 9 point hedonic scale. The nutritive value of prepared food products was calculated by using the food composition table. The highest overall acceptability was found in T4 (40%) in case of Ladoo and Noodles. All the experimental products were found to be acceptable. Significant difference in flavor and taste, body and texture and color and appearance between various treatment combinations was found. The prepared products were found to be low in calories and carbohydrate but high in fibre, calcium, iron, phosphorus, sodium and potassium content. It was concluded from the result that the products formulated by incorporation of lotus stem flour in wheat flour at different level can improve the nutritional quality of products as well as variety in diet.

Nelumbo nucifera commonly known as Indian lotus has been used as an indigenous medicine in India. Joyce and Estherlydia (2014) were evaluated the phytochemical activity and antioxidant activity of lotus stem. The lotus stem was extracted with solvents like ethanol, acetone and water. The lotus stem was found to be excellent source of protein and vitamin-C, while it is a good source of fiber and iron.

Carbohydrate, flavanoids, quinines, cardiac glycosides, terpenoids, phenol, coumarines, sterols, phyto sterols are present. The total polyphenol content (TPC) was found to be high in acetone extracts (130.88mg GAE/100ml). The total flavonoid content (TFC) was found to be high in ethanolic extracts (77.8mg Rutin equivalence/100ml). Lotus stem can be used effectively as a therapeutic agent in nutritional therapy and phyto-therapy for the alleviation of various diseases.

Different extruded snacks were prepared by fortifying corn with iron rich foods like moth beans, lotus stem(LS), karonda(KP), garden cress seeds (GS), niger seeds(NS), amaranth(AL) and bangal gram leaves(BL). The LS, KP, GC, NS, AL and BL were added to the different extruded snacks in four levels i.e. 2.5, 5, 7.5 and 10%. Moth bean was added to all the extruded snacks at 20% level. Organoleptic evaluation of the snacks revealed that extruded snacks were acceptable till the level of 10% showing overall acceptability of 7.81 and 7.56 respectively. The GC, NS, BL and AL incorporated snacks were acceptable till the level of 7.5, 5 and 7.5% with the overall acceptability scores 7.4, 7.96, 7.46 and 7.6 respectively. The developed supplemented snacks had higher protein, ash, iron and low carbohydrate in comparison to the control (corn snacks). They also had significantly higher iron content ranging from 15.4 to 21.3g/100g, compared to the control having 3.9mg/100g (Sisodia and Sadana, 2014).

In many ethnic dishes, lotus stem is usually consumed fried. Proximate analysis of raw lotus stem and fried lotus stem were carried out by Vora and Srinivasan (2015) for establishing the comparative nutritional profile of raw lotus stem and fried lotus stem. Also, the antimicrobial activity of lotus stem extract was ascertained against certain bacterial and fungal species. In addition, an edible product using lotus stem was developed and it was subjected to semi-trained panelist for sensory evaluation. The proximate principal assessed ascertains that the nutritional benefits of lotus stem are retained but reduced in frying. The antimicrobial activity of lotus stem ascertains that this vegetable could be standardized to be used as a nutrceutical. The results of

sensory evaluation prove the facts that lotus stem is a versatile ingredients which can be consumed in most recipes. Thus, lotus stem can be processed and marketed in the form of various recipes for maximum utilization of its health benefits by the general population

Factors influencing dietary iron absorption

The bio-availability of dietary iron is the proportion of iron that is actually available for absorption and utilization by the body. The bio-availability of food and dietary iron is influenced by certain factors like enhancing factors and inhibiting factors. Dietary iron absorption enhancing factors are ascorbic acid, gastric acid, citric acid, fermented food, meat, fish and poultry, certain fruits and vegetable and sprouts. Dietary iron absorption inhibiting factors are phytates, tannin, phenolic compounds, calcium, phosphate, carbohydrate beverages and soy protein.

Ascorbic acid

Ascorbic acid (vitamin C) is the potent enhancer of non-heam iron absorption even in the presence of inhibitors such as phytates, tannates and calcium. It can reduce food ferric iron to the better absorbed ferrous iron by 75-98 percent. In Indian studies, the addition of ascorbic acid to cereals and pulses enhanced the available iron (NIN, 1992). In a community level study, anemic pre-school children were given supplements of 100mg synthetic ascorbic acid at each of their two daily meals for a period of two months. This improved their iron levels significantly and the prevalence of anemia was reduced from 96 to 26 percent. In regional meals, the addition of citrus fruit juices are portion of potato, cauliflower and cabbage increased iron availability markedly (Seshadri et al., 1993 and Choudhary and Vir, 1994). The addition of 25mg of ascorbic acid as lemonade consumed at two meals a day doubled the absorption of iron from a meal and improved the iron status of the participating women. The comprehensive reviews have shown that a food source containing 50mg of ascorbic acid consumed with a main meal enhanced iron bio-availability significantly (Cook and Monsen, 1997)(Figure2.8 and 2.9).

Figure: 2.8 50mg Ascorbic acid in edible portion of Fruits (g)

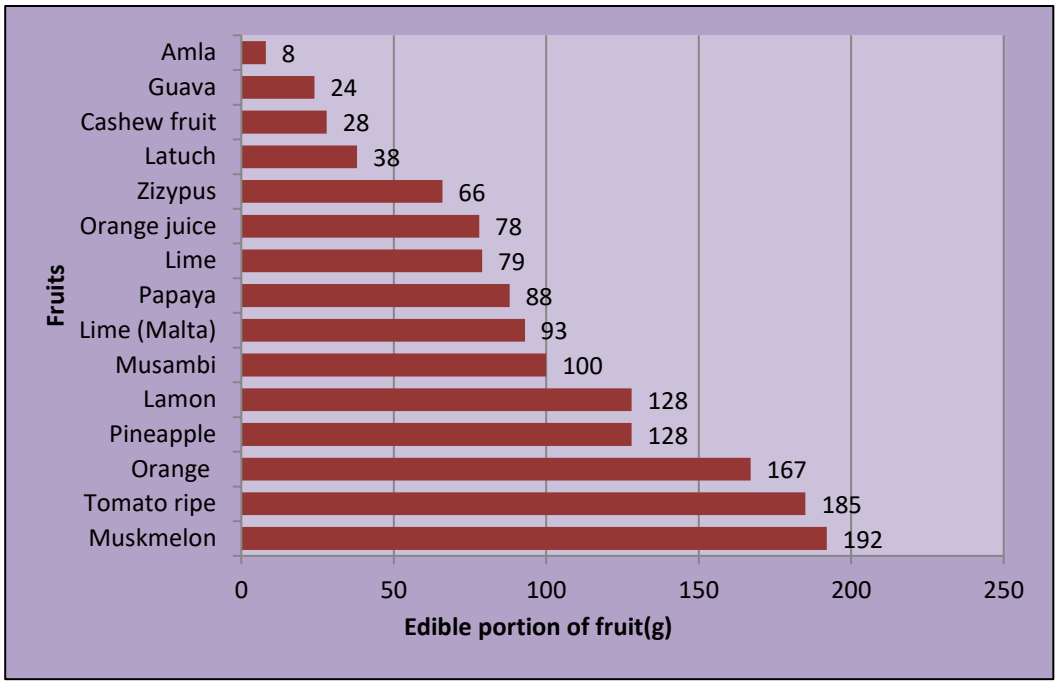
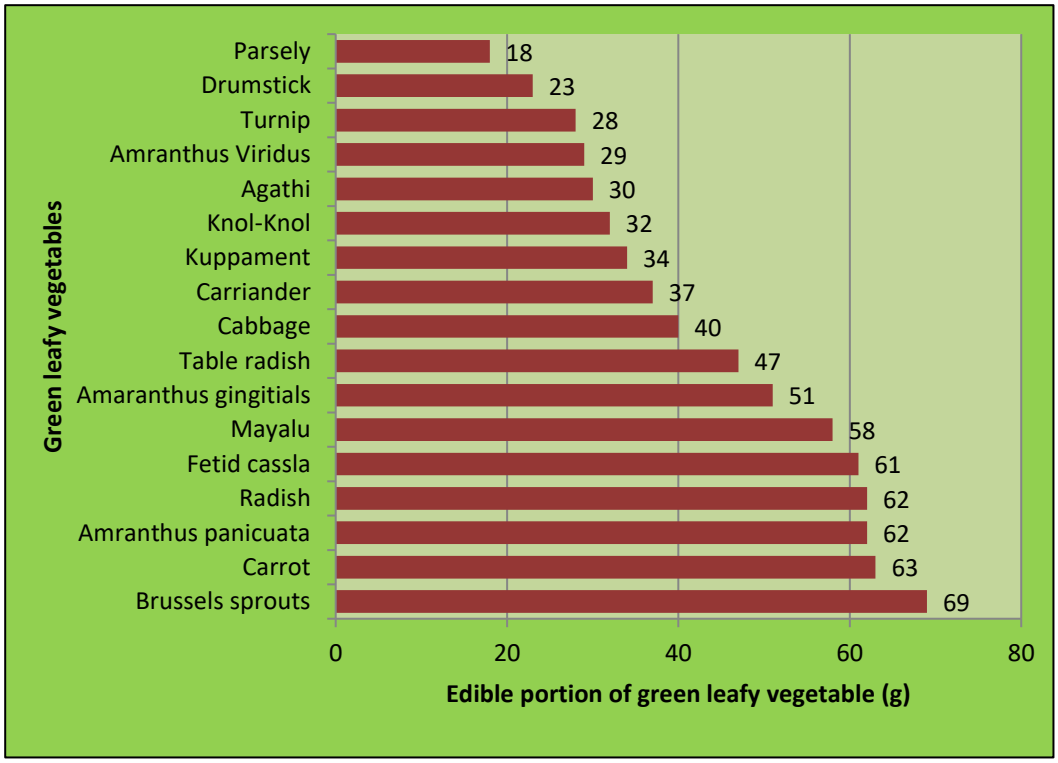


Figure: 2.9 50mg Ascorbic acid in edible portion of green leafy vegetable (g)

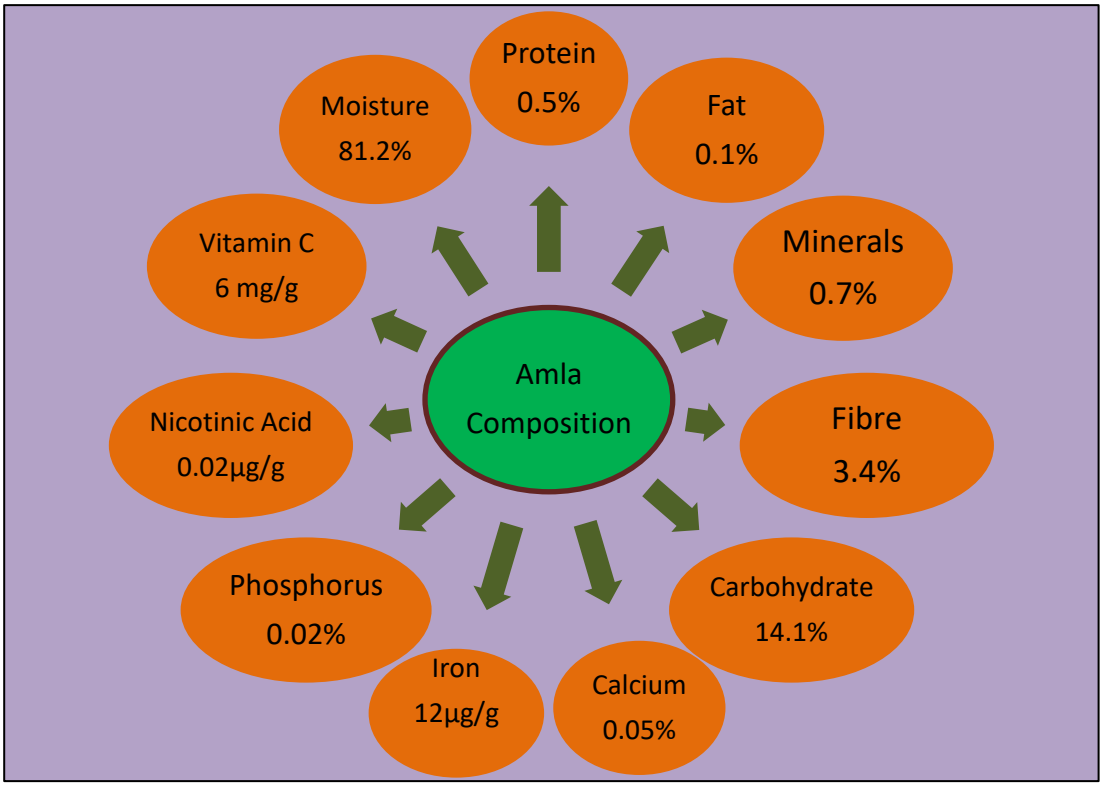


Source: Sharma (2003). Food, Nutrition and Agriculture (FAO)

Amla

Mother Nature has gifted mankind with tremendous medicinal plants to create a disease free and healthy life. Abundant medicinal plants are presented in the Indian traditional systems of medicine (like Ayurveda, Unani, Siddha), mostly used one amongst them is Indian gooseberry or Amla. Also known as Phyllanthus emblica Linn. belongs to the family Euphorbiaceae, which is an important medicinal herb in Ayurveda and Unani systems of medicine (Maurya and Srivastava, 2011). Amla is highly nutritious and is one of the richest sources of vitamin-C, amino acid and minerals (Srivasuki, 2011).

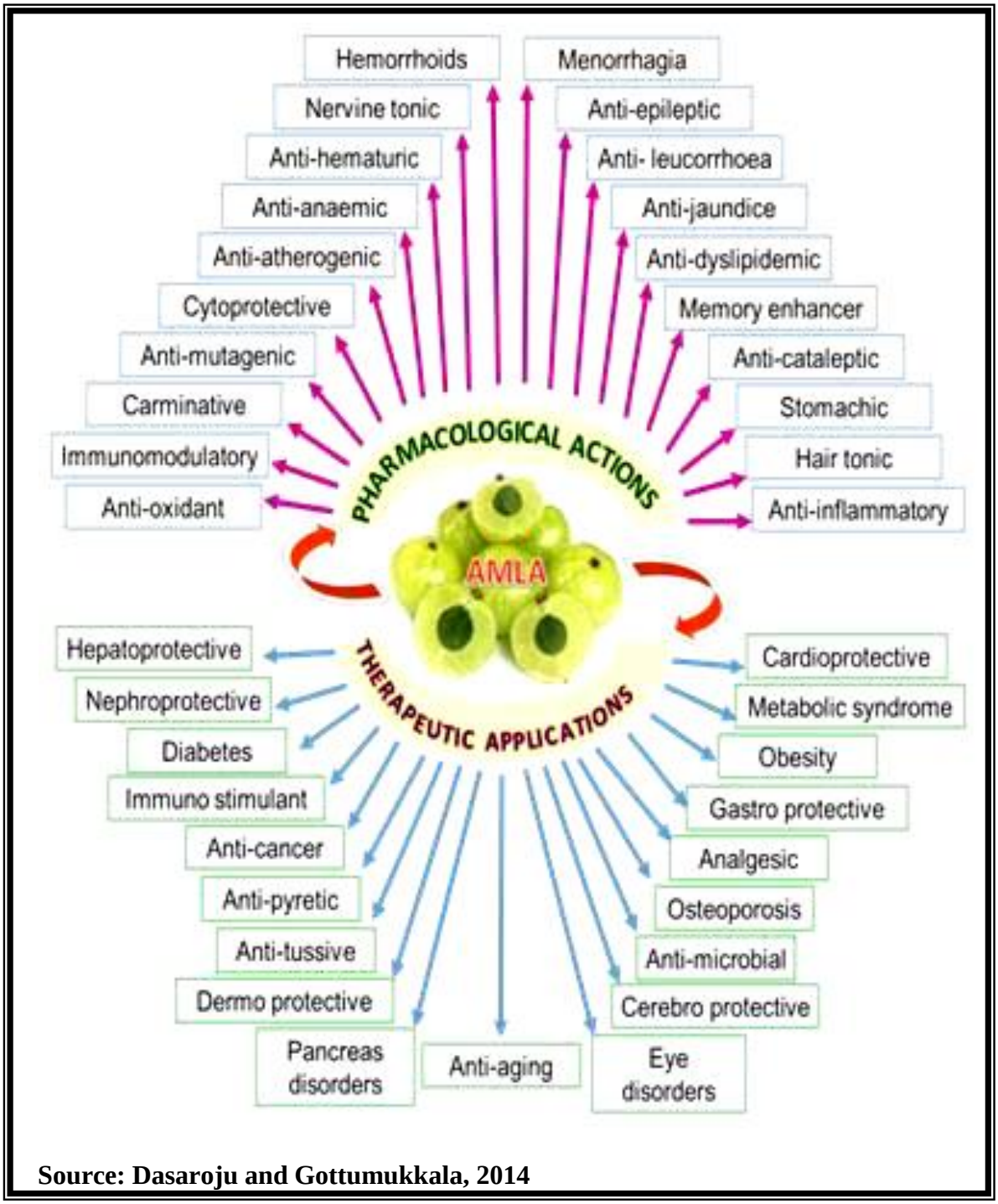
Figure: 2.10 Composition of fruit pulp of Emblica officinalis (Amla)



Amla fruit is widely used in the Indian system of medicine as alone or in combination with other plants and is used to treat common cold and fever, as diuretic, laxative, liver tonic, refrigerant, stomachic, restorative, anti-pyretic, hair tonic; to prevent ulcer and dyspepsia. It contains several chemical constituents like

tannins, alkaloids and phenols. Among all hydrolysable tannins, Emblicanin A and B, galic acid, ellagic acid are reported to possess biological activity.

Figure: 2.11 Amla: Pharmacological actions and therapeutic applications



Source: Dasaroju and Gottumukkala, 2014

Pharmacological research reports on amla reveals its analgesic, anti-tussive, anti-atherogenic, adaptogenic; cardio, gastro, nephro, neuro protective and anticancer properties (Yokozawa et al. 2007; Vasudevan et al., 2007; Madhuri, 2008; Chatterjee et al., 2010. and Baliga et al, 2013). Amla is reported to possess chemopreventive, radio, chemo and immunomodulatory, free radical scavenging, antioxidant, anti-inflammatory, anti-mutagenic activities (Figure-2.11). These properties are efficacious in the prevention and treatment of various diseases like cancer, atherosclerosis, diabetes, peptic ulcer, anemia, liver, heart diseases and various other disorders (Adil et al., 2010; Krishnaveni and Mirunalini, 2012; Prakash et al., 2012. and Santoshkumar et al., 2013).

2.3.2. Iron Supplementation

Supplementation is a form of direct intervention to solve the problem of iron deficiency anemia. It is the distribution of hematinics (iron and folate) in tablet or other suitable form. There are two types of supplementation with tablets viz. (1) Therapeutic supplementation where prevalence of anemia is high and must be cured in a short time and (2) Prophylactic supplementation where prevalence is low requiring smaller dose of iron for its prevention (WHO, 1972).

In India, the poor absorption of iron and a predominantly vegetarian diet means that despite the consumption of balanced diet, iron supplementation is required to prevent and control anemia. Weekly iron-folic acid supplementation (WIFS) and not daily supplements is proposed as a preventive long term approach to improve iron status and also for reducing the prevalence of anemia. The daily oral administrations of iron doses far exceed the capacity of an individual to assimilate (absorb, utilize and metabolize) iron safely. The positive impact of WIFS reported in various studies support the ‘mucosal block’ hypothesis, wherein administration of iron every seven days allow times for shedding of cells loaded with iron from a previous dose, thereby increasing iron absorption (Viteri, 2007).

A number of trials on weekly IFA supplements in various countries of SEAR demonstrated that WIFS can be as efficacious as daily supplements with much lower rate of side effects. In India, WIFS programme findings in nine state revealed that with one year's intervention, there was a substantial decrease in anemia prevalence-the decrease varied from 5% in Jharkhand to 43% in Andhra Pradesh and 50% in Uttar Pradesh. In Uttar Pradesh, adolescent girls were reached in school and out school setting in an entire district with an intervention package comprising WIFS, six monthly deworming and family life education (Vir et al., 2008). WIFS was administered unsupervised to out of school girls while school girls were supervised by teachers on fixed iron day, the impact was evaluated in a programme situation. In a period of four years, anemia prevalence decreased from 73.3% to 25.4% and no significant difference in impact was observed between girls who were supervised and those who were unsupervised during WIFS intake. Following this dramatic reduction in the prevalence of anemia, the WIFS programme is being up scaled in the entire state as a part of the Adolescent Health Programme. Similar range scale WIFS programme implemented in other states of India, Bihar, Gujarat and Madhya Pradesh, have demonstrated a significant decrease in anemia prevalence in adolescent school girls and those out of school girls (Kotecha et al., 2005). The programmes had a strong component of education and social mobilization activities and monitoring system. For improving management and compliance, a fixed WIFS day approach was used.

2.3.3. Nutrition education

Iyer and Venugopal (2006) reported improvements in physical activity levels, knowledge scores, dietary intake pattern and breakfast consumption among adolescents in urban Vadodara after imparting nutrition health education through poster and leaflets.

Kaur et al. (2007) reported the impact of nutrition education on nutrient adequacy of rural adolescent girls of village Shousha, district Solan, Himachal Pradesh. Before imparting nutrition education, majority (46%) of the respondents had obtained the

scores pertaining to nutrition knowledge between 10-15 followed by 5-10(40%) and 15-20(13%). After imparting nutrition education, most of the respondents (53.3%) were able to get higher score from 15-20 and 13.3 percent of the respondents were able to get the score up to 25-30. Nutrition education improved their mean nutrition knowledge scores significantly ($p<0.01$).

Kaur et al. (2011) assessed serum iron status of fifty medical girls' students and improvement in their iron status with medical education. Various hematological test measuring serum iron level, hemoglobin concentration and RBC count were done to assess their iron status at baseline, and follow up study after 12 months. It was found that 62% of girls students had mild anemia (Hb>12gm/day) and 14% of them had moderate degree (Hb>12gm/day) at baseline which was significantly improved by nutrition education intervention in the follow up study after 12 months. The study concluded that nutrition education is one of the appropriate, effective and sustainable approaches to combat iron deficiency anemia.

Singhal et al. (2012) reported significant improvements in the several domains of knowledge among the intervention group in a study on adolescent in north India. In the intervention group, significantly lower proportion of children consumed aerated drinks (15.5%; $P<0.001$) and energy dense unhealthy foods (8.9%; $P=0.03$), whereas significantly higher proportion brought tiffin (packed lunch) to school (14.9%; $P=0.004$) and brought a fruit in their tiffin (30.7%; $P<0.001$) as compared with the control group. Thus, a multi-component model of nutrition and life style education was successful in improving the nutrition-related knowledge, eating habits and life style practices of Asian Indian adolescent

Impact of education intervention on nutritional knowledge of iron deficiency among post adolescent girls was assessed by Savita et al. (2013). Nutrition knowledge and nutrition education is also considered a long term approach to combat iron deficiency anemia. A total of 207 girls in the age group of 18-25 years were screened for the

hemoglobin status. Nutrition knowledge intervention was carried out through a short lectures using visual aids (flash cards, posters, and display of raw foods such as rice source, enhancers and inhibitors of iron absorption) followed by discussion. The knowledge assessment tool was tested thrice during the study period- initially before the education, soon after the nutrition education and one month later and the subjects were classified as the score obtained. The classification was made as low, medium and high based on mean +1/2SD. 30% of the subjects scores low (<17), 42.31% scored medium (17-23) and 27.56% scored high (>23) before education. Assessment of the knowledge immediately after the education program revealed that 97.44% of subjects scored high (>23) where as 2.56% scored medium (17-23) and one month later, the knowledge level revealed that 95.51% scored high (>23) and 4.49% scored medium (17-23) reflecting that the retention of knowledge is quite satisfactory during follow up assessment. The percentage of correct response ranged from 39-69% previous followed by 71 to 96% at immediately after education intervention and 70 to 91% at one month after education intervention. The response improved after education intervention that could help to combat micronutrient malnutrition.

Yusoff et al. (2013) compared the effect between nutrition education intervention and non-nutrition education intervention on awareness regarding iron deficiency among rural school going adolescent in Tanah Merah, Kelantan district of Malaysia. The selection criteria was based on hemoglobin level (Hb=7-11.9g/dl for girls; Hb = 12.9g/dl for boys). They were divided into two groups. The first group received nutrition education package (NE), whereas other group was entitled non-nutrition education intervention (NNE). Both interventions were implemented for 3 months. Nutrition education receiver group (NE) demonstrated improvement in awareness at post-intervention. No substantial improvement was demonstrated by the counterpart group (NNE). In Multimedia nutrition education program conducted at school setting was in fact practical and effective in improving awareness on iron deficiency among anemic adolescents.

The effect of education based intervention was studied by Roshan et al. (2014) using small group discussion in empowering adolescent girls to prevent iron deficiency anemia. At baseline, independent T-test showed no significant difference between the two group (n=30 test group and n=30 control group) in the perceived susceptibility, perceived severity and self efficacy, all of which could be regarded as empowerment process components. A significant difference before and after the intervention was observed in the test group in mean of the perceived susceptibility, perceived severity and self efficacy and in the grand scheme, adolescent girls empowerment($p<0.05$). No significant difference were evident in the control group

Abraham (2015) conducted a study to assess the effectiveness of planned teaching programme regarding knowledge and prevention of anemia among adolescent girls attending high schools in Pune city. Pre-Experimental design (one group-pre test post –test) was selected for the study. A self structured questionnaire was applied on 80 adolescent girls. In pre-test, majority (51.3%) of the adolescent girls had average knowledge (score 6-10), 38.8% of them had poor knowledge (score 0-5) and 10% of them had good knowledge (score 11-15) regarding iron deficiency anemia and its prevention. Whereas in post-test, majority (53.8%) of girls had good knowledge (score 11-15), most of them (45%) of them had excellent knowledge (score 16-20) and only few of them had average knowledge regarding prevention of anemia. The study significantly proved that there is a remarkable improvement in the knowledge of adolescent girls regarding prevention of anemia after structured teaching program.

2.3.4. Improved Health Services and Sanitation

Iron supplementation programmes should be integrated into broader public health programmes which are directed to the same population target groups. Iron supplementation during pregnancy and lactation is a major component in reducing maternal morbidity and mortality. Emphasis should therefore be placed upon increasing the capacity of antenatal, postnatal and child health clinics to provide iron

supplementation for mothers, children and adolescent girls. For maximum effectiveness, link should be established with programmes such as those targeting:

- Malaria prophylaxis
- Hookworm control (Deworming)
- Immunization
- Environmental health
- Control of micronutrient malnutrition
- Community-based primary health care

Deworming

Deworming (sometimes known as worming or drenching) is the giving of an anthelmintic drug (a wormer, dewormer or drench) to a human or animal to rid them of helminths parasites, such as roundworm, flukes and tapeworm (Deworming, 2017).

Soil-transmitted helminth (STH) infections are among the most common infections worldwide and affect the poorest and most deprived communities. They are transmitted by eggs present in human faeces which in turn contaminate soil in areas where sanitation is poor. The main species that infect people are the roundworm (Ascaris lumbricoides), the whipworm (Trichuris trichiura) and hookworms (Necator americanus and Ancylostoma duodenale) (Smith and Brooker, 2010). Soil-transmitted helminth infections can impair nutritional status by causing: internal bleeding which can lead to loss of iron and anemia, mal-absorption of nutrients, diarrhea and loss of appetite which can lead to a reduction in energy intake. Infection can also cause cognative impairment as well as tissue damage that may require corrective surgery.

The nutritional impairment caused by schistosome and soil-transmitted helminth infections during childhood has been shown to have a significant impact on growth and development of children. Periodic treatment (deworming) of children together with improvement of water and sanitation, and health education may reduce transmission of schistosome and soil-transmitted helminth infections.

Global distribution and prevalence soil-transmitted helminth infections

More than 1.5 billion people, or 24% of the world's population, are infected with soil-transmitted helminth infections worldwide. Infections are widely distributed in tropical and subtropical areas, with the greatest numbers occurring in sub-Saharan Africa, the American, China and East Asia. Over 270 million preschool-age children and over 600 million school-age children lives in areas where these parasites are intensively transmitted, and are in need of treatment and preventive interventions (WHO, 2016).

World Health organization estimates that 241 million children between the age of 1 and 14 are at risk of parasitic intestinal worms in India. These children represent approximately 68% of children in this age group and approximately 28% of the number of children estimated to be at-risk of STH infections globally. The global target is to eliminate morbidity due to soil-transmitted helminthiases in children by 2020. This will be obtained by regularly treating at least 75% of the children in endemic areas (as estimated 873 million).

WHO recommended periodic treatment with anthelminthic (deworming) medicines, without previous individual diagnosis to pre-school and school aged children living in endemic areas. Treatment should be given once a year when the prevalence of soil-transmitted helminth infections in the community is over 20% and twice a year when the prevalence of soil-transmitted helminth infections in the community exceeds 50%. The intervention reduces morbidity by reducing the worm burden (WHO, 2017).

CHAPTER-3

METHODOLOGY

This chapter is devoted to the description of research procedure adopted for carrying out the study. The present study was conducted to investigate the severity and distribution of anemia among adolescent girls aged 10-19 years and development of nutrition intervention package and efficacy assessment of package in improving the iron status of adolescent girls. The study was conducted in phases and accordingly methodology has been organized under the following heads:

3.1 Locale of the study

3.2 Study design

3.3 Sample size determination

3.4 Selection of subjects

3.5 Methods and Tool/Techniques

3.5.1. Phase I:-Assessment of nutritional status and nutritional knowledge of adolescent girls and estimate the prevalence of anemia among adolescent girls

3.5.1.1. General information of the subject

3.5.1.2. Socio-demographic characteristic of the subject

3.5.1.3. Assessment of nutritional status of the subjects

3.5.1.4. Prevalence of anemia

3.5.1.5. Menstrual history

3.5.1.6. Nutrition knowledge

3.5.2. Phase II: Development of nutrition intervention package

3.5.2.1. Development of iron rich food supplement powder

3.5.2.1.1. Identification of food stuff

3.5.2.1.2. Procurement of raw material

3.5.2.1.3. Processing of raw material

3.5.2.1.4. Preparation of combination IRFSM

3.5.2.1.5. Standardization of IRFSM by preparing food product

3.5.2.1.6. Packaging and storage of IRFSM

3.5.2.2. Quality evaluation of developed IRFSM

3.5.2.2.1. Nutritional composition

3.5.2.2.2. Physical and functional properties

3.5.2.2.3. Keeping quality of developed IRFSM

3.5.2.3. Development of nutrition education material

3.5.3. Phase III: - Efficacy assessment of nutrition intervention package in improving the iron status of adolescent girls

3.6. Statistical analysis of data

3.1 Locale of the study

The study was conducted in the rural area of Bhilwara District of Rajasthan State. Bhilwara district has total rural population of 18, 97,292 with approximately 95,661 girls in the age group 10-19 years (Census of India, 2011) (Figure-3.1 and 3.2). There are 12 Panchayat Samitis in this District. Bhilwara ICDS Project was launched in 1980 and has since catered to the nutrition and health need of children, adolescent girls, pregnant and lactating women in the community. At present the project is functioning in 12 panchayat samitis. Out of 12 panchayat samiti, Suwana panchayat samitis was purposively selected for the study, keeping in mind the ease of approach and familiarity with the area. The total population of Suwana panchayat samiti was 1,79,458 with approximately 10,045 adolescent girls in the age group of 10-19 years. There are 167 Anganwadi centers (AWCs) in Suwana panchayat samiti. Out of 167 AWCs, 28 AWCs were randomly selected for inclusion in the study (Annexure-VI).

Figure: 3.1 Map of Rajasthan

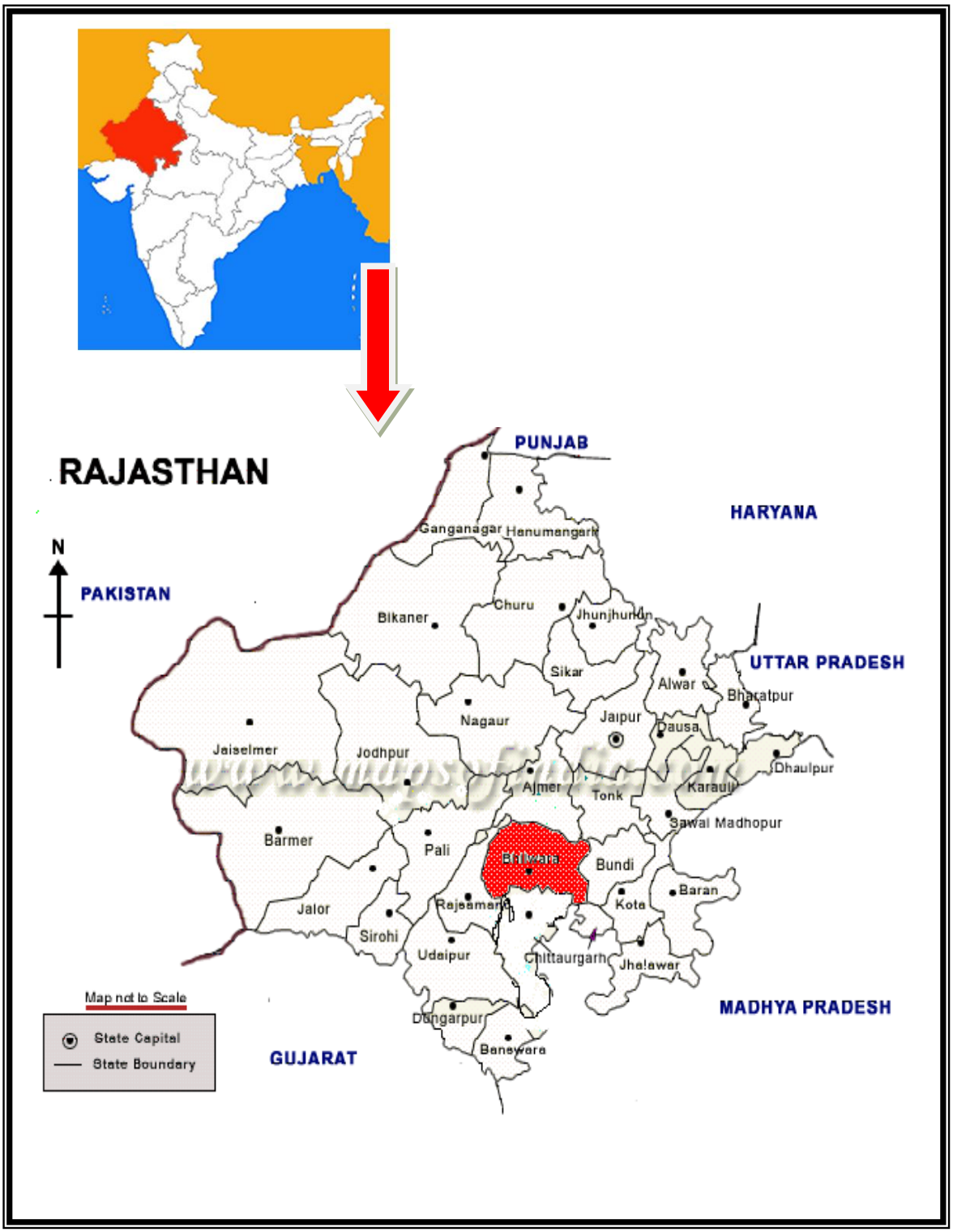
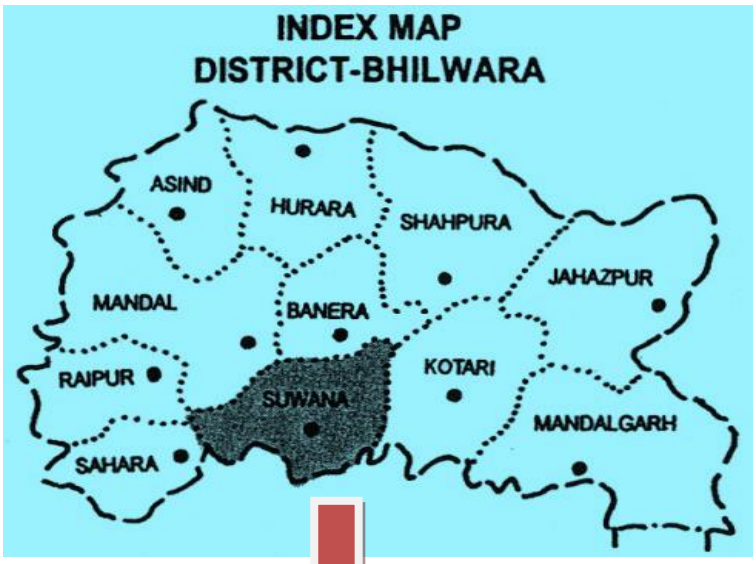


Figure: 3.2 Map showing sampling locations



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3.2 Study Design

The present study was carried out in three phases:

Phase I: Assessment of nutritional status and nutritional knowledge of adolescent girls (10-19year) and to estimate the prevalence of anemia among adolescent girls.

In this phase nutritional status of adolescent girls and prevalence of anemia was assessed using cross-sectional survey design. This phase was conducted from July 2014 to December 2014. The socio-economic features and nutrition knowledge were also assessed to provide the empirical basis for designing nutrition educational program to improve nutritional status of adolescent girls. Prior to this exercise, valid and reliable instruments were developed for assessing food and nutrient intake, nutrition knowledge and socio-economic features.

Phase II: Development of nutrition intervention package including iron rich food supplement mix and nutrition education package for adolescent girls.

In this phase nutrition intervention package was developed including development of iron rich food supplement powder and nutrition education package for adolescent girls. This phase of the study was conducted from January 2015 to June 2015. Iron rich food supplement mix was developed using locally available iron rich foods and nutritional educational material was developed based on current food and nutrient intake, food selection and traditional practices (based on the finding of phase I of the study).

Phase III:-Efficacy assessment of nutrition intervention package in improving the iron status of adolescent girls.

Pre and post experimental design was used for the efficacy assessment of nutrition intervention package. This phase of the study was conducted from July 2015 to October 2015. Adolescent girls suffering from anemia but not requiring hospitalization were considered eligible for intervention. Iron rich food product was fed to the girls in addition to the ICDS food supplement so that in each group food supplement given by ICDS was common. The educational program for girls was in

addition to the routine approach adopted in the Anganwadi's under the ICDS program. Five groups of girls were studied (as indicated in figure-3.3) viz. control group, the intervention supplementation group without vitamin-C source (Experimental group I), the intervention supplementation group with vitamin-C source (Experimental group II), the intervention nutrition education group (Experimental group III) and the intervention nutrition education cum supplementation group with vitamin C (Experimental group IV).

Figure: 3.3 Intervention study design

Control group	**Experimental group-1** (Supplementation without vitamin-C)
Experimental group-2 (Supplementation with vitamin-C)	**Experimental group-3** (Nutrition education)
Experimental group-4 (Nutrition education cum Supplementation with vitamin-C)	

3.3 Sample size determination

Sample Size:- Appropriate sample size was calculated using the standard statistical formula suggested by Bhatia and Webb, 2005.

$$n = (Z\alpha/2)^2 p (1 - p)/d^2$$

Where

Z =Confidence level at 95 % i.e. 1.96

p =Estimated prevalence of malnutrition in study area

d = Margin of error at 5% i. e.0.05

The estimated prevalence of anemia among adolescent girls as per National Family Health Suyvey-3 data is 56%. At 95% confidence level we used the prevalence of 56% anemia among adolescent girls and margin of error at 5%. This gave a required sample size of 378. A 10% safety margin is added to allow for a maximum estimated non- response, giving a sample size of 420.

Figure: 3.4 Graphic representation of the study design

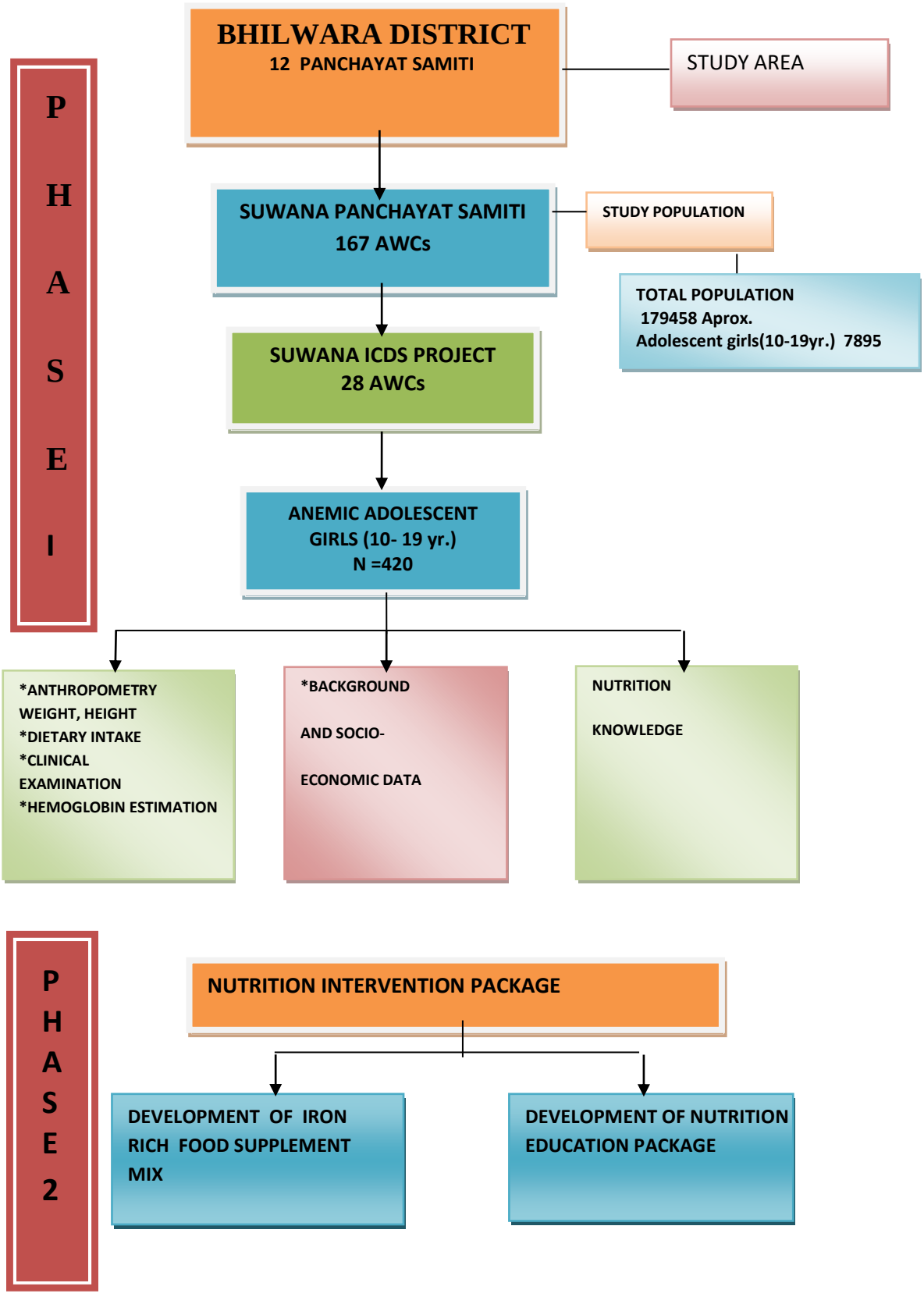
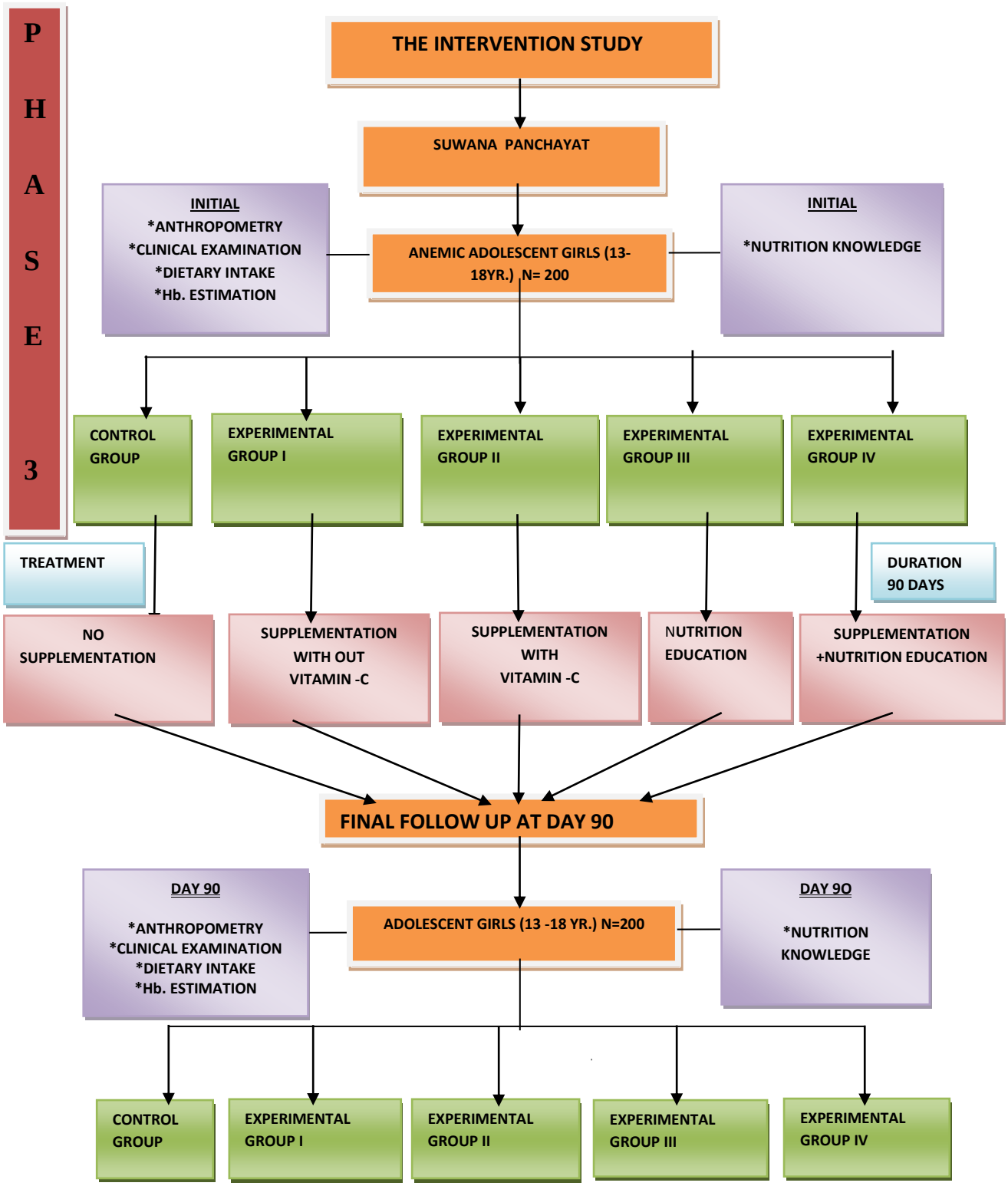


Figure: 3.5 Flow chart of intervention study design



3.4 Selection of subjects

Various meetings were organized with selected AWCs functionaries to appraise them regarding the study as well as to orient them to its importance. This exercise was extremely useful in seeking the involvement and co-operation of the functionaries. For the selection of samples random sampling method was used. A complete record of all registered adolescent girls (10-19 yr.) under the selected 28 Anganwadi centers of Suwana panchayat samiti was obtained from the respective Anganwadi workers. A total of 3952 adolescent girls were registered in 167 AWCs of Suwana panchayat samiti. Further random sample of 420 adolescent girls (10-19 years) were drawn from the selected AWCs for the present study. These subjects corresponded to about 4.2 % of the total adolescent girls residing in the Suwana panchayat samiti villages and approximately10.63 % of the adolescent girls registered in 167 AWCs .

3.5. **Ethical considerations**

Ethical permission was obtained from Deputy Director of ICDS Bhilwara District, CDPO and the parents of the subjects. They were made aware regarding the project and written permission was taken for conducting the research work in their anganwadi centers. Biochemical test were performed only on the subject whose parents consented for the same (Annexure-IV and V).

3.6 Methods and Tool/Techniques

3.6.1. Phase I:-Assessment of nutritional status and nutritional knowledge of adolescent girls (10-19yr.) and to estimate the prevalence of anemia among adolescent girls

Construction of research tool to achieve the objective of research is an important step in any research endeavor. Keeping in mind the purpose of the study and type of sample, interview method was considered most appropriate for gathering data. The interview schedule was prepared by the investigator in consultation with the subject

matter specialists (Annexure-I). To ensure the validity and feasibility of the interview schedule before administering it on the entire population pre testing was done on 10% of adolescent girls. On the basis of pre-testing, necessary modification was made. Pre-tested samples were excluded from the study. The content validity and reliability of the tool was obtained by experts in the field.

3.6.1.1. General information of the subject

Information regarding name, address, age, caste, religion, educational status and marital status was collected at the beginning of the study. Information about the date of birth of children was verified from the respective AWCs records.

3.6.1.2. Socio-demographic characteristic of the subject

In this section the socio economic variables i.e. religion, caste, occupation, educational status of family members, family type and family size were assessed. Socio-economic status (SES) of the subject was assessed using modified Pareek scale for rural area (Sharankumar, 2013) (Annexure-I).

Table: 3.1 Classification of socio-economic status according to Pareek SES scale

Symbol	Category	Score on the scale
I	Upper class	Above 43
II	Upper middle class	33-42
III	Middle class	24-23
IV	Lower middle class	13-23
V	Lower class	Below 13

3.6.1.3. Assessment of nutritional status of the subjects

Assessment of nutritional status is considered as a measure of health and it is necessary for planners to understand the food and nutrition situation of the vulnerable groups like children, adolescent girls, pregnant and lactating women.

Nutritional status of the subjects was assessed by anthropometric measurements (height, weight and BMI), dietary survey (24 hour recall method and food consumption frequency), clinical examination and biochemical examination

I. Anthropometric measurements of the subjects

Nutritional anthropometry is a good indicator of nutritional status. It is the measurement of human body at various ages and level of nutritional status. It is based on the concept that an appropriate measurement should reflect any morphological variation occurring due to a significant functional physiological change (Rao and Vijayraghavan, 2009). Anthropometric measurements such as height and weight were carried out on all individuals using standard equipments and procedures described below:

Weight

Body weight is mainly made up of muscle, fat, bone and interior organs (Jellife, 1966). It is the widely used and the simplest reproducible anthropometric measurement. It also acts as an immediate indicator of a persons nutritional status.

Technique: A platform spring balance was used for measuring weight. The balance was calibrated using standard weight after taking weight of every 3rd subject. The zero error of the weighing scale was checked before the weight and corrected as required. The subject was ask to stand on the platform bare feet, with minimum clothing and without leaning against or holding anything. The measurement were taken to the nearest of 0.5 kg.

Plate: 3.1 Weight Measurement

Plate: 3.2 Height Measurement

Height

It is the linear measurement made up of sum of four components i.e. Legs, Pelvis, Spine, and Skull (Jellife, 1966).

Technique: Height measurements of all the subjects were taken using a flexible, non-stretchable fibre glass tape. The tape was fixed vertically on the smooth wall perpendicular to the ground, ensuring that the floor was smooth. The was asked to stand erect with the shoulder, hips and heels touching the wall and with no footwear, heels together and looking straight ahead. The head was held comfortable erect, arms hanging loosely by the side. A thin smooth scale was held on the top of the subjects head in the centre, crushing the hair in the right angle to the tape and the height of the subject was read from the lower edge of the ruler to the nearest 0.1 cm.

Body Mass Index

The body mass index (BMI) is the relative weight index that shows highest correlation with independent measure of body fat. It includes both fat and lean tissue. It provides a reasonable indication of the nutritional status for young and adults (Rao and Vijayraghavan, 2008).

Technique: The body weight and height were taken as described above. To obtain the body mass index, weight in kilogram was divided by square of height in meter square as given below:

Body Mass Index (BMI) = Weight (kg) / Height (m^2)

Where, Weight in kilograms and Height in meters

To assess the prevalence of malnutrition, indices namely, BMI for age, Height for age (WHO, 2006 standard) and weight for age (Percentile) (IAP, 2015) were calculated (WHO, 2006 standard). Adolescent were categorized into various grades of nutritional status using BMI for age Z-scores (thinness) and Height for age Z-scores (stunting) as given below:

BMI for age Z scores	Nutritional grade
<Median-3SD	Severe Thinness
-3SD to -2SD	Moderate Thinness
-2SD to +1SD	Normal
+1SD to +2SD	Overweight
≥Median +2SD	Obesity

Height for age Z scores	Nutritional grade
≥Median-2SD	Normal
-2SD to -3SD	Moderate stunting
<Median-3SD	Severe stunting

II. Dietary Survey

Dietary survey was conducted, by three day 24-hr recall method using standardized cup set for three consecutive days in a week (which included two working and one non working day) , to assess the food and nutrient intake. Three days dietary survey was followed to take care of the variation in diet.

Food Intake: The dietary pattern followed at breakfast, lunch, evening tea and dinner was noted down. Raw quantity taken for cooking as well as the cooked quantity was recorded in term of household measures (standardized cup set or by weight/numbers).

The consumption of cooked food by the subject were also recorded to calculate the quantity of raw food intake. The raw amount consumed by each subject was calculated using the following formula:

$$\text{Raw amount of a particular food stuff consumed (g) by an individual from a given preparation} = \frac{\text{Individual intake of cooked food (g)}}{\text{Total cooked amount of prepared food (g)}} \times \text{Total raw amount of food stuff used in preparation(g)}$$

The mean intake of different food groups was then calculated and compared with balanced diet recommended for adolescent girls.

Nutrient intake: The nutrient intake was calculated using food composition tables (Gopalan et al., 2010). Mean intake of nutrient was compared with recommended dietary allowances (RDA). Nutrient intake was then expressed as percentage of RDA (ICMR, 2010) to assess the adequacy of the diet.

Food frequency: Food frequency method is used to assess habitual food intake of the subject, qualitatively. An exhaustive list of the commonly consumed iron and vitamin C rich food was prepared and the respondent was asked as to how frequently each of the listed food was consumed by subject. The frequency was daily, alternate days, twice a week, once a week, twice a month, once a month, rarely and never.

III. Clinical examination: Clinical examination is one of the most practical and important method used in assessing the nutritional status of community. It is external examination of the body for changes in superficial epithelial tissues especially skin, eyes, hair, nails etc. Clinical assessment can give very valuable but approximate information to the public health workers. It is an effective tool where severe malnutrition and anemia prevails. All the individuals covered for anthropometry were examined for the presence of clinical sign and symptoms of nutritional anemia/ iron deficiency anemia.

IV. Biochemical examination: Hemoglobin concentration is the most reliable indicator of anemia at the population level, as opposed to clinical measures which are subjective and therefore have more room for error. Measuring Hb concentration is relatively easy and inexpensive and this measurement is frequently used as a proxy indicator of iron deficiency.

Hemoglobin determination is regarded as a screening index useful in defining various degrees of iron deficiency anemia. It has been recommended that anemia may be diagnosed carefully and confidently when the hemoglobin concentration is lower than the level considered normal for the person's age and sex therefore, the

measure of hemoglobin in circulating blood is one of the best laboratory tests for screening of anemia (WHO, 2008).

Hemoglobin status of the subjects was assessed using HemoCue 301 system kit. The Hemocue system is a reliable quantitative method for determining hemoglobin concentrations in field surveys, based on the cyanmethemoglobin method The HemoCue Hb 301 system (Kit) is a safe and convenient solution when performing mobile anemia screening programs. It provides quick, easy access to lab quality results without compromising accuracy. The robust Hb 301 system is an accurate and effective tool for anemia also in demanding climate with high temperature and humidity. It is designed for quantitative point-of-care whole blood hemoglobin determination in primary care or blood donation settings-in urban and rural settings, using a specially design analyzer, the HemoCue Hb 301 Analyzer and specially designed microcuvettes, the HemoCue Hb 301 Microcuvettes. The HemoCue Hb 301 Analyzer is only to be used with HemoCue Hb 301 Microcuvettes. All that is needed is included in the carrying case making it ideal for transportations as well as an initial startup kit.

The kit is packed in a carrying case which contains:

- 1 Hb 301 Analyzer
- 1 Operating manual
- 1 package of AA-batteries (4)
- 1 package of Hb 301 Microcuvettes (4x50)
- 1 package of wipes
- 1 package of Safety Lancets (200)
- 1 Quick Reference Guide
- 1 package of Cleaners (5)

Plate: 3.3 HemoCue Hb 301 system (Kit)

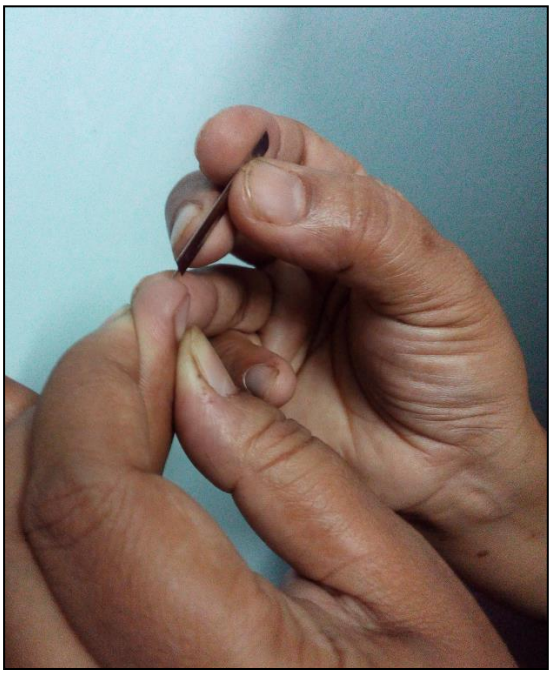
Principal of the method/procedure

The system consists of an analyzer together with microcuvettes. The microcuvette serves both as a pipette and as a measuring cuvette. A blood sample of approximately 10µL is drawn into the cavity by capillary action. The measurement takes place in the analyzer, which measures the absorbance of whole blood at a Hb/HbO2 isobestic point. The analyzer measures at two wave- lengths (506 and 880 nm) in order to compensate for turbidity. The HemoCue Hb 301 system is calibrated against the hemiglobincyanide (HiCN) method, the international reference method for the determination of the hemoglobin concentration in blood. The system is factory calibrated and needs no further calibration.

V. Morbidity Profile

Information pertaining to cough and colds, diarrhea, fever, malaria etc was elicited using a morbidity checklist using a reference period of 15 days.

Plate-: 3.4 Four simple steps of Hemoglobin estimation in HemoCue Hb 301 system



Prick the finger

Fill microcuvette

Place microcuvette into analyzer

View results

3.6.1.4. Prevalence of anemia

Prevalence of anemia was investigated on the basis of hemoglobin status of adolescent girls.

Table: 3.2 Classification of the anemia according to its severity (Hemoglobin concentration (g/dl) (NFHS, 2006)

Group	Normal	Mild anemia	Moderate anemia	Severe anemia
Adolescent girls (non pregnant)	≥12 g/dl	10 -11.9 g/dl	7 -9.9 g/dl	< 7 g/dl

Inclusion criteria

1. Adolescent girls of the age group 10-19 years.
2. Adolescent girls who were residing in the study area for a minimum period of 6 months.
3. Adolescent girls who were willing for their blood testing.

Exclusion criteria

1. Adolescent girls who were terminally ill.
2. Adolescent girls who were pregnant.
3. Adolescent girls who were not given consent to got their blood tested.

3.6.1.5. Menstrual history

This section pertained to the menstrual history of the respondents. The questions included in this section were age of menarche, Menarcheal status, dysmenorrhea, foods avoided and taken during menstruation, duration of the blood flow & interval between the next menstrual cycles.

3.6.1.6. Nutrition knowledge:

Knowledge is the important component of the behavior and it plays a major role in the covert and overt behavior of human being. English and English (1958) defined knowledge as a body of understood information possessed by an individual or by a culture. The content validity and reliability of the tool was obtained by experts in the field.

In the present study nutritional knowledge, related to anemia, of adolescent girls was assessed. A pre-tested structured and close ended questionnaire was developed for this purpose. Information regarding knowledge of food groups and nutrients, iron rich food and their functions in our body, foods favoring iron absorption and inhibition, causes, signs /symptoms and prevention of anemia, functions of hemoglobin and role of agencies /institution to control anemia was obtained from the subject (Annexure-II)

Scoring procedure: The respondents were asked to reply on each question. The correct response was assigned 'one' and incorrect response was assigned 'zero'. Aggregate scores were computed for each question. The knowledge scores were converted into mean percent score (MPS). The respondents were then distributed into three categories based on equal interval as follows:

Categories	**Knowledge**
Poor	Below 33 %
Average	33 to 66 %
Good	Above 66 %

3.6.2. Phase II Development of nutrition intervention package

Nutrition intervention package was developed for adolescent girls for improving the iron status of girls. This package was developed in two parts:-

I. Development of iron rich food supplement mix

II. Development of Nutrition education material

3.6.2.1. Development of iron rich food supplement mix

3.6.2.1.1. Identification of food stuff

With a stand point of utilizing natural food a list of raw food material possessing relatively higher iron content was prepared using food composition table (Gopalan et al., 2010). From this list Rice flakes, Lotus stem (Nelumbo nucifera), Cauliflower leaves (Brassica Oleracea) and Garden cress seeds (Lepidium sativum) were identified for the preparation of IRFSM.

3.6.2.1.2. Procurement of raw material

Rice flakes, Lotus stem (Nelumbo nucifera), Cauliflower leaves (Brassica Oleracea) and Garden cress seeds (Lepidium sativum) were purchased from the local market in a single lot to avoid varietal differences.

3.6.2.1.3. Processing of raw material

Rice flakes, Lotus stem, Cauliflower leaves and Garden cress seeds were processed in the following manner to obtained IRFSM.

a. Rice flakes: Rice flakes were cleaned and dried in the open sun and then grind.

b. Cauliflower leaves: Cauliflower leaves were dried using following procedure:

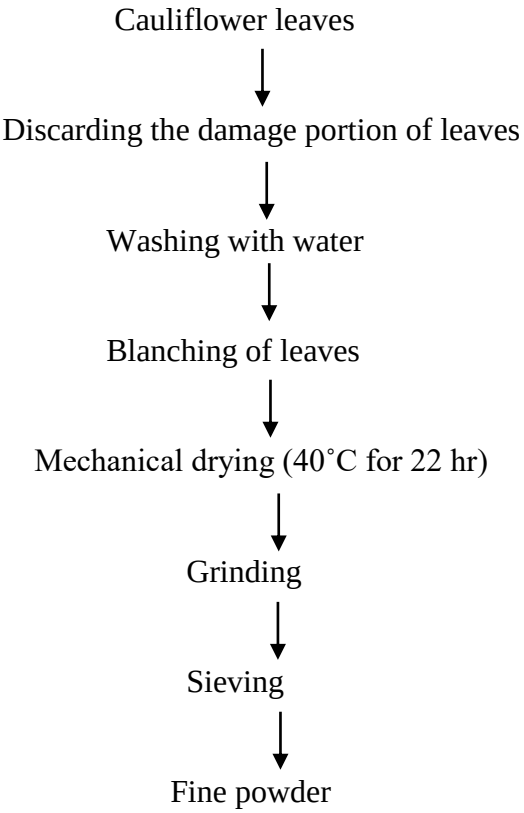


Figure: 3.6 Flow diagram for the preparation of cauliflower leaves powder

Figure- 3.7 Process chart of raw material

Rice Flakes

Powdered Rice Flakes

Garden Cress Seeds

Powdered Garden Cress Seeds

Fresh Cauliflower Leaves

Dry Cauliflower Leaves

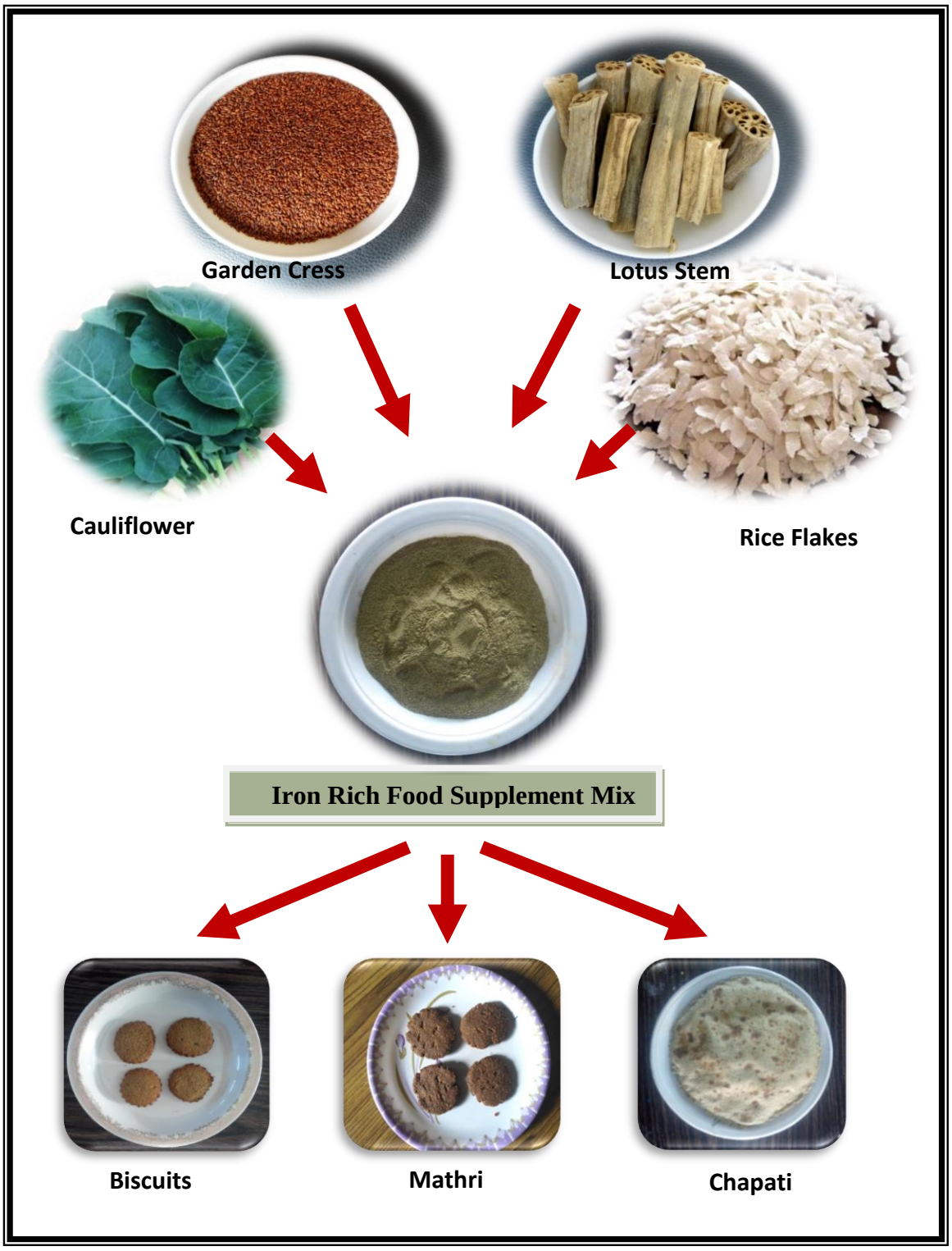
Powdered Cauliflower Leaves

Fresh Lotus Stem

Dry Lotus Stem

Powdered Lotus Stem

Plate: 3.5 Iron rich food supplement mix



The stems were peeled out and trimmed into small pieces. In order to reduce the oxalate content, these lotus stems pieces were boiled in water for 10-15 minutes and allowed mechanical drying (50˚C for 22 hr). The dried stem was converted in to the fine powder form using mixer grinder.

d. Garden cress seeds: Garden cress seeds were cleaned, washed and dried in the open sun and then grind.

3.6.2.1.4. Preparation of IRFSM combination

Rice flakes, Lotus stem (Nelumbo nucifera), Cauliflower leaves (Brassica Oleracea) and Garden cress seeds (Lepidium sativum) were selected for the preparation of IRFSM

Flours (rice flakes, lotus stem, cauliflower leaves and garden cress seeds) were mixed in different ratio for the development of IRFSM. Different proportions of iron rich food mix used for the preparation of IRFSM are presented in the table-3.3.

Table: 3.3 Preparation of IRFSM combination

S.No.	Ratio	Ingredients								Total
		Rice flakes	:	Lotus stem	:	Cauliflower leaves	:	Garden cress seeds		
1	I	70	:	10	:	10	:	10		100
2	II	60	:	20	:	10	:	10		100
3	III	50	:	30	:	10	:	10		100
4	IV	40	:	40	:	10	:	10		100

Identical to the present study, there are some studies on cauliflower leaves products and garden cress seeds products. In which the maximum limit of cauliflower leaves and garden cress seeds used was 10%, in order to obtain acceptable food product. They have also prepared food products using cauliflower leaves and garden cress seeds, in which the maximum limit of wheat flour replacement was 10% with cauliflower leaves or garden cress seeds. They have made various food products like biscuits, mathri, extruded products, cake and pancake.

3.6.2.1.5. Standardization of Iron Rich Food Supplement Mix by preparing food products.

For the purpose of standardization of IRFSM, the most common recipe Chapati was selected and used as control, which was already standardized by Sharma, 2010, and Avinash 2012. In the preliminary, Chapati was prepared from 80% wheat flour and 20% different ratio of selected iron rich indigenous foods (rice flakes, lotus stem, cauliflower leaves and garden cress seeds), in order to obtained acceptable product. The most acceptable ratio of IRFSM was selected for further analysis**.**

Table: 3.4 Preparation of Chapati

Treatment	**Wheat flour (g)**	**IRFSM(g)**	**(Rice flakes**	**: Lotus stem**	**: Cauliflower leave**	**: Garden cress seeds)**
1	80	20	(7	: 1	: 1	: 1)
2	80	20	(6	: 2	: 1	: 1)
3	80	20	(5	: 3	: 1	: 1)
4	80	20	(4	: 4	: 1	: 1)

For the purpose of selection of recipe for intervention, the most common recipe Biscuits and Mathri were selected and used as control, which were already standardized by Sharma, 2010 and Avinash, 2012 with some modification. Each recipe was prepared with different ratio of IRFSM, in order to obtain the maximum acceptability range of IRFSM in products. Wheat flour was replaced with 10, 20, 30, 40 and 50% of IRFSM for the preparation of Biscuits and Mathri. All the developed products along with control were subjected to sensory evaluation. The detail of sensory evaluation of the recipe has been described here under:

Sensory evaluation: sensory quality and evaluation is a combination of different senses of perception which come into play for choosing and eating a food or it can be defined as a scientific discipline used to evoke, measure, analyze and interpret result of those characteristics of food as they are perceived by the senses of sight, smell, taste and touch. Therefore, the sensory qualities were evaluated by the panel of judges selected for ensuring acceptability of products.

Selection of panel members: Threshold test, which is described as one of the subjective test, useful in selection and training of panel (Srilakshmi, 2015) was used for selection of the panel. For this test, five dilution of different concentration each from salt and sugar sample was prepared. All the dilution samples were marked and arranged in random manner. Twenty members including staff and UG students of the Department of Home Science, SMM Govt. Girls College, Bhilwara, were asked to arrange the solution in correct order of salinity and sweetness. A panel of 10 members who arranged the solution in correct order, willing and available during the study period was selected. For the sensory evaluation of products panel members were explained about the objectives of the study and the methods to be followed.

Development of score card: For evaluating the products for it sensory qualities viz. color, taste, texture, flavor, appearance and overall acceptability, a score card was developed (Annexure-III). Nine points hedonic scale (ranging from 9 as liked extremely to 1 as disliked extremely) was used for rating of sensory attributes of each product. All the panel members were asked to assign scores to indicate their preference.

Method of evaluation: Sensory evaluation requires concentration on the part of the panel members. Therefore disturbance such as noise, off odors etc. were avoided during the entire time period. Coded samples were presented to panelists with score cards for evaluating the degree of acceptability of each characteristics being tested. The way of presenting the sample was kept uniform. A glass of water was served to avoid intermingling of taste of two sample and ensured proper evaluation. The temperature of test sample was also kept at an optimum level.

The standardized control recipe of Chapati, Biscuits and Mathri consisted of following ingredients with varying proportions and method is mentioned in Tables-3.5 to 3.7 and Figures-3.8 to 3.10.

Plate: 3.6 Selection of Panel Member by Threshold Test

Plate: 3.7 Sensory evaluation by panel member through developed score card

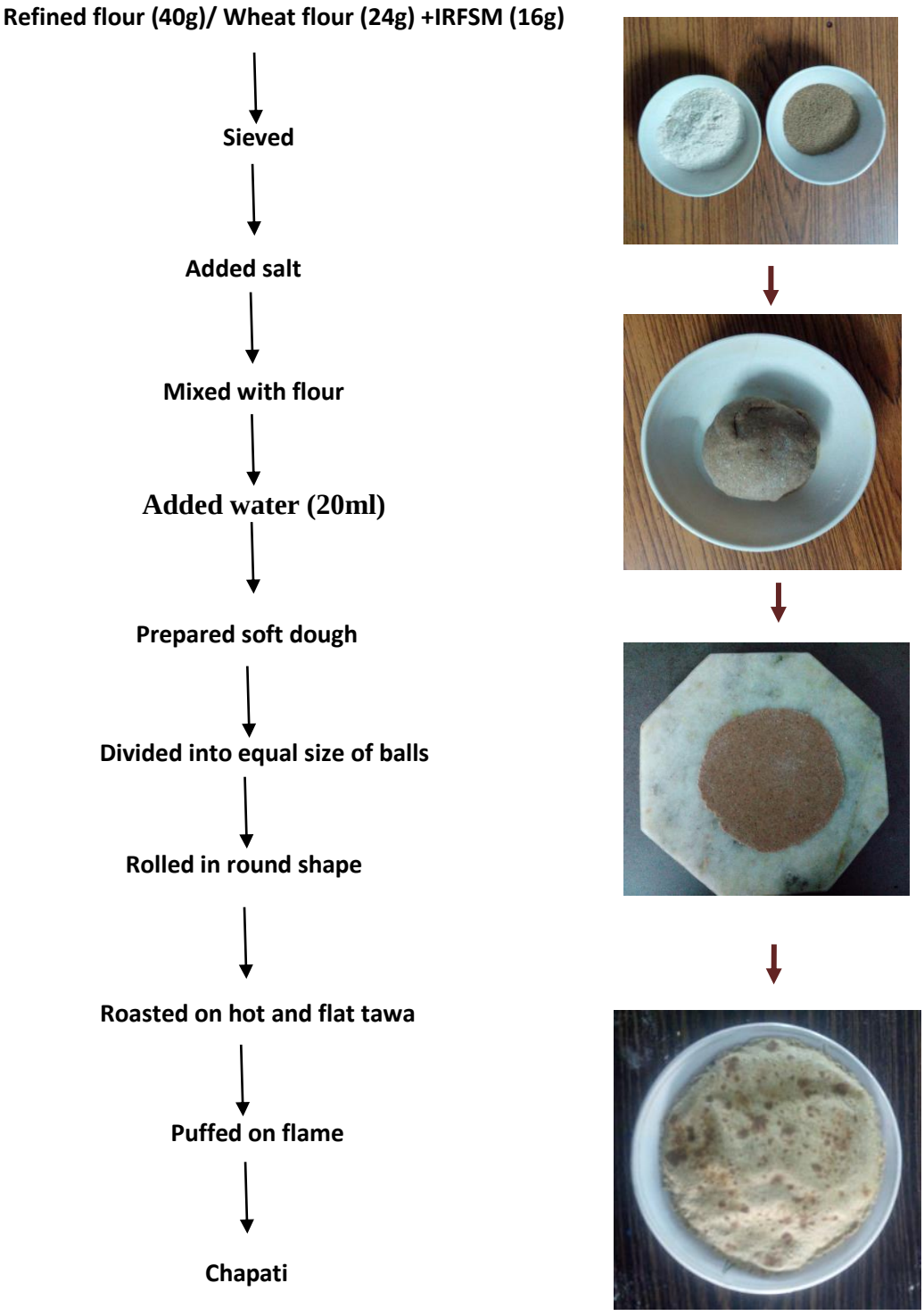


Figure: 3.8 Flow diagram for the preparation of Chapati

Table: 3.5 Standardized recipe of Chapati

S.No.	Ingredients	Amount	Procedure
1	Whole wheat flour	40 g	i. Salt and water were added to wheat flour and made soft dough.
2	Water	20 ml	ii. Dough was divided into 2 balls.
3	Salt	1/8tsp	Each ball was rolled into fairly thin round chapatis
4	Ghee	1 ts	iii. Chapati was cooked on heated tawa and puffed up iv. Ghee was applied to the hot chapatis
			Size of serving: 2

IRFSM chapati is made up of 40 mg whole wheat flour and IRFSM(70:30) in place of whole wheat flour

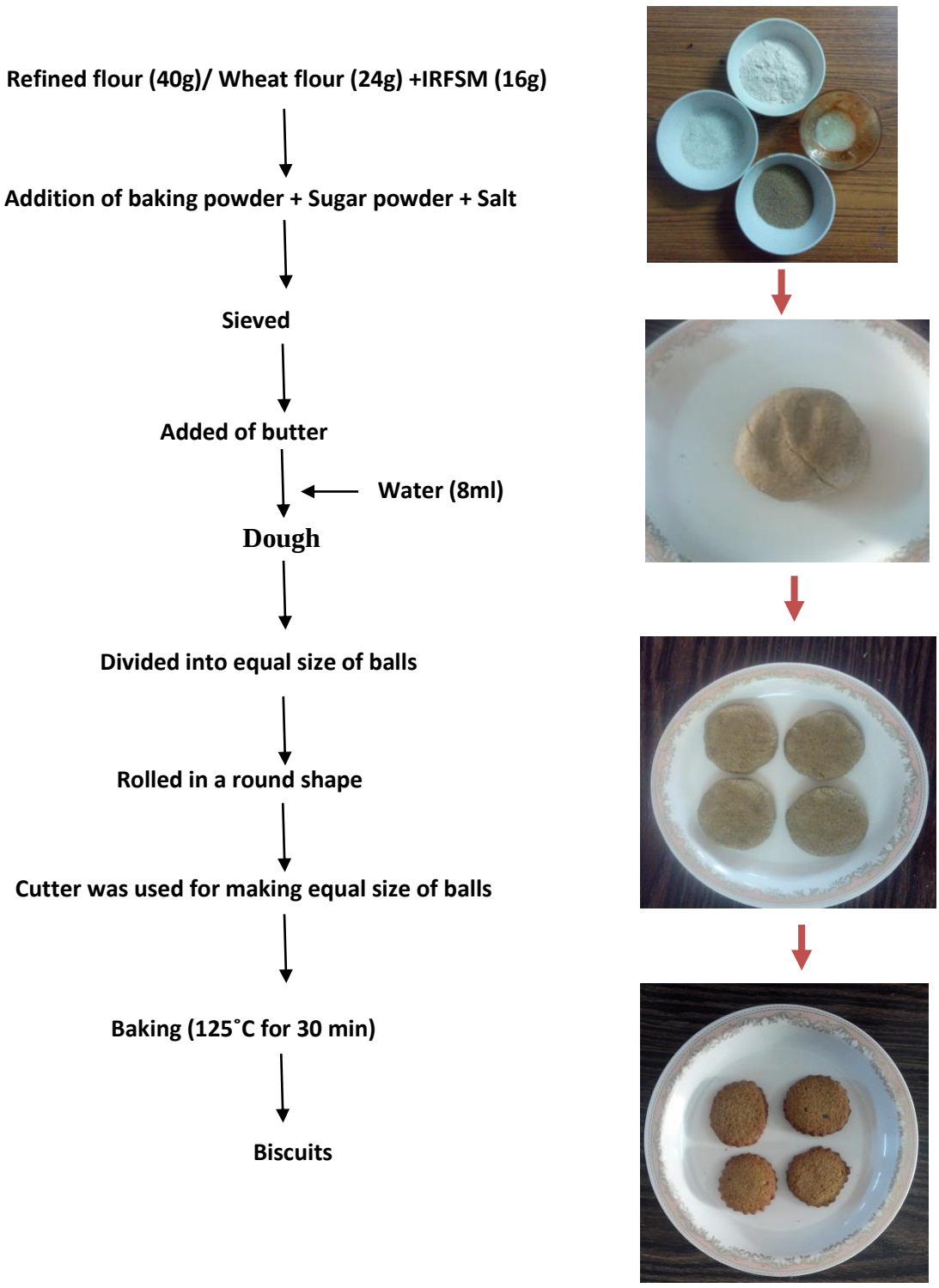


Figure: 3.9 Flow diagram for the preparation of Biscuits

Table: 3.6 Standardized recipe of Biscuit

S.No.	Ingredients	Amount	Procedure
1	Refined Flour	40g	i.Dry ingredients (Refined wheat flour, baking soda and Baking powder) were sieved twice for uniform mixing of leavening agent to the flour
2	Butter	15g	ii.Weighed amount of butter was taken in a bowl and stirred until it melted, then sugar was added and same procedure was repeated for creaming.
3	Sugar	15g	iii.Flour was added in smaller amount into the cream and was simultaneously mixed. Soft dough was prepared by sprinkling Small quantity of water.
4	Baking powder	265mg	iv.Dough was rolled (1cm thick) and then biscuit were cut from the rolled dough into small round shape using biscuit cutter.
5	Baking soda	150mg	v.Biscuits were kept in an electric oven for 30 minutes at 125˚C for uniform baking.
6	Water	8 ml	Size of serving: 4 Biscuit

IRFSM Biscuits are made up of 40g whole wheat flour and IRFSM(70:30) in place of Refined wheat flour

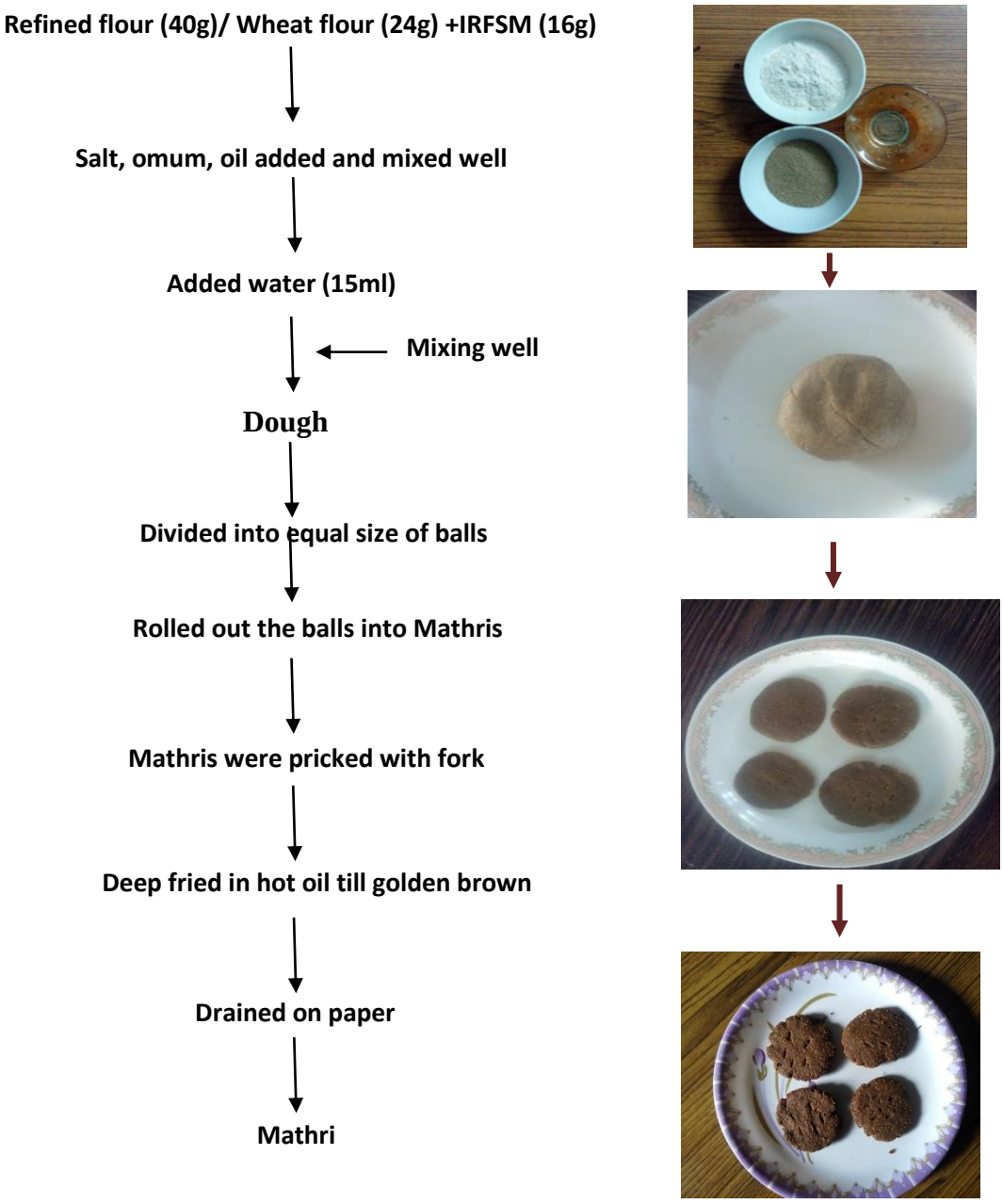


Figure: 3.10 Flow diagram for the preparation of Mathri

Table: 3.7 Standardized recipe of Mathri

S.No	Ingredients	Amount	Procedure
1	Refined Flour +IRFSM	40 g	i. Refined wheat flour + IRFSM and salt was added. Oil was rubbed in with finger tips
2	Omum	1/4 ts	ii. Stiff dough was made using water, covered and left for 20 minutes.
3	Salt	1/4 tsp	iii. Dough was divided into four portion and made balls into thick round 2.0 inches diameter Mathris.
4	oil (shortening)	1 ts	iv. Mathris was pricked with fork.
5	Water	15 ml	v. Mathris were fired in hot oil on slow fire till golden brown from both sides.
6	Oil	For frying	vi. Drained on brown paper and cooled.
			Size of serving: 4 Mathri

IRFSM Mathri are made up of 40g whole wheat flour and IRFSM(70:30) in place of whole wheat flour

3.6.2.1.5. Packaging and storage of IRFSM: Packaging is necessary to keep the product free from contamination and prevents deterioration during storage. In the present study, attempts were made to assess the shelf life of the developed products under the packaging condition.

Required quantity of most acceptable IRFSM was prepared and divided into four parts; one part was used to assess the sensory qualities, nutrients composition and keeping quality at 0 month. Remaining three parts were stored in high density polythene (HDPE) packets having density 0.65gm/cm3 and 0,0mm thickness. Packets were packed by ordinary heat sealing.

Three packets of sample were stored in room temperature in a dry place for a period of three month and for the quality assessment at monthly intervals during storage period. During the storage period, the minimum range of room temperature varied from 10˚C to 27˚C whereas, the maximum range of temperature was from 28˚C to 42˚C. The minimum relative humidity recorded during the study period varied between 7 to 31 percent and maximum from 26 to 63 percent.

3.6.2.2. Quality Evaluation of Developed IRFSM

Quality, form a scientific stand point , can be define as an orderly classification of a product's chemical , physical, nutritional, microbial and aesthetic characteristics that have significance in determining the degree of acceptability of the product to the consumer. Hence, the developed product in the present investigation was subjected to the quality assessment.

The quality of developed IRFSM at 0 month of storage i.e. fresh IRFSM was evaluated by measuring nutrient composition and keeping quality parameters. Shelf life and sensory qualities of mix were also assessed at an interval of one month during the entire storage period of three month.

3.6.2.2.1. Nutritional composition

Nutrient evaluation of the IRFSM was done for their proximate composition and mineral profile. Percentage carbohydrate and energy content were determined by calculation using difference method and At-water factors, respectively. All the determination was done in triplicate and average values were adopted.

Moisture: Ten gram of sample was placed in a petry-dish and dried in an oven at 80◦C overnight and cooled in desiccators. The process of heating and cooling was repeated till a constant weight was achieved and moisture percentage was calculated using following formula:

$$\text{Moisture \%} = \frac{\text{initial weight} - \text{Final weight}}{\text{Weight of sample}} \times 100$$

Ash

Principle: The ash of the food stuff is the inorganic residue remaining after the organic matters have been burnt away. The ash obtained is not necessarily of exactly the same composition as the mineral matter present in the original food as there may be losses due to volatilization or some interaction between constitutions.

Procedure: Five grams of sample was weighed accurately into a porcelain crucible. The crucible was placed in muffle furnace for 3-5 hours at about 600◦C. It was then cooled in a dessicator and weighed. The crucible was again heated in the muffle furnace for half an hour, cooled and weighed. The procedure was repeated till ash was almost white and grayish white in color. The ash content was determined by the following formula:

$$\text{Ash \%} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample}} \times 100$$

Plate: 3.8 SOCS PLUS Soxlet Apparatus for Fat estimation

Plate: 3.9 Muffel Furnanc for Ash estimation

Fat

Principle: Fat from food is solubilized in petroleum ether and then distilled of completely to estimate the crude fat in the sample.

Procedure: Five grams of moisture free sample was weighed and transferred to a 10 x 10 cm whatman no.41 filter paper. It was folded in such a manner that during extraction the sample does not come out. The packet was placed in the extracting tube of soxhlets apparatus. An empty round bottom flask was weighed and filled to three fourth and then connected with extractor. Flask was heated for about 16 hours for completed extraction of fat. The flask was disconnected, cooled in a dessicator and weighed after ether evaporated. The difference in initial and final weight of the flask calculated to find out the fat content.

$$\text{Fat \%} = \frac{\text{Weight of ether extracted fat}}{\text{Weight of sample (g)}} \times 100$$

Fiber

Principle: Fiber is an insoluble vegetable matter which is indigestible by proteolytic and diastatic enzymes and cannot be utilized except by microbial fermentation. It is usually composed of cellulose, hemi-cellulose and lignin. During the acid and subsequent alkali treatment, oxidative hydrolytic degradation of native cellulose and considerable degradation of lignin occur. The residue obtain after final filtration is weighed, incinerated, cooled and weigh again. The loss in weight gives the crude fiber content (NIN, 2003).

Procedure: Five gram of moisture free and fat free sample was taken in 500 ml beaker and added to 200 ml of 1.25 percent H2SO4 to it. The mixture was boiled for 30 minutes keeping the volume constant. Residue was filtered through a muslin cloth and residue was washed with hot water to make it acid free. The residue was then transferred to the same beaker and 200 ml of 1.25 percent NaOH was added. After boiling for 30 minutes as earlier, the mixture was filtered again through muslin cloth.

The residue was washed with hot water till free from alkali, followed by washing with 50 ml alcohol and 50 ml ether. The material was then transferred to a crucible, dried overnight at 80-100◦C and weighed (W1). The content was then heated in a muffle furnace at 600◦C for 8 hours, cooled and weighed again (W2). The difference between residue and ash represented the weight of crude fiber. The crude fiber content was calculated as under:

$$\text{Crude fiber \%} = \frac{\text{Weight of residue (W1) – Weight of ash(W2)}}{\text{Weight of sample}} \times 100$$

Protein

Micro kjeldahl method is commonly used to determine the protein content of food stuff by estimating the nitrogen content of the material multiplying nitrogen value by 6.25. it is considered as crude protein because non protein nitrogen (NPN) present if food purine, pyrimidine base , vitamin, amino sugar, alkaloids, compound of lipids etc, is also included in total nitrogen. T he nitrogen present in protein or any other organic materials converted to ammonium sulphate by sulphuric acid during digestion. This salt on steam distillation liberates ammonia which is collected in boric acid solution. Ammonia forms a loose compound, ammonium borate with boric acid and titrated against standard acid (NIN, 2003).

Procedure: Crude protein was estimated in powdered moisture free sample using Micro kjeldahl method (Kel plus nitrogen estimation unit). The method involved the following steps:

Digestion :100 mg of sample in duplicate was digested in Micro kjeldahl flask with 2 ml concentrated H2SO4 and 0.5 g digestion mixture(98 parts K2SO4+ 2 parts CuSO4) on a digestion rack till a clear solution was obtained . A reagent blank was run simultaneously.

Distillation: this was carried out by adding 100 ml of 40 percent NaOH to the digested sample, which was then boiled. The steamed librated ammonia was collected in a conical flask containing 25ml of boric acid (4%) with 2 drop of mixed indicator, till the distillate collected was about 15ml.

Plate: 3.10 Atomic Absorption Spectrophotometer

Plate: 3.11 Kel Plus Nitrogen Estimation Unit

Titration: the content of the conical flask was titrated with 0.1N HCl till an end point of pink color was reached. The amount of HCl used was noted as titer value and calculation was done as follows:

$$\text{Nitrogen N \%} = \frac{14.01 \times 0.1 \times (\text{Titer value} - \text{Blank value}) \times 100}{\text{Weight of sample} \times 1000}$$

Protein % = Total nitrogen % X general factor 6.25

Carbohydrate

Carbohydrate content of the sample can be determined by difference method i.e. sum of moisture, protein, crude fiber, fat and ash, subtracted from 100 (Gopalan et.al. 2007).

Carbohydrate (g/100 g) = (100-(moisture + protein + crude fiber + fat + ash)

Energy

The energy content of the food sample was determined by multiplying protein, fat and carbohydrate content with their physiological fuel value as follows:

Energy (kcal / 100 g) = (% protein x 4) + (% carbohydrate x 4) + (% fat x 9)

Minerals

In the present investigation mineral element i.e. iron and calcium content were estimated by standard procedure:

Iron and Calcium: These minerals were analyzed using Atomic Absorption Spectrophotometer (ECIL, model AAS 4141). Diluted sample was drawn up in the atomizer burner assembly through a capillary and convert by means of stream of compressed air to a fine spray which after condensation of large droplets was mixed with acetylene and burnt in a long flame at the burner light coming from the hollow cathode lamp, after transversing the flame entered a monochromatic wave set at 324 nm and fell on photomultiplier tube (photocell). The tube converts the light radiation into electrical energy which was measured by galvanometer. Iron was analyzed at 249.1 nm and Calcium at 422.7 nm wavelength (NIN, 2003).

3.6.2.2.2. Physical and functional properties

Bulk density:

The bulk density of the mix was determined by using a sample in a 100 ml graduated cylinder with gentle uniform tapping filling. The cylinder was filled to the mark and the weight of the mix was measured. The bulk density was calculated as Mass by volume and expressed in g/ml (Singh et al., 2005).

Water absorption capacity and water solubility capacity:

IRFSM (2.5g) was mixed with 30 ml of distilled water using a glass rod and cooked at 90 C for 35 minutes in a water bath. The cooked paste was cooled to room temperature and transferred to centrifuge tubes and centrifuged at 3000 rpm for 10 minutes. Water absorption capacity and water solubility capacity of mix were determined using the method given by Singh et al. (2005).

$$\text{Water absorption capacity} = \frac{\text{Weight of sediment (g)}}{\text{Weight of dry solid (g)}}$$

$$\text{Water solubility capacity} = \frac{\text{Weight of dissolved solid in supernatant (g)}}{\text{Weight of dry solid (g)}}$$

Swelling capacity:

Three gram of mix (dry basis) was transferred into clean, dry graduated (50 ml) cylinder. Sample gently leveled into it and the volume noted. Distilled water was added to sample; the cylinder was swirled and allowed to stand for 60 minutes while the change in volume (swelling) was recorded every 15 minutes. The swelling power of sample was calculated using the method given by Ukpabi and Ndimele (1990).

$$\text{Swelling capacity} = \frac{\text{volume after soaking (ml)} - \text{volume before soaking (ml)}}{\text{Weight of sample (g)}} \times 100$$

3.6.2.2.3. Keeping quality of developed IRFSM

A. Insect infestation

In dry food flour, insects and their fragments may originates during primary infestation before milling and/or from secondary infestation during the storage of flour and flour products on the food processing time (Trematerra and catelano, 2010). Dead and alive insects were observed by sieving the flour samples and inspecting the flour and contents in the sieve.

B. Sensory quality

Fresh and stored IRFSM was evaluated for its acceptability in term of appearance, taste, flavor, texture and overall acceptability. After opening the packets, IRFSM was physically examined for any infestation by insects, foul smell and change in color or spoilage like caking which were visually perceptibly. IRFSM was used for Chapati, biscuit and Mathri preparation if it was found satisfactory. The methodology followed for sensory evaluation is explained under section 3.5.2.1.5.

C. Moisture

Moisture content of packed IRFSM was assessed at monthly interval during three month storage period as mentioned in section 3.5.2.2.1.

D. Microbial load / Examination: Microorganism are closely related to the health and welfare of human being

In the present investigation the microbial load of IRFSM was enumerated in term of total viable count (TVC), yeast and mold count and coliform count at zero and monthly interval up to three month of storage, as per the method described by American public health association (APHF,1985). The method of preparation and composition of media used to carry out the estimation is as follows:

Plate: 3.12 Laminar Air Flow Chamber

Plate: 3.13 Incubation

Plate: 3.14Colony counter

(a) Sterilization: Cleaned heat resistant glassware like petriplate, pipettes, conical flask, test tube were sterilized in an oven maintained at the temperature of 160˚C for a period of two hours (Vij and Subramanian, 1999).

(b) Preparation of media: For total viable count nutrient agar media (0.5% peptone, 0.15% beef extract, 0.15% yeast extract, 0.5% sodium chloride, 2.4% agar and 100 ml distilled water) was used for yeast mold count. For the coliform count, violet red bile agar (0.3% yeast extract, 0.7% peptone, 0.5% sodium chloride, 0.15%bile salt, 0.1% lactose, 0.003% neural red, 0.0002% crystal violet, 1.5% agar and 100 ml distilled water) was used. Weighed amount of media was taken and dissolved in distilled water by boiling, poured in screw capped media bottles in proportion of 100 ml each and autoclaved at 121˚C for 15 minutes.

(c) Enumeration of microbial growth

I. Preparation of dilution: one gram of sample was added to 9 ml of sterile saline solution in a sterilized environment and mixed thoroughly for the first dilution i.e. $1/10^{th}$ concentration of original sample. Subsequent dilutions were obtained by transferring 1 ml of previous dilution to 9 ml of sterile saline in cotton plugged test tube.

II. Plating technique: One milliliter dilution was transferred in already marked sterilized petriplates in triplicates. Agar medium was melted (if solidified) in hot water bath; 15 ml of media was poured into each petriplate. It was then mixed with sample by rotating without spreading over the edge of petridish. The mixture was evenly spread over the bottom of the plate and media was allowed to solidify.

III. Incubation and counting of colonies: The plates with solidified medium and sample were inverted and incubated in incubator at temperature (37˚C) and time given in table. Developed colonies were counted expressed as colony forming unit/gm (cfu/g) of sample.

Table: 3.8 Details of enumeration of microbial growth

S.No	Type of organism	Media used	Incubation temperature	Incubation period(hour)	pH
1	**Total viable count**	Nutrient agar	37˚C±2	24±2	7
2	**Yeast and mold**	Potato dextrose agar	30˚C	70 -90 ±2	3.5
3	**Coliform**	Violet red bile agar	37˚C±2	24±2	6.8

3.6.2.3. Development of nutrition education material

The main objective of the Nutrition education material is to inculcate changes in nutrition knowledge of girls and improvement in the nutrient intake leading to improvement in their nutritional status.

Nutrition education material was based on a multi- media approach i.e. written method of communication, demonstration, discussion and audio-visuals. The educational material was developed based on current nutrient intake, food selection, consumer belief, traditional practices and nutrition knowledge of girls regarding health.

Designing of educational material: Teaching aids related to nutrition education such as folders, chart, poster, power point presentations etc. were designed and developed (Annexure-XIX).

3.6.3. Phase III Efficacy assessment of nutrition intervention package in improving the iron status of adolescent girls

The efficacy of the package was assessed through nutrition intervention program. Intervention program was conducted in three phases:-

A. **Pre test phase**

The data obtained from the phase I of the study was used as the baseline data. Anemic adolescent girls, but not requiring hospitalization for anemia, were considered eligible. Following base line data was used:-

Plate: 3.15 Presentation of Educational Package






Anthropometric measurements

Dietary intake

Clinical examination

Biochemical estimation

Nutritional knowledge

B. **Treatment phase:-** Subjects were dewormed prior to intervention by Albendazole tablets. This phase was divided in two parts:-

Part I Nutrition education Package was presented to adolescent girls of experimental group III and IV for four weeks.

Part II Developed iron rich supplementary food product was fed to the girls of experimental group II and IV with vitamin C source (Lemon juice/Amla) and experimental group I without vitamin C source, for 90 days. Subjects in the control group were not received any intervention (supplementation and nutrition education). In all the groups the ICDS supplement was given as is the practice but intake of IFA tablet was stopped for three months.

C. Post test phase

At the end of the four months all the base line parameters were carried out. Girls were re-examining for anthropometric measurements, dietary intake and clinical examination and biochemical examination. Nutrition knowledge of girls was assessed.

3.7. Statistical analysis of date

The data were statistically analyzed as per the objectives of the study. Formula used for analysis of data are given below (Gupta, 2004).

- Frequency distribution and percentage were calculated for all parameters that were expressed in a rank order fashion.
- Mean standard deviation and standard errors were calculated for all parameters that were expressed numerically.

- **Mean**

$$\bar{x}=\frac{x_1+x_2+x_3+...+x_n}{n} \quad \text{or} \quad \bar{x}=\frac{1}{n}\sum_{i\ 1}^{n} x_i$$

Where, x= observation

n = number of observation

i = 1, 2, 3, …….n

- **Standard deviation**

$$\sigma=\sqrt{\frac{(x_1-\bar{x})^2+(x_2-\bar{x})^2+(x_3-\bar{x})^2+...+(x_n-\bar{x})^2}{n}}=\sqrt{\frac{\sum_{i\ 1}^{n}(x_i-\bar{x})^2}{n}}$$

Where Σ = Sum of

x = Individual score

n = Sample size (number of scores)

σ = Standard deviation

- **Standard error of mean**

$$\sigma_M=\frac{\sigma}{\sqrt{N}}$$

- **Student‘t’ Test**

‘t’ Test is often called student’s ‘t’ test in the name of its founder ‘Student’. Paired‘t’ test was used to assess the difference between the mean of the same group before and after intervention period. The formula for Paired ‘t’ test is given below:

$$t=\frac{\bar{X}_1-\bar{X}_2}{\sqrt{\frac{S_1^2}{n_1}+\frac{S_2^2}{n_2}}}$$

Where,

$\bar{x}_1$ = Mean of first set of values

$\bar{x}_2$ = Mean of second set of values

S_1 = Standard deviation of first set of values

S_2 = Standard deviation of first set of values

n_1 = Total number of values in first set

n_2 = Total number of values in second set

- **Chi Square (χ^2)**

A Chi Square is one way to show a relationship between two categorical variables. The value can be calculated by using the given observed frequency and expected frequency. The Chi Square is denoted by χ^2 and the formula is:

$$\chi^2 = \frac{\sum (O-E)^2}{E}$$

Where,

O = Observed Frequency

E = Expected Frequency

$\sum$ = Summation

χ^2 = Chi Square value

ANOVA

ANOVA is a statistical test which analyzes variance. It is helpful in comparing mean of three or more groups. ANOVA was used to compare differences between the means in different groups. Data obtained from the organoleptic evaluation, microbial analysis, and physical properties of developed IRFSM and effect of nutrition intervention package on the hemoglobin levels, nutrition knowledge, growth and nutrient intake of the subjects, were subjected to analysis of variance (one way clasification).

Source of variation	**Degree of freedom (d.f.)**	**Sum of Squares**	**Mean squares**	**Variance Ratio (F)**
Treatment	k-1	SST	MST= $\frac{SST}{k-1}$	F= $\frac{MST}{MSE}$
Error	rk-k	SSE	MSE= $\frac{SSE}{rk-k}$	~ F[(k-1), (rk-k)]
Total	rk-1	TSS		

Where,

F = ANOVA coefficient

SST = Sum of squares due to treatment

SSE = Sum of squares due to error

MST = Mean sum of squares due to treatment

MSE = Mean sum of squares due to error

k=Numbers of replications

r= Treatments

Critical Difference (CD) = For each variance ratio, the critical difference was calculated for finding out the significance difference between the corresponding two mean values (Treatments).

$$CD = SE * T_{prob\ value,\ errod\ d.f.}$$

$$SE = \sqrt{2MSE/r}$$

CHAPTER- 4

RESULTS AND DISCUSSION

Empirical and verifiable interpretation of the data collected during the course of investigation plays a pivotal role in determining the success of any study. Suitable statistical tools were used to analyze the data, which has been tabulated and systematically presented with the help of supportive material. The finding and interpretation of the study have been discussed under the following headings:

Phase I

4.1. General information and socio demographic profile of the subjects

4.2. Nutritional status of the study subjects

4.2.1. Anthropometric measurements of the subjects

4.2.1.1 Growth patterns

4.2.1.2 Prevalence of mal-nutrition (under-nutrition and over-nutrition)

4.2.2. Dietary and nutrient intake of the subjects

4.2.2.1. Intake of various food groups

4.2.2.2. Nutrient intake by the subjects

4.2.2.3. Frequency of consumption of iron and vitamin-C rich food

4.2.3. Clinical signs and symptoms of anemia

4.3. Morbidity profile of the adolescent girls

4.4. Menstruation history

4.5. Prevalence of anemia

4.6. Socio-demographic correlates of nutritional anemia in study subjects

4.7. Nutrition knowledge of the subject

Phase II

4.8. Development of iron rich food supplement mix (IRFSM)

4.8.1. Preparation of IRFSM

4.8.2. Standardization of iron rich food mix (IRFSM)

4.8.3. Quality assessment of developed IRFSM

4.8.3.1. Nutrient compositions

4.8.3.2. Physical and functional properties

4.8.3.2.1. Bulk density

4.8.3.2.2. Water absorption capacity and water solubility capacity

4.8.3.2.3. Swelling capacity

4.8.4. Keeping quality assessment of the developed IRFSM

4.8.4.1. Sensory quality

4.8.4.2. Microbial load

4.8.4.3. Moisture

4.8.4.4. Insect infestation

4.8.5. Cost analysis of IRFSM

Phase III

4.9. Impact of nutrition intervention package in improving the iron status of adolescent girls

4.9.1. Impact of nutrition education on the nutrition knowledge of the subjects

4.9.2. Impact of nutrition intervention package on hemoglobin status of the subjects

4.9.3. Impact of nutrition intervention on the nutrient intake of adolescent girls

4.9.4. The impact of nutrition intervention on growth of the subjects

4.1. General information and socio demographic profile of the subjects

Age: Perusal of the table-4.1 reveals that majority of the subjects (42.86%) were on the age group of 14-16 years, 34.28 percent belonged to age group of 10-13 years. Rest of them (22.86 %) was in the age group of 17-19 years. Among them, 55% were in the late adolescent age group, 19.9% were in mid-adolescent age group and 25.2% belonged to early adolescent age group.

Religion: In the present study majority of the subjects (78.57%) belonged to Hindu religion while 17.44 percent were Muslim. Only 11% and 7% belonged to Sikh and Christian religion respectively.

Caste: Perusal of the table-4.1 depicts that 36.43 percent of the subjects were from backward caste, while 24.29% and 16.20% belonged to SC and ST caste respectively. Nearly one-fourth of them (23.10%) belonged to general caste like Brahmins, Rajputs and Vaishyas.

Education: With respect to parental education, data indicate that most of the mothers (49.39%) were illiterate. Only 21.41% were educated up to primary level and 6.60 percent were educated up to secondary level. In case of fathers, 25.85% had primary education and 18.36%, 11.6% and 75 had secondary education, higher education and graduation respectively. There were 20.77 percent fathers who were illiterate.

Type of family: Type of family classified in term of joint and nuclear revealed that majorities (57.86%) of families were nuclear and 42.14 percent were joint.

Family size: Number of members in the house hold data reveals 55.24% families had 5-8 members residing in the house hold, 27.38% had more than 8 members and 17.38% had up to 4 members.

Table: 4.1 General information and socio demographic profile of the subjects

S.No.	Particular	Frequency(N=420)	Percentage (%)
1	**Age (year)**		
	10- 13	144	32.28
	14-16	180	42.86
	17-19	96	22.86
2	**Religion**		
	Hindu	330	78.57
	Muslim	72	17.44
	Sikh	11	2.62
	Christian	7	1.67
3	**Caste**		
	Schedule caste	68	16.2
	Schedule tribe	102	24.29
	OBC	153	36.43
	General	97	23.1
4	**Occupation of father**		
	Laborer	128	30.48
	Artisan	42	10
	Business	43	10.24
	Independent profession	45	10.75
	Cultivation	122	29.05
	Service	40	9.52
5	**Education of Father**		
	Illiterate	86	20.93
	Can read and write only	68	16.43
	Primary	107	25.85
	Secondary	76	18.36
	Higher secondary	48	11.6
	Graduate	29	7
6	**Education of Mother**		
	Illiterate	243	59.12
	Can read and write only	93	22.63
	Primary	48	11.67
	Secondary	27	6.6
	Higher secondary	0	0
	Graduate	0	0

S.No.	Particular	Frequency(N=420)	Percentage (%)
7	**Education of subjects**		
	school going	230	54.76
	School dropout	153	36.43
	Illiterate	37	8.81
8	**Family Type**		
	Nuclear	243	57.86
	Joint	177	42.14
9	**Family Size**		
	Small (upto 4 members)	73	17.38
	Medium (5- 8 members)	232	55.24
	Large (>8 members)	115	27.38
10	**No. of siblings**		
	0-1	59	14.05
	2-3	190	45.24
	3-4	123	29.29
	>5	48	11.43
11	**Marital status of subject**		
	Married	122	29.05
	Unmarried	293	69.76
	Widow	5	1.2
	Divorce	0	0
12	**Food habits**		
	Vegetarian	353	84.05
	Non-vegetarian	67	15.95
13	**Socioeconomic status**		
	Upper class I	0	0
	Upper middle class II	13	3.1
	Middle class III	68	16.19
	Lower middle class IV	228	54.29
	Lower class V	111	26.43

Number of siblings: The number of sibling's data reveals that half of the subjects had 2-3 siblings, 23.81% had 3-4 siblings. Only 14.05% had one sibling and 11.43% had more than 5 siblings.

Socio economic status: information specific to socio-economic status reveals that more than half (54.29%) of the subjects belonged to lower middle class, 16.19% belonged to middle class. Very few (3.09%) subjects were in upper middle class and none of the subjects were in upper class.

Occupation: Data specific to parental occupation reveals that 30.48% of the fathers were labourer, followed by 29.05 percent cultivators, 10.75% engaged in independent profession, 10.24% in business and 9.52% in service.

Food habits: Majority (84.05%) of the subjects consumed vegetarian diet while only 15.05% were non-vegetarian.

Marital status: Information specific to marital status of the subjects reveals that majority (69.76%) of the subjects were unmarried while 29.05% were married. Only 1.2% subjects were widow.

4.2. Nutritional status of the study subjects

Changes in body dimensions reflect the overall health and welfare of individuals and population. Anthropometry is used to assess and predict performance, health and survival of individuals. Anthropometry is widely used, inexpensive and non-invasive measure of the general nutritional status of an individual or a population group (Cogil, 2003). Thus, for the present study, anthropometric data was collected to get on idea of the prevalence of malnutrition in rural adolescent girls.

4.2.1. Anthropometric measurements of the subjects

To assess the nutritional status various parameters were studied namely, height, weight and BMI.

The overall mean weight, height and BMI of the study population were 39.13±8.91 (SE 0.43, 95%CI 38.28-39.98), 147.03±7.18 (SE 0.35, 95%CI 146.34-147.72) and 16.83±6.73 (SE 0.32, 95%CI 16.18-17.47) respectively. Mean weight, height and BMI according to the stage of adolescent (Early, middle and late adolescent) is presented in the Table-4.2.

Table: 4.2 Mean Height, Weight and BMI according to the stage of adolescent

Particular	**Early adolescent 10-12 years**	**Middle adolescent 13-15 years**	**Late adolescent 16-19 years**	**Over all 10-19 years**
	N=144	**N=180**	**N=96**	**N=420**
Weight				
Mean	30.83±9.02	40.27±8.24	44.6±7.82	39.13±8.91
SE	0.75	0.61	0.8	0.43
95%CI	29.34 to 32.32	39.06 to 41.48	43.02 to 46.18	38.28 to 39.98
Height				
Mean	137.73±6.83	147.92±7.94	153.37±6.43	147.03±7.18
SE	0.57	0.6	0.66	0.35
95%CI	136.60 to 138.86	146.75 to 149.09	152.07 to 154.67	146.34 to 147.72
BMI				
Mean	15.36±4.62	16.85±5.42	17.92±4.38	16.83±6.73
SE	0.39	0.4	0.45	0.32
95%CI	14.60 to 16.12	16.05 to 17.65	17.32 to 18.81	16.18 to 17.47

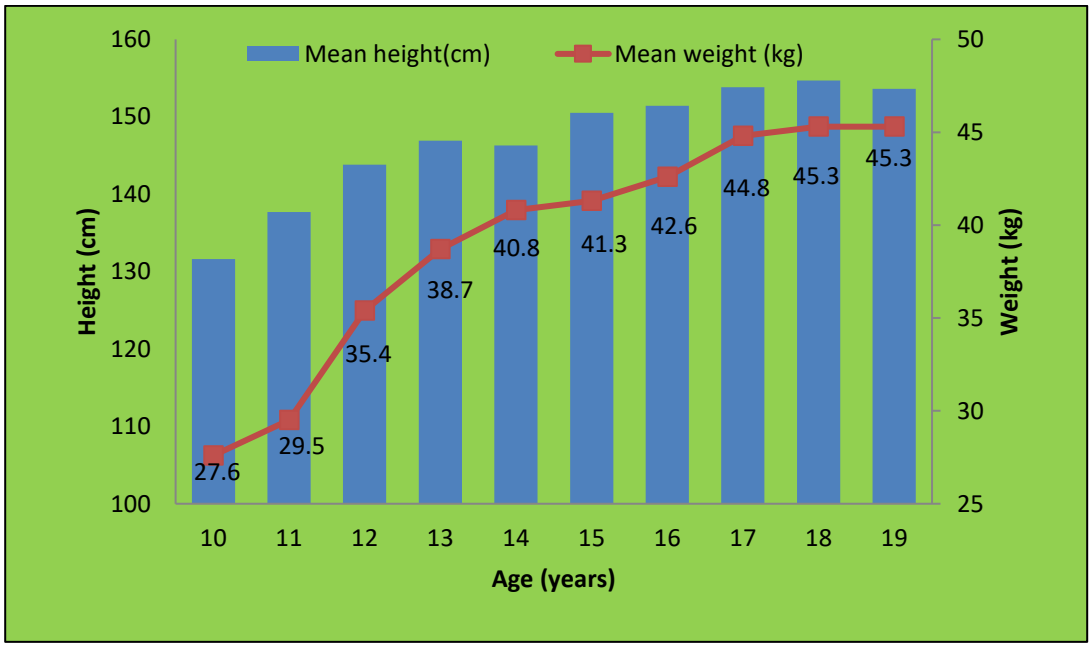
The adolescent of the present study had lower mean height and weight but comparable BMI- for-age compared to those reports in other studies on adolescents from Indian cities (Rajaretham et al.,2012; Patil et al.,2013 and Kumaravel et al., 2014) but higher mean height and weight, but lower BMI compared to adolescents form the rural area of Wardha, Maharashtrs and rural area of northern Karnataka (Taksande et al., 2008 and Bano, 2012).

4.2.1.1 Growth patterns

As expected, the height correlated positively with the age, increasing as age advanced. The mean height of the girls ranged from 131.6±7.8cm at age 10years to 153.6±6.7cm at 19 years as shown in the figure. The maximum increment in mean height was 6.1cm at 11 years of age.

Similarly for weight, it was observed that mean weight of the girls ranged from 27.6±7.7kg at age 10 years to 45.3±7.6kg at 19 years of age. The maximum increment in mean height was 5.9kg at 12 years of age (Figure-4.1).

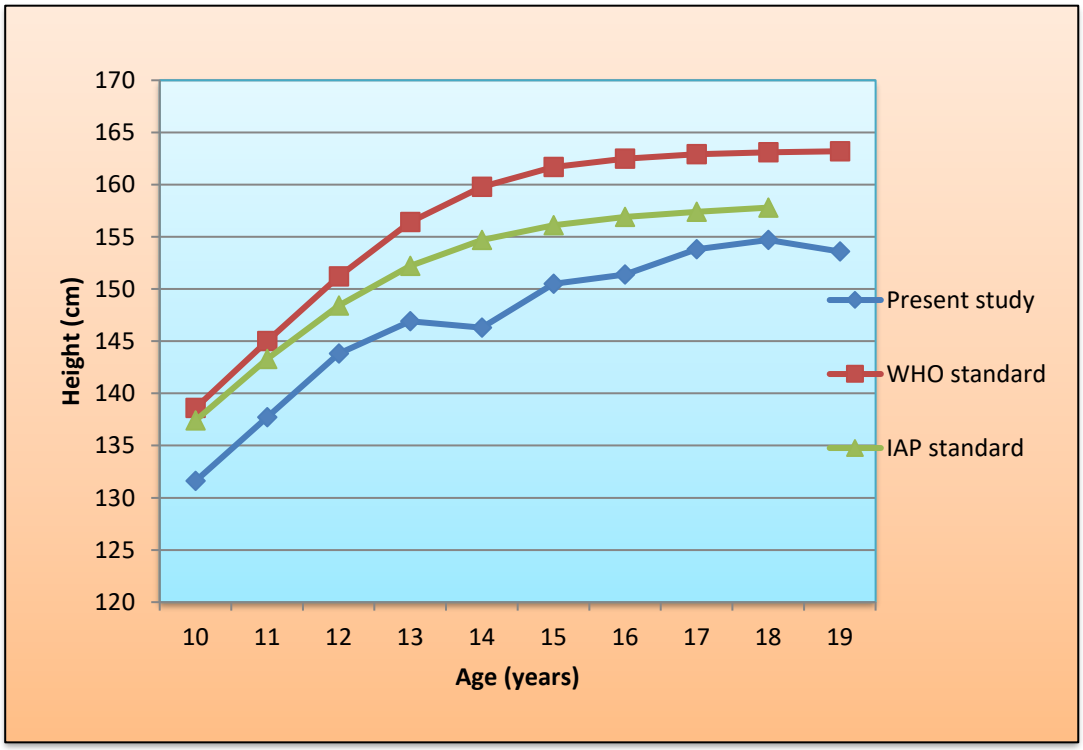
Figure: 4.1 Growth pattern in girls at different ages (N=420)



Comparison with various reference standards

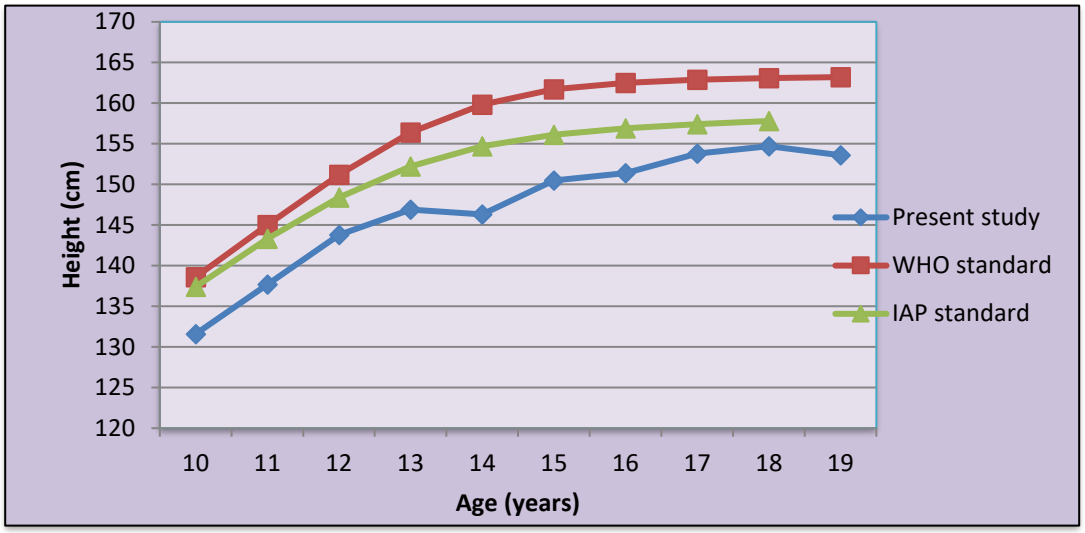
Anthropometric measurement and indicators found in the present study were compared with reference standards including WHO growth standards ((2006) and IAP growth standards (2015). On comparison of mean height of the girls in the present study with the reference standards it was observed that the girls had lower value of height. These observations indicate that the subjects are not able to keep up with the pace of growth, with which they enter adolescent. Thus early care is strongly recommended for these girls for an optimal adolescent growth (Figure-4.2).

Figure: 4.2 Comparison of Height for Age with other Reference Standards



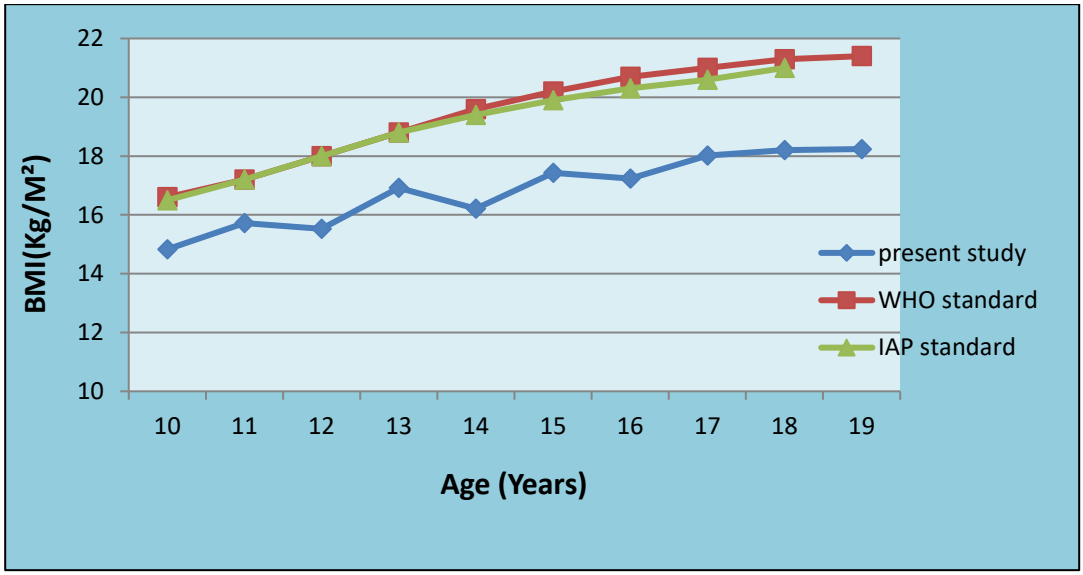
On comparison of weight for age median value with the widely used standards, it was observed that the girls had low weight for age value than all the standards. These observations show the inability of the subjects to allow full growth during the late stage of adolescence (Figure-4.3).

Figure: 4.3 Comparison of Weight for Age with other Reference Standards



The values of BMI for age were lower in the present study as compared to WHO and IAP standards (Figure-4.4). Similar findings were reported among the school-going adolescent (10-17 years) in Vadodara by Sengar, (2013). Anthropometric measurements including height for age, weight for age and BMI for age were compared with NCHS (2000), WHO (2006) and Agarwal et al. (1995) standards.

Figure: 4.4 Comparison of BMI for Age with other Reference Standards



An age wise summary of height and weight showed that height and weight increased with the increase in age (table). The distance curve of height and weight showed gradual increase with age. An average yearly increment in the mean height of the girls was 2.4 cm and weight was 2.2 kg. The maximum weight difference between two successive age groups (4.6 kg) was observed in girl's age during 12 to 13 years. The highest increase in height (5.03 cm) was also found between 12 to 13 years of age. The rapid increase in weight and height in the age group of 12 to 13 years for girls indicates the adolescent growth spurt. Adolescent growth spurt is a universal phenomenon and occurs in all children during adolescence, though it varies in intensity and duration from one child to another. Growth spurt among girls was observed around the age of 13 years and it was around this age when menarche was attained (median age at menarche of the study girls was 13.7 years after that the BMI tapered off and so did height (Bano, 2012 and Patil et al., 2013).

4.2.1.2 Prevalence of mal-nutrition (under nutrition and over nutrition)

To assess the prevalence of malnutrition, indices namely, BMI for age (BAZ), Height for age (HAZ) (WHO, 2006 standards) and Weight for age (Percentile) (IAP, 2015) were used. The WHO global database on child growth and malnutrition uses a Z-score cut-off point of <-2SD to classify low height for age and low BMI for age as moderate and <-3SD to define as severe under nutrition.

As shown in table-4.3 it has been concluded that the overall prevalence of underweight (low weight for age) was 29.52% with reference to IAP (2015). The adolescent girls with the age group of 10 to 12 years had high percentage of underweight (10.95%) and the age group of 13 to 15 years and 16 to 19 years had 10.24% and 8.33% prevalence of underweight respectively.

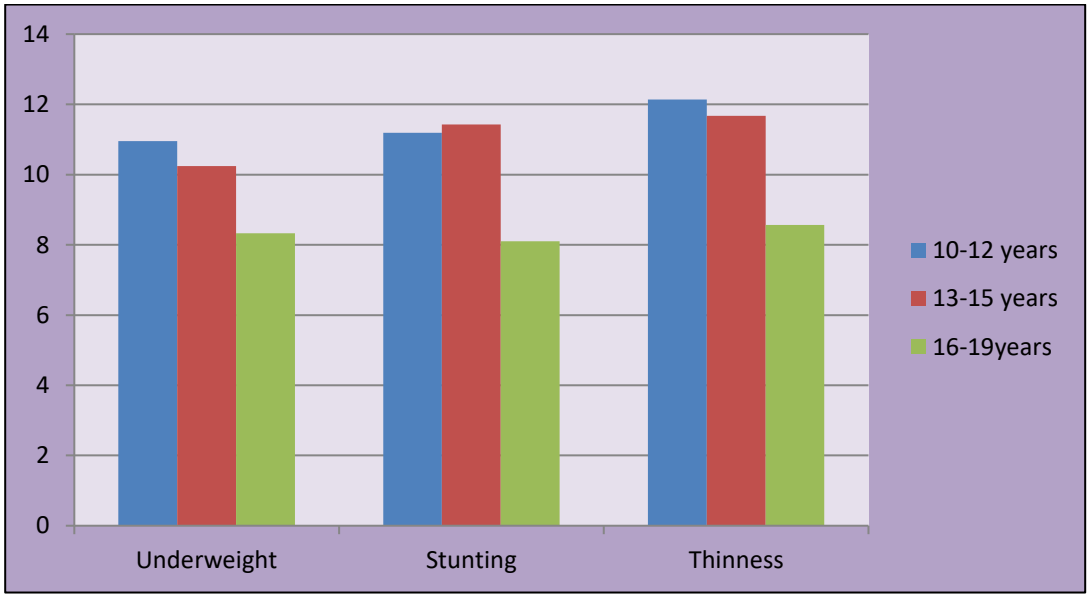
The overall prevalence of stunting was found 30.71 % as compared to height-for-age z scores (HAZ scores) (WHO, 2006). In the age group of 10 to 12 years, 13 to 15 years and 15 to 19 years prevalence of stunting was 11.19%, 11.43% and 8.10% respectively.

Similarly 32.38 % of the adolescent girls were found too thin as describe by WHO (2006) criteria (BMI for age z scores). Prevalence of thinness among 10 to 12 years, 13 to 15 years and 16 to 19 years of adolescent girls was12.14%, 11.67% and 8.57 % respectively.

Table: 4.3 Prevalence of Underweight, Stunting and Thinness in different age groups

Age group	Underweight		Stunting		Thinness	
	N	%	N	%	N	%
10-12 years	46	10.95	47	11.19	51	12.14
13-15 years	43	10.24	48	11.43	49	11.67
16-19 years	35	8.33	34	8.1	36	8.57
Overall 10-19 years	124	29.52	129	30.71	136	32.38

Figure: 4.5 Prevalence of Underweight, Stunting and Thinness in different age groups



Prevalence of Stunting among adolescent girls

It is also apparent from the study that overall prevalence of stunting was 30.71% among studied subjects which was almost similar as compared with the finding (23.28%) reported in Bareilly district, (UP), India by Singh et al. (2014) and 21.08%

in the selected village of Kolar district, Karnataka, India with use of WHO reference. However, use of Indian reference data, Maiti et al.(2013) found 18.10% of stunting among early adolescent girls of Paschim Medinapur district, West Bengal and Anand et al.(1999) reported 20% prevalence of stunting at rural north India which was lower compared with the present study. In contrast to this, many studies reported high prevalence of stunting among rural adolescent girls. The extent of stunting was higher (50.3%) at rural area of Darjeeling district of West Bengal. A study from Belgaum reported that adolescent girls between the age group of 10-14 year were more stunted (63.82%) as compared to 15-19 year of age (39.43%) (Baliga et al.,2014). The prevalence of stunting in the present study was also lesser than the prevalence of stunting observed in various other studies conducted by Seema et al.(2003), Haboubi et al. (2009) and Kalhan et al. (2010).

Table: 4.4 Prevalence of Stunting among adolescent girls

Height for age	10-12 years		13-15 years		16-19years		Total	
	N	%	N	%	N	%	N	%
< median -3SD	6	4.17	6	3.33	4	4.17	16	3.18
-3 SD to -2 SD	41	28.47	42	23.33	30	31.25	113	26.96
-2 SD to +1 SD	97	67.36	132	73.33	62	64.58	291	69.28
+1 SD to+2 SD	0	0	0	0	0	0	0	0
≥median +2 SD	0	0	0	0	0	0	0	0

Prevalence of Thinness among adolescent girls

The prevalence of thinness in our study comparable to the observation by Saraswathi et al. (2011) (32.6%) in their study on the adolescent girls in Mysore and Chakarbarty et al. (2008)in their study on the adolescent girls (35.8%)of rural Orissa but is much less compared to that reported by Deshmukh et al.(2006)with use of WHO reference value. Venketesh et al. (2015) also reported that prevalence of thinness was 23% (95% CI 18.3-28.4) among adolescent girls of urban school of

Pondicherry using WHO BMI for age Z scores. The study from Mysore by Premanatha et al. (2010), reported a lower prevalence of 17.2% of thinness among school-going girls, Kumaravel et al. (2014) also reported a lower prevalence of thinness of 13.45 among adolescent girls.

Table: 4.5 Prevalence of Thinness among adolescent girls

BMI for age	10-12 years		13-15 years		16-19years		Total	
	N	%	N	%	N	%	N	%
< median -3SD	5	3.47	7	3.89	3	3.12	15	3.57
-3 SD to -2 SD	46	31.94	42	23.33	33	34.37	121	28.81
-2 SD to +1 SD	93	64.58	131	72.78	60	62.5	284	67.62
+1 SD to+2 SD	0	0	0	0	0	0	0	0
≥median +2 SD	0	0	0	0	0	0	0	0

In contrast, there was high prevalence of thinness reported in many studies. A community based cross sectional study was carried out on adolescent girls (10-19 year) in selected village of Kolar district, Karnataka (Shivarama et al., 2011) and reported the prevalence of thinness as 73.5% as per Indian standard. Choudhary et al. (2003) has reported 68.52% of adolescents were thin in rural area of Varanasi.

NNMB survey (2012) reported that the overall prevalence of thinness among girls (10-13 years) was about 36 %(CI: 34.5-37.7) and severe thinness was 12%. The proportion of thinness in the State of Gujarat, Karnataka and Madhya Pradesh was (about 44% each) and Tamil Nadu(43.3%), followed by Orissa(35.2%), Uttar Pradesh and Andhra Pradesh (34% each), Maharashtra (32.4%) and lowest in Kerala(21.1%) and West Bengal (27.9%). This survey also reported that the overall prevalence of thinness among girls (14-17years) was about 23% (CI: 21.3-24.1) and severe thinness was 6%. The proportion of thinness was highest in the state of Karnataka (32.7%), followed by Tamil Nadu (30.1%), Andhra Pradesh, Gujarat and Maharashtra (26% each), Utter Pradesh and Madhya Pradesh (about 20% each) and

observed lowest in the state of Orissa and West Bengal (13% each) and Kerala (16.8%).

Although number of studies from India have been published on adolescents anthropometry from urban and rural areas reporting prevalence of under-nutrition ranging from 17% to 65 %(Kumaravel et al.,2014).

4.2.2. Dietary and nutrient intake of the subjects

Proper nutrition during the growing stage of life not only helps to promote health but also prevents the occurrence of deficiency diseases and other health hazards. Ingesting too many or too little of nutrient can interfere with health and wellbeing (Srilakshami, 2004).

Thus, the mean intake of various food groups and nutrient intake of the subjects were calculated over a period of three consecutive days. Mean nutrient intake of adolescent girls was calculated by using Food Composition Tables (Gopalan et al., 1989). Mean nutrient intake of was compared with recommended dietary allowances (RDA) (ICMR, 2010).

4.2.2.1. Intake of various food groups

The nutritional status of any individual is directly affected by food intake. Men need a wide range of nutrient to lead a healthy and active life and these are derived through the diet that person consumed daily. The component of diet should be chosen so that it provides all the nutrient in adequate amount and in proper proportion (ICMR, 2010). Intake of various food groups presented in Table-4.6.

Cereals

Cereals are the part of Indian diet and provide energy and several other nutrients at a very low cost. All the respondents of the study were found to consume wheat daily while rice, semolina, refined wheat flour and maize were used infrequently. These are the cheapest and widely available sources of nutrients, particularly in developing countries like India. Table-4.6 shows the mean intake of cereals among the subject.

Table: 4.6 Mean food intake of adolescent girls

Age group	Cereals and millets g	Pulses g	Milk and milk products ml	Roots and tubers g	Green leafy vegetables g	Other vegetables g	Fruits g	Sugar g	Fats / oil g
10-12 year									
RDI	240	60	500	100	100	200	100	30	35
Mean	152.68	26.63	205.65	68.56	29.43	69.82	20.56	19.82	20.52
SD	101.5	16.86	121.6	25.6	17.84	12.82	11.29	8.88	8.93
% of RDI	63.62	44.38	41.13	68.56	29.43	34.91	20.56	66.07	58.63
% deficient	36.38	55.62	58.87	31.44	70.57	66.09	79.44	33.93	41.37
13-15 year									
RDI	330	60	500	100	100	200	100	25	40
Mean	168.02	28.4	228.86	65.42	28.64	83.78	22.64	18.67	19.24
SD	98.24	15.89	162.5	36.92	16.82	15.38	12.82	12.82	6.83
% of RDI	50.92	47.33	45.72	65.42	28.64	41.89	22.64	74.68	48.1
%deficient	49.08	52.62	54.28	34.58	71.36	58.11	77.36	25.32	51.9
16-19 year									
RDI	330	75	500	200	100	200	100	25	35
Mean	166.72	38.56	225.63	96.56	31.23	85.68	20.69	19.82	20.83
SD	112.8	20.7	112.8	48.28	11.25	19.25	11.87	12.83	10.89
% of RDI	50.52	51.41	45.13	54.23	31.23	42.84	20.69	79.28	59.51
%deficient	49.48	48.59	54.87	51.72	60.77	57.16	79.31	20.72	40.49

The Value are Mean ± SD; #RDI: Recommended Dietary Intake by ICMR 2010

It was found to be 152.68±101.5g/day,168.02±98.24g/day and 166.72±112.8g/day in 10-12 year, 13-15 year an 16-19 year of age group respectively. It was 63.62%, 50.92% and 50.52% of the balanced diet suggested by RDI (2011). Intake of cereals was found to be lower than RDI.

Pulses

Pulses are the major source of protein in Indian diet. Bengal gram, green gram, red gram and black gram were the common pulses consumed by the subjects. Mean intake of pulses by subjects was found to be 26.63±26.86g/day, 28.40±15.89g/day and 38.56±20.72d/day in 10-12 years, 13-15 years and 16-19 years of age group respectively.

Table-4.6 indicates that the mean intake of pulses was 44.38%, 47.33% and 51.41% of the RDI, which is a lower consumption of pulses than recommended. Among subjects most of the girls were vegetarian and pulses were the important source of protein in their diet.

Green leafy vegetables

Green leafy vegetables are the rich source of Calcium, iron, β-carotene, vitamin-C, riboflavin and folic acid. The main green leafy vegetables consumed by the subjects were spinach, methi, bathua and cabbage. Mean intake of green leafy vegetables among subject was found to be 29.43±17.84g/day, 28.64±16.82g/day and 31.23±11.25g/day in 10-12 years, 13-15 years and 16-19 years of age group respectively, which was deficient by 60%, 57.03% and 55.77% of RDI in the age group of 10-12 years, 13-15 years and 16-19 years respectively. This may be attributed to low preference for green leafy vegetables by study subjects.

Roots and tubers

Roots and tubers are the good source of energy in our diet. Besides energy, they also provide b carotene, vitamin-C and calcium and other micro-nutrient. Commonly consumed roots and tubers by the subjects were potato and onion. The consumption of roots and tubers among the subjects ranged from 10 to 150g/day with a mean intake of 68.56±25.6g/day in 10-12 years, 65.42±36.92g/day in 13-15 years and

96.56±54.23g/day in 1619 years of age. The mean intake was deficient by 31.44%, 34.58% and 54.23% of recommended intake for the respective age group.

Other vegetables

Other vegetables included those, which are not covered under green leafy vegetable, roots and tubers. These groups of vegetable not only add variety to the diet, but also provide vitamin, minerals and dietary fiber. The commonly consumed other vegetable by the subjects were bottle guard, cucumber, pumpkin, brinjal, ladyfinger and cauliflower.

Mean intake of other vegetable was 69.82±16.82g/day, 83.78±15.38g/day and 85.68±19.25g/day in the age group of 10-12 years, 13-15 years and 16-19 years respectively, which was less than half (34.91%, 41.89% and 42.84%) in view of suggested quantity (200g/day)by ICMR for of 10-12 years, 13-15 years and 16-19 years of the age group.

Fruits

Fruits are generally good source of vitamin-C but along with this, some food contains good amount of carbohydrate (sucrose, fructose and fiber), water and other minerals. Additional fruits provide b carotene (papaya), energy (banana), iron (dried fruits) and other vitamin and minerals. Fruits also contain pectin which provide bulk to the diet and help in bowel movement. Among fruits apple, banana, grapes and mango were commonly consumed by the subjects. Data in table- shows that the consumption of fruits was found to be 20.56±11.29g/day, 22.64±12.82 and 20.69±11.82g/day in the age group of 10-12 years, 13-15 years and 16-19 years respectively, which was nearly one forth of balanced diet (100g/day). The mean intake was deficient by 79.44%, 77.36% and 79.28% of RDI among all the group of adolescent girls. The source of fruit was tomato which was used in vegetable preparation. The intake of fruits was significantly lower because subjects were not aware about the nutritive value of food and low availability of fruits according to their socio-economic status.

Milk and milk products

Milk and milk products are not only good source of protein but it also provides calcium and riboflavin. All the subjects consumed milk and its products in the form of butter milk, curd, ghee etc. Mostly was consumed milk in tea preparation. The mean intake of milk and milk products was found to be 205.65±12.6mg/day, 228.86±162.5mg/day and 225.63±112.8mg/day among all the three groups' viz.10-12 years, 13-15 years and 1619 years of age. This was nearly half of the balanced diet (300g/day). Mostly adolescent girls were not consumed milk in their diet.

Fats and oil

The visible fats commonly consumed in India are oil, hydrogenated fat, butter and ghee. These are concentrated sources of energy producing 9kcal/g. Fats were used by all the families in the preparation of food. Mean intake of fat by the subject was 20.52±8.93g/day, 19.24±6.83g/day and 20.83±10.89g/day in the age group of 10-12 years, 13-15 years and 16-19 years respectively. Intake was almost 50-60% in comparison with the suggested quantity.

Sugar and jiggery

Sugar and jiggery are the sweetening agent and were consumed by all the subjects in varying amount. These were added to the beverages, sweets and other food to increase their palatability. They supply energy but jiggery also contains iron. Mean intake of sugar and jiggery was found to be 19.82±8.88g/day, 18.67±12.82g/day and 19.82±12.83g/day in the age group of 10-12 years, 13-15 years and 16-19 years respectively, which was 66.07%, 74.68% and 79.28% of balanced diet.

Result of this food intake can be supported by the study conducted by Malhotra and Passi (2007) , they reported that the mean daily intake of milk and milk products, pulses, green leafy vegetables, other vegetables and fruits was grossly inadequate meeting only 47%, 36%, 26%, 34% and 3% of the recommended allowances. The study also reveals that not only a high incidence of under-nutrition is found but also an inadequate energy and micronutrients intake among the beneficiaries of adolescent girl's scheme.

NNMB survey (2012) reported that the mean intake of cereals and millets was 220g/day, 324g/day and 346g/day among the adolescent girls of 10-12 years, 13-15 years and 16-19 years of age respectively. The average intake of pulses and legume was 25g/day, 27g/day and 29g/day in 10-12 year, 13-15 year and 16-19 year of age respectively, which was less than the suggested RDI.

In general, the proportion of adolescent girls consuming protective/income elastic food such as green leafy vegetables, milk and milk product, fats and oil, and sugar and jiggery in amount <50% of RDI was very high(51-98%) among 10-12 year old girls. The average intake of green leafy vegetable was 16g/day and 15g/day, while mean intake of milk and milk products was 58ml/day and 65ml/day in 13-15 year and 16-19 years of age respectively.

4.2.2.2. Nutrient intake by the subjects

Table-4.7 shows the mean intake of various nutrients by the study subjects.

Energy

The energy requirement of an individual is the level of energy intake from food that will balanced energy expenditure when the individual has a body size , composition and level of physical activity, consistent with long term good health, and that will allow for the maintenance of economically necessary and socially desirable physical activity (Gopalan et al., 2010).The mean intake of energy among 10-12 year of age was 1205±236.52 kcal/day, 13-15 year of age was1355.5±242.60 kcal/day and 16-19 year of age was1426.5 ±383.77 kcal/day respectively. Energy intake was deficient by 40.05 %,41.82 %,and 41.54 % of RDA in the age group 10-12 years, 13- 15 years and 16 -17 years respectively. Majority of subjects had energy intake less than 60%. This may be because more than 50% girls skipped their breakfast regularly and 10-20% girls skipped their meal mainly at night.

Table: 4.7 Mean nutrient intake of adolescent girls

Age group	Energy kcal	Protein g	Fat g	Calcium mg	Iron mg	Vitamin-A µg	Thiamin mg	Riboflavin mg	Niacin mg	Vitamin-C mg	Carbohydrate G
10-12 year											
RDA	2010	40.4	35	800	27	600	1	1.2	13	40	301.5*
Mean	1205	24.6	19.5	386.05	10.8	290.82	0.49	0.59	7.4	26.24	163.45
SD	236.52	19.6	16.3	299.43	12.6	127.23	0.43	0.35	5.34	13.42	126.84
% of RDA	59.95	60.89	55.71	48.25	40	48.47	49	49.17	56.92	65.6	54.21
%deficient	40.05	39.1	44.19	51.75	60	51.53	51	50.83	43.08	34.4	45.79
13-15 year											
RDA	2330	51.9	40	800	27	600	1.2	1.4	14	40	349.5*
Mean	1355.5	32.7	21.5	392.91	11.6	320.65	0.61	0.68	7.9	25.83	183.43
SD	242.6	15.6	18.5	249.25	12.2	186.56	0.41	0.51	4.53	12.26	134.87
% of RDA	58.17	63.05	53.75	49.11	42.96	53.44	49.17	48.57	56.43	64.58	52.48
%deficient	41.82	36.99	46.25	50.88	57.03	46.56	50.53	51.42	43.57	35.42	47.51
16-19 year											
RDA	2440	55.5	35	800	26	600	1	1.2	14	40	366*
Mean	1426.5	30.6	20	402.35	11.5	309.42	0.5	0.64	8.2	27.72	199.8
SD	383.77	16.5	18.6	256.63	9.2	126.62	0.46	0.56	6.42	11.42	124.5
% of RDA	58.46	54.95	57.14	50.29	44.23	51.7	50	53.33	58.57	69.3	54.59
%deficient	41.54	45.04	42.86	49.7	55.77	48.43	50	46.67	41.43	30.7	45.4

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

A survey of teenage life style has revealed that teenage girls are regularly skipping breakfast and lunch because they want to lose weight. Nearly a third of 14-15 year old girls often miss breakfast, one in five skip lunch and up to one in 12 routinely goes without either breakfast or lunch (Clark, 2012).

Protein

Proteins are vital to any living organism. Proteins are the important constituent of tissue and cell of the body. They form important components of muscle and other tissue and vital body fluids like blood. Proteins are one of the most important nutrients required by the body and should be supplied in adequate amount in the diet. The adequacy of protein in the diet is an important measure of adequacy and quality of a diet.

Data in Table-4.7 indicate that the mean intake of protein was 60.89%, 63.05% and 54.95% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively. Majority of subject had protein intake less than 65%.

Low intake of protein in the present study was due to the low intake of milk and pulses. The best sources of protein are animal based foods like milk, egg, meat, fish etc. Indian families, are mostly vegetarian, avoid foods like meat, fish and egg. For those families consuming non-vegetarian food, the frequency of intake is very low and for some it is occasional. Beside this, these foods are expensive and difficult to digest. Therefore, the chief sources of animal protein in the Indian diet are limited to milk and its products, which are sometime unaffordable especially in families with large numbers of family members (joint families) and limited source of income (Mittal and Srivastava, 2006; Pant, 2008 and Sukchan et al., 2010).

The diets in Indian families mainly rely on pulses and to some extent milk as a source of protein. The plant proteins have poorer nutritive value in relation to essential amino acids and thus need to be supplemented with cereals to make the protein a complete protein.

Maliye et al. (2010) reported that Majority of the adolescent girls (82.5%) of rural wardha had calorie intake less than 1400 kcal. 7.5% girls had calorie intake less than 1000 kcal. The average energy intake was 1239.6±176.4 kcal/day.

The calorie intake of adolescent girls was less than the recommended dietary allowances for their age. The average calorie intake was deficient by 39%. The average protein intake was 39.5±7 gm/day which was deficient by 36%. The average iron intake was 13.2±2.5 mg/day and was deficient by 48%.

Fat

The human body requires dietary fat and essential fatty acid for normal growth and development. Fat is a concentrated source of energy and increase the energy density of diet. Dietary fat also provide essential fatty acid (EFA) which are functional component of membrane lipids and have important metabolic functions (Gopalan et al., 1989). Mean intake of fat among 10-12 year of age was 19.5±16.3g/day, 13-15 year of age was 21.5±18.5g/day and 16-19 year of age was 20±18.6g/day respectively. Fat intake was deficient by 44.19%, 46.25% and 42.86% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively.

Carbohydrate

Carbohydrate provide about 60-70% of energy in human diet, especially in tropical area. Carbohydrate rich food, such as fruits, vegetable, whole grain and legume are also main source of dietary fiber. Table-4.7 reveals that the mean intake of carbohydrate was 160.79 g/d in 13-15 year of age group and 183.38 g/d in 16-19 year of age group. It was deficient by 41% and 46%

Calcium

Calcium is the most important divalent cation in human body, making up to 1.5-2% of total weight. It performs various structural regulatory functions. Among the five major food group's milk and milk products forms a major source of calcium in diet. Calcium needs during adolescent are greater than they are in either childhood or adulthood because of the dramatic increase in skeletal growth. The intake of calcium was found to be 386.05±299.43mg/d in 10-12 year of age group,

392.91±249.25mg/d in 13-15 year of age group and 402.35±153.63mg/d in 16-19 year of age group respectively. Intake of calcium was less respectively to RDA. It was deficient by 51.75%, 50.88% and 49.70% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively (Table-4.7). It may be due to low inclusion of calcium rich food in daily diet and majority (75%) of subject included tea in morning.

Calcium is present in both animal and plant foods. The richest source of calcium among animal foods is milk and among the vegetable sources is a green leafy vegetable. Most cereal and millets contain some amount of calcium but foods like green leafy vegetables are rich in oxalates which bind calcium to form insoluble calcium oxalate and thus render calcium unavailable to the body. Similarly, phytates present in whole cereals bind calcium (ICMR, 2010). Food intake data in the present study also shows low intake of milk and green leafy vegetables. Similar results were found in other studies Rao et al. (2010); Sukchan et al. (2010) and Gao et al. (2013).

Iron

Iron has several vital functions in the body, as a carrier of oxygen to the blood from lungs, as a transport medium of electrons, with in cell and as integral part of important enzymes reaction in various tissues (Gopalan et al., 1986). For both male and female adolescent, the need for iron increase with rapid growth and the expansion of blood volume and muscle mass.

Perusal of Table-4.7 clearly depicts that the mean iron intake by the respondent was 10.8±12.6mg/d, 11.6±12.2mg/d and 11.5±9.2mg/d in 10-12 year, 13-15 year an 16-19 year of age group respectively. The mean values were lower than the recommended allowance due to very low intake of green leafy vegetable and iron rich dietary sources in their daily diet. It was deficient by 60%, 57.03% and 55.77% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively.

Ascorbic acid

Ascorbic acid is used by the body for many different functions including creating collagen, converting carbohydrate into energy and its uses as an antioxidant. For this reason vitamin-C is an important nutrient during adolescent growth and

development. Ascorbic acid is found in large variety of food, but is the highest amount in citrus and other fruits and vegetables. Mean intake of ascorbic acid by respondent of all the age group was less than recommended value (RDA). It was 65.6%, 64.58% and 69.3% of RDA for adolescent in the age group of 10-12 years, 13-15 years and 16-19 years respectively. The present deficit in intake of ascorbic acid in their diet may be because they were consuming very less amount of fruits in their daily diet.

Beta-carotene

Beta-carotene is considered a pro-vitamin because it can be converted to vitamin-A. Vitamin-A serve several biological function including involvement in the synthesis of certain glycoprotein, which is a molecule, composed of a protein and carbohydrate. β-carotene is also converted to retinol, which is essential for vision. The mean intake of beta carotene in all age group was lower than the recommended value i.e. 950.83±µg/d in 10-12 year age group, 983.83±µg/d in 13-15 year age group and 1029.26±µg/d in 16-19 year age group. The source of beta carotene included by the respondent in their diet was maize, milk, tomato, channa dal and pumpkin.

The mean intake of thiamine, riboflavin and niacin in all the age group were lower than the recommended value. The mean intake of these nutrients was less than 60% of RDA in all the age group. Cooking losses may further destroy the riboflavin making it unavailable for the body. The flesh food is negligible due to the most of the subjects being vegetarian and those consuming flesh foods, the consumption was very low.

Inadequate consumption of cereal, pulses and meat may be possible reason for the deficiency of niacin. Rao et al. (2010) and Gao et al. (2013) also reported deficient intake of riboflavin, thiamine and niacin in adolescent girls. In general, the diet of adolescent girls was grossly deficient in macro and micro nutrients. Similar findings were also observed by Goyle et al. (2009) and Kaur et al. (2007).

In the present study it was observed, that the percent deficit of protein intake from the RDA was the among 16-19 year old girls while Choudhary et al. (2014)in their

study among adolescent girls in Bikaner district observed that in all the three age groups there was a protein deficit of 23-29% than RDA.

Sachan et al. (2013) in their studies of nutritional status of adolescent school student in Lucknow district also observed that regarding energy, protein, iron and calcium intake/day in all three age groups, daily intake was less than RDA as per ICMR guidelines in most of the girls.

A study conducted by Baliga et al. (2014) reported that the average calorie intake of adolescent girls was 1272.2 ± 133.38 kcal/day and calorie intake was deficient by 35%. The average protein intake was 40.99 ± 3.32 gm/day, and the protein intake was deficient by 32%. The average iron intake was 14.42 ± 2.58 mg/day and was deficient by 37%. A study done in Wardha reported that the average energy intake was 1239.6±176.4 kcal/day and the calorie intake was deficient by 39%. The average protein intake was 39.5 ± 7 gm/day, and protein intake was deficient by 36%. (Maliye et al., 2010).

The dietary survey exhibited that all the nutrients namely energy, protein, fat, calcium, iron, beta carotene, thiamine, riboflavin and vitamin C were lower than the ICMR recommended allowance for adolescent girls. The major reasons for the lower intake of nutrients may be attributed to the socio-economic condition and low purchasing power of the subjects, lack of knowledge and awareness regarding the food groups and nutrients and lack of availability of food sources in the locality.

4.2.2.3. Frequency of consumption of iron and vitamin-C rich food

Frequency of consumption of food rich in iron and vitamin-C is presented in Table-4.8. The staple cereals of the subjects were wheat and rice. All the subjects consumed wheat flour daily in the form of chapatti and bati (traditional recipe of Rajasthan) followed by 19.76% consumed rice daily and 20.24% consumed on alternate days. Consumption of whole wheat was very low among the subjects.

Bajra (Pearl millet) was consumed in winter season. Majority of the subjects consumed bajra bi -weekly followed by 10.24% consumed daily and 21.9% on alternate days. Regular intake of rice flakes and puffed rice was also low, 29-32% subjects consumed it once a week followed by 15.48% consumed rice flakes on alternate day and 20.24% consumed bi weekly.

Pulses consumption was seen in majority as bi weekly (28.57%) and once a week (21.9%) while 20.48% consumed daily. Black gram and Bengal gram were the commonly consumed pulses among the subjects. Majority (38.81%) of the subjects consumed black gram bi weekly whereas another 15.71% and 20.24% were consumed daily and on alternate days. Consumption of lentil, rajmha, red gram, soya bean, horse gram and cowpea was very less. Mostly subjects consumed roasted Bengal gram occasionally. Sprouted pulses and cereals were consumed by less than half of the subjects and they were irregular. Only 2.86% subjects consumed biweekly and 3.75% consumed once a week.

Majority of the girls did not consume green leafy vegetables regularly. The overall consumption of green leafy vegetables was only 9.29% as daily basis and 10.24% on alternate days where another 21.19% and 22.86% subjects consumed as biweekly and once a week respectively. Commonly consumed green leafy vegetables were spinach, fenugreek leaves, coriander leaves and mustered leaves. Majority of subjects (21-35%) consumed those vegetable as biweekly where as only 5-15% consumed daily and 10-21% consumed on alternate days.

Table: 4.8 Frequency of consumption of iron and vitamin-C rich food (percent distribution)

Food item	Daily	Alternately	Twice a week	Once a week	Every 15th day	Once a month	Rarely	Never
Cereals:								
Wheat Flour	100	0	0	0	0	0	0	0
Whole Wheat	0	9.29	16.19	24.76	27.62	10.24	11.9	0
Rice	19.76	20.24	25.24	15.24	3.33	5.95	10.24	0
Rice flakes	0	15.48	20.24	29.76	25	9.52	0	0
Puffed rice	0	5.24	6.9	32.38	23.33	15.48	16.67	0
Bajra	10.24	21.9	39.05	18.57	5	2.86	2.38	0
Pulses and Legumes								
Overall pulses	20.48	19.52	28.57	21.9	4.29	5.24	0	0
Black gram	15.71	20.24	38.81	20.95	4.29	0	0	0
Greengram	0	0	24.29	30.71	24.76	14.29	5.95	0
Bengalgram	4.76	19.05	29.76	26.19	15.48	4.76	0	0
Roasted Bengalgram	0	9.52	15.48	15.24	25	22.86	11.9	0
Lentil	0	0	0	23.33	25.95	29.29	13.33	8.1
Rajmha	0	0	0	14.05	16.9	25.71	20	23.33
Red gram	0	0	16.19	25	13.1	33.81	11.9	0
Soya been	0	0	10.71	11.67	19.76	35.24	19.76	2.86
Horse gram	0	0	16.43	20	19.29	8.57	20.24	15.48
Cowpea	0	0	0	0	0	0	0	0
Moth been	0	0	0	0	0	0	0	0
Sprouts of Pulses	0	0	2.86	3.57	20	23.33	29.76	20.48

Food item	Daily	Alternately	Twice a week	Once a week	Every 15th day	Once a month	Rarely	Never
Green Leafy Vegetable								
Overall green leafy vegetable	9.29	10.24	21.19	22.86	12.38	5.71	14.52	3.81
Coriander Leaves	15.48	21.19	34.76	28.57	0	0	0	0
Fenugreek Leaves	5.95	13.1	32.14	23.81	12.14	5.95	6.9	0
Colocasia Leaves	0	0	0	0	16.19	19.05	35	29.76
Radish Leaves	0	0	21.19	25	22.86	9.52	13.1	8.33
Amaranth Leaves	0	0	16.19	22.86	11.19	17.86	20.48	11.43
Mint Leaves	0	0	18.57	25.71	15.71	5.71	22.62	11.67
Spinach	6.67	13.33	27.38	22.86	18.1	11.67	0	0
Mustard Leaves	0	6.67	18.57	22.62	6.19	20.48	25.48	0
Cauliflower leaves	0	0	0	0	0	0	0	0
Bengal gram Leaves	0	0	10	9.05	11.43	9.76	39.52	20.24
Cabbage	0	9.29	16.19	24.76	27.62	10.24	11.9	0
Onion Stalk	0	11.43	20.48	26.67	18.1	5.24	18.1	0
Other Vegetables								
Cucumber	0	15.24	20	40.24	9.76	0	14.76	0
Kanroda	0	0	0	0	21.19	23.33	35.48	20
Lotus stem	0	0	0	0	0	0	21.9	78.1
Roots and Tubers								
Beet root	0	0	0	7.62	20	22.86	34.76	14.76
Carrot	10	19.76	38.57	25	6.67	0	0	0

Food item	Daily	Alternately	Twice a week	Once a week	Every 15th day	Once a month	Rarely	Never
Fruits								
Overall fruits	17.38	18.1	25	19.76	9.52	5	5.48	0
Guava	19.52	24.29	34.05	15.24	6.9	0	0	0
Amla	0	15.71	27.38	29.05	21.19	0	6.67	0
Zizyphus	14.76	20	25.71	14.76	15	9.76	0	0
Lemon	10.24	20.48	21.43	22.86	19.05	0	5.95	0
Orange	16.19	17.86	18.57	21.19	19.29	0	6.9	0
Papaya	0	3.81	21.43	32.14	28.57	0	14.05	0
Tomato	46.67	30.95	15.24	7.14	0	0	0	0
Dates	0	0	19.05	25.71	18.1	0	26.19	10.95
Ripe Mango	0	0	0	0	0	0	0	0
Watermelon	0	0	0	0	0	0	0	0
Pomegranate	0	0	11.43	17.86	21.9	19.76	23.1	5.95
Sapota	0	0	0	5.71	15.48	22.62	35	21.19
Custard Apple	0	0	0	10	20.48	23.33	26.67	19.52
Oil seeds								
Garden cress seeds	0	0	0	0	0	0	0	100
Niger seeds	0	0	0	0	0	0	29.05	70.95
Sesame seeds	6.67	18.1	19.52	21.9	12.14	0	21.67	0
Dryfruits								
Tender Coconut	0	0	0	27.62	43.81	22.62	5.95	0
Dry Coconut	0	12.86	18.1	31.43	14.29	0	15.71	7.62
Cashew nut	0	0	0	0	6.43	6.9	56.67	30
Pistachio	0	0	0	0	3.57	5.95	39.52	50.95
Almond	0	0	0	0	20.24	25	31.43	23.33
Roasted Groundnut	0	5.95	23.33	45.71	19.52	0	5.48	0
Rasine	0	6.67	13.33	22.86	18.1	27.38	11.67	0
Water melon seeds	0	0	0	0	0	0	68.1	31.9
Jaggery	16.67	21.19	29.76	21.67	0	0	10.71	0
Non-vegetarian food								
Egg	0	0	4.05	6.9	2.38	2.62	0	84.05
Meat	0	0	0	2.86	4.52	5	3.57	84.05
Fish	0	0	0	0	0	0	8.81	91.19

The frequency of consumption of radish leaves, amaranth and Bengal gram leaves was very low, Due to low intake of green leafy vegetables mostly girls were suffering from iron deficiency. Among the other vegetable, lotus stem is a rich source of non heam iron but mostly girls (78%) never consumed this vegetable. Beet root was also not popular among the subjects. Carrot was consumed by 10% subjects daily whereas another 19.76% and 38.57% subjects consumed on alternate days and bi-weekly basis respectively.

Daily fruits consumption was reported by only 17.38% subject and 18.10% subjects reported consumption on alternate days. Twenty five percent subjects consumed fruits biweekly and 19.76% consumed once a week. Guava, zizyphus, tomato, papaya and lemon were the commonly consumed fruits but their daily consumption was very less (10-47%). Fruits which are rich in Vitamin-C help in the absorption of non-heam iron. The frequency of consumption of Vitamin-C rich food was very low.

Mostly girls did not know about garden cress seeds. Daily consumption of sesame seeds was reported by only 6.67% subjects where as 18.1% and 19.52% subjects consumed on alternate days and bi weekly respectively. The consumption of iron rich dry fruits was negligible due to the high price of those foods. They were not affordable for rural girls.

Jaggery is rich source of energy as well as iron also. Daily consumption of jaggery was reported by 16.67% subjects whereas 29.76% and 21.67% subjects consumed it biweekly and once a week respectively.

Non- vegetarian foods like egg, meat, fish etc are rich source of heam iron. Consumption of non-vegetarian food was reported by only 16% subjects and they were not consumed regularly. Egg was consumed by only 4.05% subjects biweekly and 6.90% consumed once a week.

Overall the adolescent girls did not frequently consume iron and vitamin-C rich foods and those that did consumed it in inadequate amount. Similar results were observed by Sen and Kanani (2007). They also reported that the consumption of green leafy vegetable and other iron rich food was inadequate among adolescent girls.

4.2.3. Clinical signs and symptoms of anemia

Anemia is associated with increased susceptibility to infection, reduction in work capacity and poor concentration. In the present study clinical sign and symptoms of anemia were observed among the adolescent girls.

Table: 4.9 Distribution of adolescent girls by clinical signs of anemia

Signs of Anemia	**Respondents**	
	No.	**Percentage**
Eye		
Normal	322	76.67
Pale conjunctiva	98	23.33
Lip		
Normal	324	77.14
Angular stomatitis	96	22.86
Tongue		
Normal	234	55.71
Pale	103	24.52
Red	83	19.76
Skin		
Normal	238	56.67
Pale conjunctiva	182	43.33
Gum		
Normal	273	65.00
Bleeding	147	35.00
Nail		
Normal	366	87.14
Brittle nail	33	7.86
Koilonychia	21	5.00
Leg		
Normal	353	84.05
Oedema	67	15.95

Clinical signs of anemia among adolescent girls are presented in Table-4.9. According to clinical signs of anemia 43.33% of subjects had pallor skin, followed by 24.52% had pallor tongue. One third of the subjects had bleeding gums followed by 22.86% subjects had angular stomatitis. Conjunctiva pallor was the most common ocular manifestation of anemia seen in 23.33% subjects. Only very small numbers of subjects (5%) had spoon shaped and 7.86% had brittle nails. Oedema on leg was present in 15.95% subjects.

Data on Table-4.10 reveals the clinical symptoms of anemia. More than half of the subjects reported weakness always while 35.95% subjects felt weakness sometimes. Fatigue was reported by nearly half of the subjects followed by lethargy (58%) and fainting episodes (16%). Lack of concentration was reported by 49.95% subjects always and by 29.05% sometimes.

Table: 4.10 Distribution of adolescent girls by clinical symptom of anemia

Symptoms of Anemia	Always		Sometimes		Rarely		Never	
	N	%	N	%	N	%	N	%
Weakness	212	50.48	151	35.95	41	9.76	16	3.81
Fatigue	206	49.05	146	34.76	53	12.62	15	3.57
Dizziness	86	20.48	128	30.48	173	41.19	33	7.86
Lethargic	80	19.05	165	39.29	110	26.19	65	15.48
Breathlessness	123	29.29	126	30.00	128	30.48	43	10.24
Lack of concentration	172	40.95	122	29.05	88	20.95	38	9.05
Headache	86	20.48	142	33.81	192	45.71	0	0.00
Body ache	63	15.00	203	48.33	154	36.67	0	0.00
Leg pain	23	5.48	201	47.86	180	42.86	16	3.81

More than one-fourth of the subjects reported symptom of breathlessness always whereas 30% reported sometimes. Headache and body ache were the common symptoms present mostly in girls. Coldness of hands and feet were present in 22%always whereas another 19.56% felt it sometimes

Mamta and Devi (2014) reported the clinical signs and symptoms of anemia among reproductive age women (15-45 years). More than half of the subjects reported weakness followed by fatigue (55%) and lethargy (47.5%). According to the clinical signs of anemia 65% of respondent had pallor skin, followed by 37.5% had pallor tongue, whereas only very small numbers of subjects (7.5%) had spoon shaped nails.

4.3. Morbidity profile of the adolescent girls

The morbidity profile of the girls was collected by asking them to report any illness suffered during last 15 days for which they had to go to doctor. Adolescent is generally considered as a time of being relatively free of diseases. However 61% subjects reported to have experienced some or other form of morbidities. Table- 4.11 shows the common morbidities experienced by the subjects. The most common morbidity was cough and cold (40%) followed by headache (44.29%), fever (18.81%) and vomiting (17.14%). Majority of the girls reported to have been experiencing stomachache due to their menstrual cycle. Except of diarrhea, the present subject was experiencing various morbidities in the 15 day preceding the survey.

Table: 4.11 Morbidity profile of the adolescent girls

Morbidity	N=420	Percentage
Malaria	48	11.43
Fever	79	18.81
Diarrhoea	123	29.29
Constipation	98	23.33
Cold/cough	168	40.00
Headache	186	44.29
Vomiting	72	17.14
Stomach ache	208	49.52

4.4. Menstruation history

Menstruation is a normal physiological process but the onset of menstruation is a unique phenomenon for adolescent girls. It is considered as a landmark in the growth and development of an adolescent girl. The age of the onset and the patter of menstrual cycle vary on different factors. The age of menarche is generally between 10-16 years; however it may vary depending on geographic variation, environmental condition, nutritional status etc. From both medical and social perspectives, it is often considered as the central event of female puberty, as it suggest the possibility of fertility. After menarche many adolescent girls face problem s of irregular menstruation, excessive bleeding and dysmenorrheal (Thakre et al., 2012).

Out of 420 adolescent girls 314 had attained menarche. The mean age of menarche was 13.4±1.2 years with 10 and 17 years being the lowest and highest age of menarche respectively. Similar finding were reported by Solanki et al., 2012(13.5 years), Sachan et al., 2012(13.6 years), Patil and Angadi, 2013(13.45 years) and Wasnik et al., (2015) (13.5 years). In another study in Maharashtra (Pune city), the mean age of menarche was found to be 12.62 +1.05 year and in rural Orissa, the mean age of menarche was found to be 12.97 years, which is less as compared to our study (Naik,2012).

Table-4.12 shows that majority of girls (80.90%) had attained menarche at 13-15 year of age, followed by 14% at the age of 10-12 years and 5.1% at 16-18 years of age.

Table: 4.12 Distribution of adolescent girl according to age of menarche

Age of menarche(years)	No.	Percentage
10-12	44	14
13-15	254	80.9
16-18	16	5.1

Most of them (66.24%) had regular menstrual cycle and 33.76% had irregular cycle. The most common menstrual pattern found among girls was >30daysfollowed by 28-30 days. Most of them (74.8%) had 3-5 days duration of flow and16.2 % had 5-7 days (Table-4.13). Similar study by Wasnik et al. (2015) shows that the duration of blood flow was within 5 days in 75.85 of adolescent girls with 24.2% having prolonged menses(>5 days).

Table: 4.13 Information regarding menstrual pattern

Variables	No.	Percentage
Menstrual cycle length		
25-28 days	69	22
28-30 days	64	20.4
>30 days	181	57.64
Duration of flow		
<3 days	19	6
3-5 days	235	74.8
5-7days	51	16.2
>7 days	9	2.9
Menstruation		
Regular	208	66.24
Irregular	106	33.76

Irregular menstruation means cycle less than 20 days (Polymenorrhea) was found in10 % girls and cycle greater than 40 days (Oligomenorrhea) was found in23.90 %. Oligomenorrhea was the most frequently reported problem (23.90%) and polymenorrhea was much less prevalent (10%). Menorrhoegia was found in 18.89% girls. It is due to hormonal fluctuation taking place in peri-pubertal and peri-menopausal age of women (Table-4.14).

Table: 4.14 Distribution of subjects according to menstruation problems

Problems during menstruation	N=420	Percentage
Dysmenorrhea	198	63.06
Premenstrual symptoms	114	36.3
Oligomenorrhea	75	23.9
Polymenorrhea	31	10
Menorrhegia	59	18.89
Abdominal pain	254	80.89
Cramp	89	28.34
Body ache	62	19.74
Backache	21	6.79
Headache	40	12.73
Uncomfortable	19	6.05
Irritability	15	4.8
Weakness	124	39.5
Breathlessness	73	23.25
Breast tenderness	14	4.4
Constipation	35	11.15

The finding of the present study showed a high prevalence of dysmenorrhea 63.06 %(Table-4.14), amongst the subjects suffering from dysmenorrhea, 20% had been experiencing it almost every cycle. Wasnik et al, (2015) also reported a high prevalence (62.3%) of dysmenorrhea among rural adolescent girls of Amravati, Maharashtra. Similar finding were reported by Kumbhar et al., 2011 (65.02%), Waghachavare et al., 2013(63.4%), and Patil and Angadi, 2013(64.56%). Comparatively lower prevalence had been reported by Sharma et al., 2011(33%) and Verma et al., 2011(50.6%).

Followed by dysmenorrhea, weakness, easy fatiguability or breathlessness were the second most common set of complaint. Premenstrual symptoms were present in36.30 % subjects. 80.89% girls had abdominal pain during menstruation followed by 28.34% cramp, 12.73% were uncomfortable, 19.74% backache, 6.05% headache and 11% had constipation. A set of complaints like swelling of feet, breast tenderness

were reported by 4.4% of the subjects (Table-4.14). Similar findings was reported by Wasnik et al. (2015) among rural school going l adolescent girls of Amrawati district of Maharashtra and Patil and Angadi (2013) reported among rural adolescent girls in Bijapur. 23.3% of the girls reported the use of sanitary napkins during menstruation, 51.8% reported the use of old cloth and15.6% were used new cloths during menstruation. The study by Jogcand and Yerpud (2011) in rural area of Guntur district reported 34.63% girls used old cloth during menstruation.

4.5. Prevalence of anemia

Among 420 rural adolescent girls 334 were found to be anemic with prevalence of 79.52% and remaining 86 (20.48%) were non anemic (Figure-4.6). In the present study, the mean hemoglobin level among adolescent girls was 11.15+1.07g/dl and the range varies from 6.8-13.6 g/dl. The perusal of the table- and figure- cleared that the prevalence of mild, moderate and severe anemia among total participated (420) adolescent girls was 44.29%, 29.52% and 5.71 % respectively. Among the anemic subjects (334), 55.69percent had mild, 37.13percent had moderate and 07.81percent of subjects had severe degree of anemia.

Figure: 4.6 Prevalence of Anemia

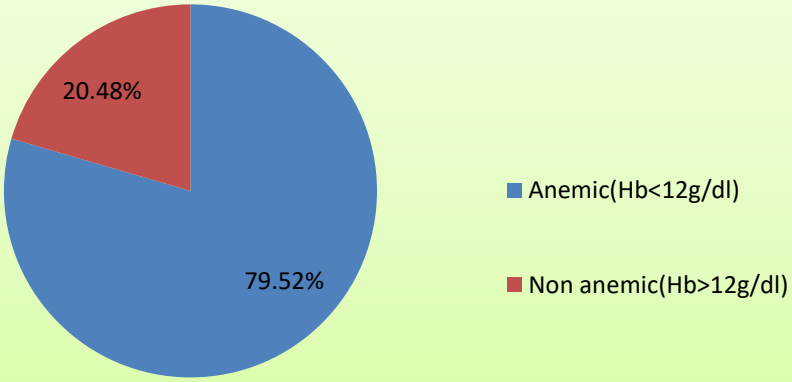
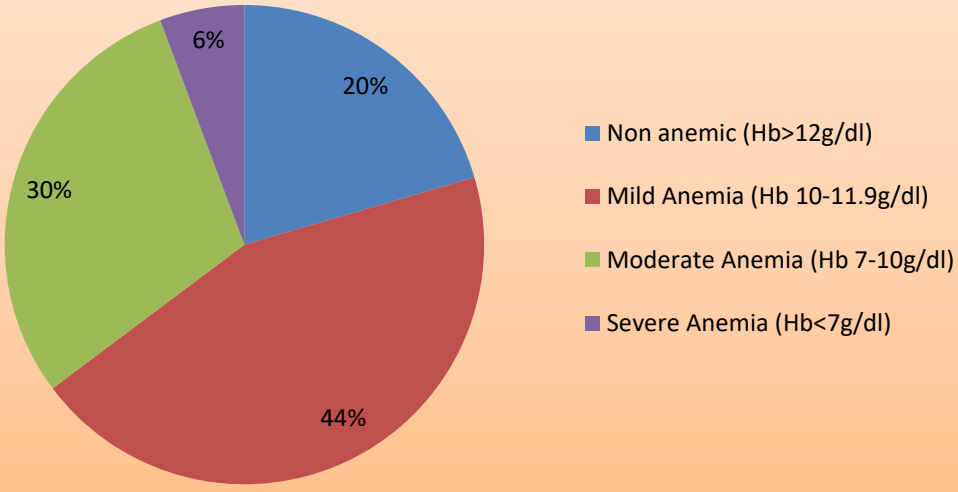


Figure: 4.7 Prevalence of Anemia according to Severity



Findings of the study are almost in the accordance with Singh et al. (2008), Kotecha et al. (2009) (74.7%), Premlatha et al. (2012) (78.75%); Kaushik et al. (2012) (76.5%). However Sachan et al. (2012) and Biradar et al. (2012) reported a lower prevalence of 43.4% and 57.9% respectively. Verma et al.(2004); Toteja et al. (2006); Gupta and Kocher (2008); Bharti et al.(2009) and Mishra et al.(2012) reported a higher prevalence of 96.8%, 99.9%, 81.81%, 90% and 81.8% respectively. Several studies have reported prevalence of anemia between 5.6 to 75% in different part of the world (Basu et al.,2004; Choudhary et al.,2008 and Atto et al., 2012).

Mean hemoglobin level was found to be 11.15+1.07g/dl, which was similar to that reported by Agarwal (2003) and Sharma et al.(2008), but lower than that reported by other studies (Basu et al., 2004 and Atto et al., 2012). This value was higher than the values reported for urban Vadodara girls by Kotecha et al., 2012.

This difference in the prevalence of anemia may be due to difference in the study area. WHO/UNICEF has suggested that the problem of anemia is a very high magnitude in a community when prevalence rate exceeds 40% (WHO, 2001).Considering that anemia development is a consequence occurred at a later stage of iron deficiency, the problem of iron deficiency in these adolescent girls with a prevalence of 79.52% should be considered serious and call for an action.

Thus, the result of various study which have been mentioned above, demonstrated that the prevalence of anemia in the study was high as in other part of the country. This indicated the importance of including adolescent in the risk group to improve their iron status and the need for planning intervention programs that would increase the hemoglobin levels among the adolescent girls through prophylaxis treatment, dietary modification and worm infestation control.

4.6. Socio-demographic correlates of nutritional anemia in study subjects

Anemia in adolescent has gained importance in last two decades. But still there is a question of increase in the prevalence of anemia that emphasize on the investigation of factors associated with anemia. Though there are various factors that contribute to the prevalence of anemia, the current study has helped narrow down the major contributors such as anthropometry, literacy status of mother, diet, age, socioeconomic status and menstrual discharge. Various socio-demographic factors which were found to be significantly associated with anemia in adolescent girls have been presented in the Table-4.15.

Religion

Prevalence of anemia among Hindu girls was highest 91.52 % as compared to Muslim girls (31.94%) and this was statistically significant at $p<0.01$.

Caste

The study shows high prevalence of anemia in scheduled caste community, which could be due to lack of money, poverty or more number of children in the family and lack of knowledge about child care practices. The prevalence of anemia was 87.59% among the adolescent girls in scheduled caste/scheduled tribes as against 81.36% in OBC and 72.16 percent in General caste, which is comparable to the study by Singh et al. (2008) on adolescent girls in rural area of Meerut.

Education

A significant association was found between the level of parental education and anemia, particularly the education of mothers is a significant factor for girls. Prevalence of anemia was also found to be significantly higher ($p<0.01$)in those adolescent girls having illiterate (87.68%) and just literate mothers (78.5 %)as compared to better literate mothers. Singh et al. (2008) also reported that prevalence of anemia was more (43.2%) in adolescent daughters of illiterate mothers as compared to educated mothers.

Family type

In the present study, the prevalence of anemia was significantly higher (88.7%) among the adolescent girls belonging to joint families as compared to(72.84%)those from nuclear families($p<0.01$), which may be due to availability of quantitatively and qualitatively adequate food in nuclear families.

Family size

A significantly high ($p <0.01$) prevalence of anemia was found in adolescent girls belonging to families having family size >8 members(90.43%), than 86.21% and 41.10% in those girls belonging to families having family size 5-7 members and less than 4 members respectively. This may be due to availability of adequate diet to all family members in small families. The current study concur the report of Rawat et al. (2001); Singh (2008) and Choudhary et al. (2008) which show high prevalence in joint families.

Occupation

Prevalence of anemia is related to parents occupation was found to be significant ($p<0.01$) which may be because of availability of better quality food to the girls of agriculture and service class families. Prevalence of anemia was found to be significantly higher (90.62%) in those adolescent girls whose fathers were working as labourers than those of agriculturers (70.50%).

Food habits

Relationship of anemia with diet has been proven by various studies which delineated the preponderance of anemia on vegetarian. Present study reported that vegetarian adolescent girls (88.67%) were more anemic than non-vegetarian (31.34%) which corroborates with the findings of Kaur et al. (2008) and Premlatha et al. (2012).

Table: 4.15 Socio demographic correlates and prevalence of anemia in rural adolescent girls

Particular	Normal		Anemic		Total		χ^2	Df
	N	%	N	%	N	%		
Age (years)								
10-12	26	18.05	118	81.94	144	34.28		
13-15	42	23.33	138	76.67	180	42.86	1.5962	2
16-19	18	18.75	78	81.25	96	22.86	ns	
Religion								
Hindu	28	8.48	302	91.52	330	78.57	139.23**	3
Muslim	49	68.06	23	31.94	72	17.44		
Sikh	6	54.55	5	45.45	11	2.62		
Christian	3	42.86	4	57.14	7	1.67		
Caste								
ST	20	29.41	48	70.59	68	16.2	12.279**	3
SC	17	12.41	120	87.59	102	24.29		
OBC	22	18.64	96	81.36	153	36.43		
GEN	27	27.84	70	72.16	97	23.1		
Education of father								
Illiterate	18	20.93	68	79.07	86	20.93	14.7678 ns	5
can read and write only	18	26.47	50	73.53	68	16.43		
Primary	11	10.28	96	89.72	107	25.85		
Secondary	18	23.68	58	76.32	76	18.36		
Higher secondary	8	16.67	40	83.33	48	11.6		
Graduate	11	37.93	18	62.07	29	7		
Education of mother								
Illiterate	25	12.32	178	87.68	243	59.12	39.252**	5
can read and write only	20	21.5	73	78.5	93	22.63		
Primary	20	22.73	68	77.27	48	11.67		
Secondary	17	62.96	10	37.04	27	6.6		
Higher secondary	0	0	0	0	0	0		
Graduate	0	0	0	0	0	0		
Education of subjects								
school going	44	19.13	186	80.87	230	54.76	3.5749**	2
School dropout	30	19.61	123	80.39	153	36.43		
Illiterate	12	32.43	25	67.57	37	8.81		

Particular	Normal		Anemic		Total		χ^2	df
	N	%	N	%	N	%		
Occupation								
Labour	12	9.38	116	90.62	128	30.48	40.73**	5
Cast occupation	6	14.29	36	85.71	42	10		
Business	6	13.95	37	86.05	43	10.24		
Independent profession	6	13.33	39	86.67	45	10.75		
Cultivation	36	29.51	86	70.5	122	29.05		
Service	20	50	20	50	40	9.52		
Family type								
Nuclear	66	27.16	177	72.84	243	57.86	15.83**	1
Joint	20	11.3	157	88.7	177	42.14		
Family size								
Small (upto 4 members)	43	58.9	30	41.1	73	17.38	80.97**	2
Medium (5-8 members)	32	13.8	200	86.21	232	55.24		
Large (.8 members)	11	9.56	104	90.43	115	27.38		
Marital status of subject								
Married	20	16.4	102	83.6	122	29.05	6.23 Ns	2
Unmarried	63	21.5	250	78.49	293	69.76		
Widow	3	60	2	40	5	1.2		
Divorce	0	0	0	0	0	0		
Food habits								
Vegetarian	40	11.33	313	88.67	353	84.05	113.64**	1
Non-vegetarian	46	68.66	21	31.34	67	15.95		
Socioeconomic status								
I	0	0	0	0	0		26.21**	3
II	9	69.23	4	30.77	13	3.1		
III	20	29.41	48	70.59	68	16.19		
IV	42	18.42	186	81.58	228	54.29		
V	15	13.51	96	86.49	111	26.43		

****significant at 0.01%, * significant at 0.05%, ns= non significant**

Socio-economic status

Reverse association was seen between socio-economic status and prevalence of anemia in adolescent girls: lower the socio-economic status higher the prevalence of anemia.

In the present study, the prevalence of anemia was high among girls who belonged to low socio-economic groups (86.49%in class IV and 81.58% in class V) as compared to the girls who belonged to higher socio-economic groups(30.7%in class II). This was statistically significant ($p< 0.01$), which is comparable with the study conducted by Singh (2008) with maximum prevalence (47.65%) in class V and minimum (29.1%) in class I and II. Birader et al. (2014) reported that majority of the adolescent girls were anemic (43.1% in class IV and 100% in class V) who belonged to low socio-economic class.

These findings correlated with those of the studies which were conducted among adolescent girls in Chandigarh, Nagpur, UP and Delhi, where it was revealed that anemia was high in lower socio-economic groups (Choudhary et al., 2008; Maliya et al., 2010; Mishar et al., 2012 and Verma et al., 2013). This may be because of better availability of high quality food for children with better socio-economic status.

A significant association of anemia with low socio-economic status suggested a need to develop strategies for intensive adult education and to improve the socio-economic status of the population through poverty alleviation programs.

4.7. Nutrition knowledge of the subjects

Findings related to the knowledge of rural adolescent girls about nutrition have been given in this section under the following heads:

Overall knowledge of the subjects

To know the overall knowledge of respondents their knowledge categories were made i.e. low, medium and high on the basis of the score obtained by respondent in the knowledge test.

Table: 4.16 Overall nutritional knowledge of the subjects

Level	Scores	Initial Knowledge	
		N	%
Low	<14.85	358	85.24
Medium	14.85-29.7	68	14.76
High	>29.7	0	0

It is evident from the Table-4.16 that majority (85.24%) of the adolescent girls had low level of knowledge and very few (14.76%) had medium knowledge. None of them exhibited good knowledge about nutrition. Nutrition knowledge was low in rural adolescent girls in pre-test, due to lack of knowledge regarding the importance of nutrition especially during this period of life. They are unaware about the health problems of this age group and their consequences.

Overall mean knowledge scores were 13.64 ±20.54 with highest scores of 24 (Table-4.17).

Table: 4.17 Overall mean Knowledge score

Knowledge scores	N	Mean scores	SD	Highest Scores	MPS
Overall scores	420	13.64	20.54	24	30.31

Aspect wise mean score also reveals that the knowledge was low in each aspect viz. food group and nutrients, Iron rich food and their function, food favouring iron absorption and inhibition, hemoglobin and its function, iron deficiency anemia, its causes and preventive measures and role of ICDS to control anemia (Table—4.18).

Table: 4.18 Aspect wise mean scores (N =420)

S.No.	Aspects	Mean score
1	Food group and nutrients	3.23±4.64
2	Iron rich food and their function	3.8±5.28
3	Food favouring iron absorption and inhibition	2.7±6.43
4	Hemoglobin and its function	0.8±5.62
5	Iron deficiency anemia, its causes and preventive measures	2.5±7.42
6	Role of ICDS to control anemia	1.9±5.65

Mamta and Devi (2014) assessed knowledge regarding anemia among women of reproductive age group residing in village Abhipur, Mohali, and Punjab. 40 women were recruited for the study. More than half of the subjects had average knowledge and about 15% had poor knowledge. There was not even a single woman with excellent knowledge regarding anemia.

Abrahme (2015) assessed the knowledge regarding anemia of adolescent girls attending high schools in Pune city. They also found that majority (51.3%) of the adolescent girls had average knowledge regarding anemia and its prevention. 38.8% of them had poor knowledge and 10% of them had good knowledge regarding anemia and its prevention.

4.8. Development of Iron Rich Food Supplement Mix (IRFSM)

4.8.1. Preparation of IRFSM

Iron rich food Rice flakes, Lotus stem (Nelumbo nucifera), Cauliflower leaves (Brassica Oleracea) and Garden cress seeds (Lepidium sativum) were selected for the preparation of IRFSM (refer section **3.5.2.1.**).

Flours (rice flakes, lotus stem, cauliflower leaves and garden cress seeds) were mixed in different ratio for the development of IRFSM. Different proportions of iron rich food powder used for the preparation of IRFSM is presented in table-3.3.

Identical to the present study, there are some studies on cauliflower leaves products and garden cress seeds products. In which the maximum limit of cauliflower leaves and garden cress seeds used was 10%, in order to obtain acceptable food product. Zanvar and Devi (2007); Wani and Sood (2013) and Patil et al.(2015) have also prepared food products using cauliflower leaves and garden cress seeds, in which the maximum limit of wheat flour replacement was 10% with cauliflower leaves or garden cress seeds. They have made various food products like biscuits, mathri, extruded products, cake and pancake.

4.8.2. Standardization of Iron Rich Food Supplement Mix (IRFSM)

IRFSM standardization was done by preparing food products and for selecting the best acceptable ratio nine point hedonic scale was used. The result of sensory evaluation of three common products viz. chapatti, mathri and biscuits which were prepared using various proportion of IRFSM and wheat flour have been presented in tables-4.19 to 4.21.

Chapati

Chapatti is Indian unleavened flat bread which accounts for the cereals group in a balanced diet. Chapatti was prepared from wheat flour (80%) and different ratio of rice flakes, lotus stem, cauliflower leaves and garden cress seeds (20%). The score assigned by the panel members for individual sensory attributes of chapatti were found as follows, values in the range of 8.00 to 8.33 for control (100% wheat flour) and 6.96 to 8.30 for IRFSM flour (T1-T5) chapatis. Chapati was used or taken as sample which permits us to draw conclusion that the product varied from liked slightly to like very much (Table-4.19). The ratio of T1, T2 and T3 was in acceptable range and liked moderately while T4 and T5 were not in acceptable range and not liked by the panel members.

Incorporation of IRFSM in chapatti along with wheat flour not only improves the texture, taste and overall acceptability but also improves the nutritive value of this product without adding much to the cost of the product. ANOVA showed a significant ($P<0.01$) difference between control and experimental (T1-T5) samples and another observation was noticed that all the three treatments (T1, T2 and T3) were not significantly different to each other (Annexure-VII). The nutritional value of T3 ratio was higher as compare to T1 and T2 and ratio of T3 was in acceptable range. In general, the study indicated that in terms of sensory acceptability T1 was found to be the best but in terms of nutritional supplements T3 was to be the best. Hence, IRFSM with ratio (T3) of rice flakes, lotus stem, cauliflower leaves and garden cress seeds (50:30:10:10) were selected for further study of quality evaluation and storage of IRFSM, as it increases nutritional aspect especially iron and fibre content of chapatti as compared to control. The result of the present reveals that incorporation of higher percentage of lotus stem, cauliflower leaves and garden cress seeds in the flour decreased the overall acceptability of the product.

Table: 4.19 Mean sensory scores of Chapati

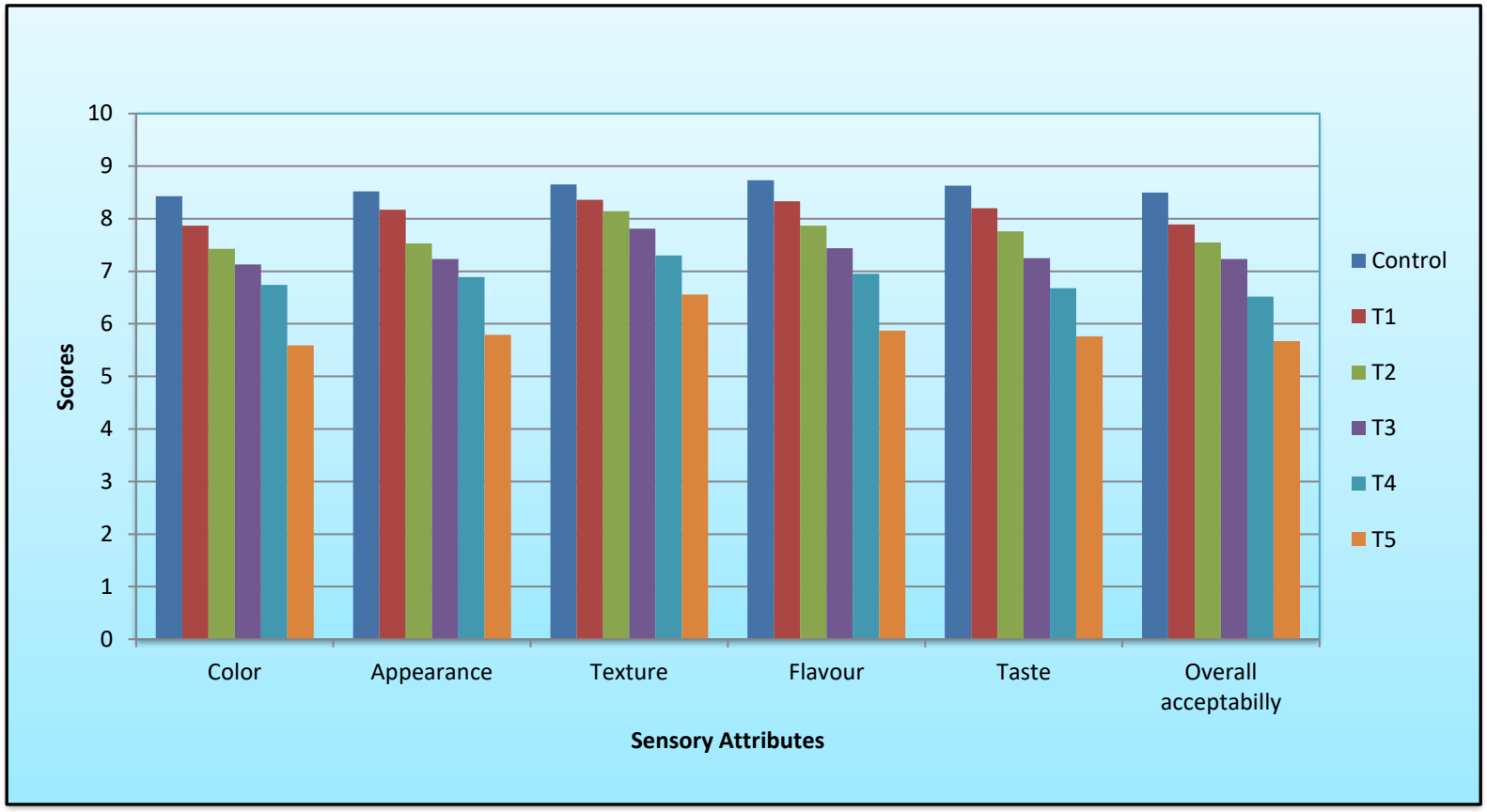
Treatment	Color	Appearance	Texture	Flavour	Taste	Overall acceptabilly
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Control	8.43±0.22	8.52±0.33	8.65±0.17	8.73±0.24	8.63±0.39	8.5±0.31
T1	7.87±0.5	8.17±0.48	8.36±0.32	8.33±0.35	8.2±0.31	7.89±0.30
T2	7.43±0.3	7.53±0.31	8.14±0.39	7.87±0.47	7.76±0.47	7.55±0.35
T3	7.13±0.33	7.23±0.26	7.81±0.43	7.44±0.26	7.25±0.30	7.23±0.27
T4	6.74±0.49	6.89±0.41	7.3±0.44	6.95±0.67	6.68±0.59	6.52±0.55
T5	5.59±0.58	5.79±0.50	6.56±0.28	5.87±0.73	5.76±0.48	5.67±0.47
ANOVA (F value)	53.94**	61.61**	47.2**	43.62**	71.34**	68.08**
CD5%	0.38	0.35	0.32	0.44	0.39	0.35
CD1%	0.51	0.47	0.42	0.59	0.52	0.46
CV	13.76	13.1	10.03	14.05	14.26	13.83

Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM. **significant at 0.01%, * significant at 0.05%

The present findings depicting slightly to high acceptability of the chapatti are in conformity with those reported by Kadam et al. (2012) where chickpea, soy and methi leaves powder were incorporated at different ratio in the wheat flour chapatis. The results revealed that the sensory score of various attributes viz. color, appearance, flavor, taste, texture and overall acceptability were in between 6.0 to 8.7.

Khan et al. (2005) also made chapatti with wheat and soy hull in different ratio and evaluated its acceptability on nine point hedonic scale where results showed that the color, flavor, taste, texture and appearance ranged between 4 to 7, 5.5 to 8.5, 5 to 7.5, 4.5 to 8 and 4 to 7. The highest scores of chapatis fell into the range of neither liked or disliked to like very much, similarly to the sensory scores of chapati prepared in the present study.

Figure: 4.8 Mean sensory scores of Chapati



Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM

Shahzadi et al. (2005) prepared chapati of composite flour by blending wheat flour with lentil, chickpea, bathua leaves powder and guar gum in different proportions as compared to control (100% wheat flour). The sensory evaluation of chapati of various treatments showed that the scores for the different composition range between 5.27 to 7.60 for color, 5.07 to 7.60 for flavor, 5.07 to 7.27 for taste and 5.07 to 7.07 for texture. The result also revealed that the chapatis under the experimental group fell into the range of neither liked or disliked to like moderately. Similarly the sensory scores of IRFSM chapatis fell into the range of neither liked or disliked to like very much.

Biscuit

A biscuit is baked, wheat flour based product, eaten as a snack. It differ from other baked product like cake and bread because of it low moisture content, comparatively free from microbial spoilage and long shelf life of the products. In the present study, biscuits were prepared from various proportions of IRFSM (10%, 20%, 30%, 40% and 50%) and wheat flour (T1-T5) and served along with a control prepared from refined wheat flour. Table–4.20 and Figure-4.9 portrays that the overall acceptability of control sample (8.67±0.32) was significantly higher than the experimental samples. The quality attributes of overall acceptability of biscuits reveals that the maximum score was recorded in 90:10 ratio of wheat flour and IRFSM, whereas the minimum score was recorded in 50:50 ratio of wheat flour and IRFSM.

As the Lotus stem, cauliflower leaves and garden cress seeds were dark in color, it gave dark color to the biscuits. It was light in color at the lower level (10%) which was increases to darker shade in biscuits at 20%, 30%, 40% and 50% (T2, T3, T4 and T5). Dark color was not a hindrance to acceptance as was clear from the acceptability scores of all the products up to 30% (T1 to T3) of incorporation of IRFSM. Biscuits prepared from 10%, 20% and 30% replacement of IRFSM were well accepted in terms of appearance and color, while gradual decrease in acceptability scores could be seen as the level of IRFSM incorporation increased.

Table: 4.20 Mean sensory scores of Biscuits

Treatment	Color	Appearance	Texture	Flavour	Taste	Overall acceptabilly
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Control	8.5±0.39	8.5±0.39	8.89±0.18	8.75±0.23	8.7±0.42	8.67±0.32
T1	7.87±0.55	7.87±0.55	8.37±0.35	7.93±0.29	8.3±0.29	8.08±0.32
T2	7.45±0.43	7.45±0.43	8±0.32	7.6±0.29	7.7±0.47	7.66±0.24
T3	7.15±0.24	7.15±0.24	7.63±0.39	7.24±0.26	7.48±0.39	7.43±0.49
T4	6.75±0.31	6.75±0.31	7.08±0.42	6.78±0.54	6.56±0.45	6.68±0.35
T5	5.39±0.41	5.39±0.41	6.6±0.36	5.35±0.53	5.3±0.48	5.72±0.60
ANOVA (F value)	69.84**	69.84**	60.09**	92.12**	85.09**	67.61**
CD5%	0.36	0.36	0.31	0.34	0.38	0.36
CD1%	0.48	0.48	0.41	0.45	0.51	0.48
CV	14.68	14.68	10.83	15.44	16.56	14.08

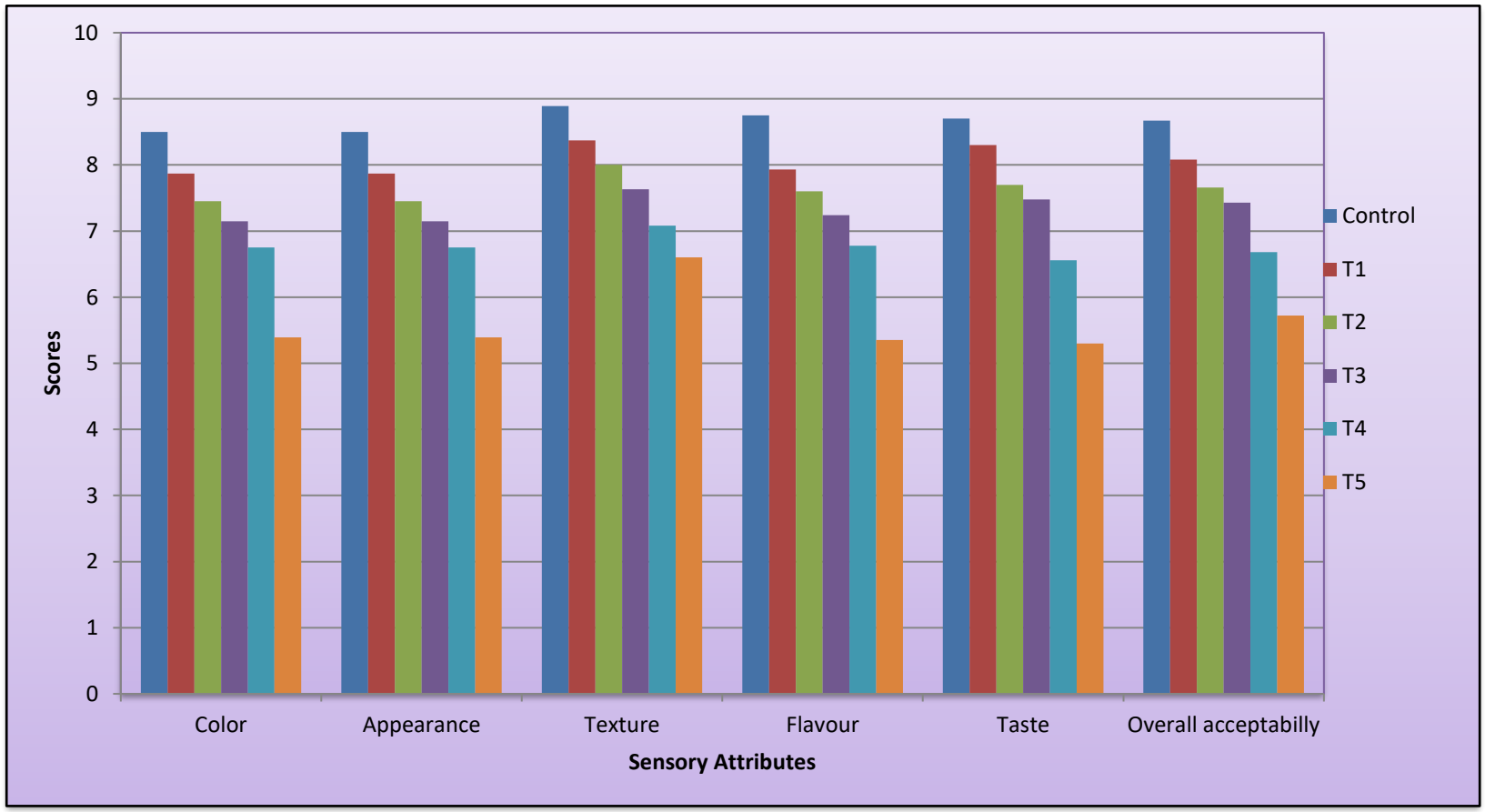
Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM. **significant at 0.01%, * significant at 0.05%

Flavor of the biscuits secured higher score at the level of 10% but the score gradually decreased at higher level of incorporation of IRFSM. 10%, 20% and 30% (T1, T2 and T3) incorporation were acceptable in term of flavor while 40% and 50% (T4 and T5) were not liked by the panel members.

All the variations of Biscuits had good texture at 10% to 40% (T1 to T4) level of IRFSM incorporation but average acceptability scores was low in more than 40% incorporation of IRFSM in Biscuits.

All the variations of Biscuits were well accepted in term of taste up to the level of 30%. However, an inverse relationship was observed between the level of IRFSM and the taste. Average acceptability scores for taste decreased markedly at 40% and 50% of IRFSM incorporation.

Figure: 4.9 Mean sensory scores of Biscuits



Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM

Statistical analysis (ANOVA) for the sensory attributes of all the IRFSM incorporated recipes showed a significance difference ($P<0.05$) in control and experimental samples. The product of T4 and T5 was not acceptable only T1, T2 and T3 were in acceptable range. The iron content of T3 biscuits was higher as compare to T1 and T2, hence 30% IRFSM incorporated biscuits were selected for intervention.

Biscuits were prepared by Wani and Sood (2013) from wheat flour and cauliflower leaves powder incorporation at 10%, 20% and 30% in flour. The quality attribute of overall acceptability of biscuits revealed that at the maximum score of 8.20 was recorded in 90:10 ratio of wheat flour and cauliflower leaves powder, whereas the minimum score of 5.58 was recorded in 70:30 ratio of wheat flour and cauliflower leaves powder biscuits. The incorporation of cauliflower leaves powder in biscuits up to 10% not only improves the texture, taste and overall acceptability but also improves the nutritive value of these product without adding much to the cost of the product.

Iron rich biscuits were developed by Zanvar and Devi (2007) using locally available iron rich food stuff i.e. garden cress seeds and rice flakes biscuits were tested for its acceptability by panel members. Among all the variation of biscuits, variation III (10% garden cress seeds) was highly accepted for all sensory characters.

The results of the present study agree favorably with the result of Patil et al. (2015). In the study garden cress seeds were incorporated in the traditional recipes of biscuits. The biscuits were prepared, in which wheat flour was replaced by garden cress seeds at 5, 10, 15 and 20 percent (T1, T2, T3 and T4). Sensory evaluation of garden cress seeds biscuits prelist that the score of control biscuits was higher i.e. 9 as compared to experimental biscuits. Among the garden cress seeds biscuits the sample T2 recorded the highest score.

The overall acceptability of biscuits was significantly affected by increased level of garden cress seeds, lotus stem and cauliflower leaves. It has been also noticed that

when the level of incorporation of dry vegetable and garden cress seeds increased beyond the accepted level in preparations, the mean scores for the organoleptic evaluation for appearance, color, texture, taste, flavor and overall acceptability were decreased.

Mathri

Mathri is deep fried snack made in mainly refined wheat flour. In present study mathri was prepared with incorporation of various percent of IRFSM (10%, 20%, 30%, 40% and 50%) and wheat flour (T1-T5) and served along with a control prepared from refined wheat flour. Figure-4.10 clearly depicts that the mathri samples prepared using selected combination of IRFSM and wheat flour in different ratio could secure the overall mean scores range from 8.55 to 5.62 whereas control Mathri was liked very much. Though the results revealed that all the treatment (T1-T5)were not liked extremely as compared to control, yet treatment (T1-T3) were in acceptable range but T4 and T5 were not liked by the panel members (Table-4.20).

In another study, Verma and Jain (2012) developed the same products using fresh and dehydrated vegetable (spinach, mint, carrot and lotus stem). Organoleptic evaluation of fresh vegetable mathri showed the highest overall acceptability attribute i.e.7.8±0.19 where as dried vegetable mathri sample shows the lowest acceptability score i.e. 7.3±0.66, followed by control mathri sample.

Singh et al. (2013) developed lotus stem powder enriched recipes viz. mathri and namkeen sev. Lotus stem powder (30%) enriched mathri and namkeen sev were sensory evaluated and they found that the mean scores of mathri were lower than namkeen sev for various attribute. The mean score for mathri was 7 while it was higher for namkeen sev i.e. 7.5.

Table: 4.21 Mean sensory scores of Mathri

Treatment	Color	Appearance	Texture	Flavour	Taste	Overall acceptabilly
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Control	8.39±0.31	8.39±0.31	8.37±0.32	8.67±0.19	8.7±0.42	8.5±0.16
T1	7.25±0.24	7.25±0.24	8±0.32	7.73±0.24	8.3±0.29	7.71±0.46
T2	7.15±0.24	7.15±0.24	7.63±0.4	7.3±0.23	7.59±0.29	7.36±0.23
T3	6.75±0.31	6.75±0.31	7.58±0.29	7.29±0.26	7.38±0.44	7.51±0.38
T4	6.02±0.39	6.02±0.39	7.08±0.42	6.9±0.39	6.46±0.45	6.5±0.49
T5	5.29±0.36	5.29±0.36	6.17±0.68	5.81±0.50	5.57±0.61	5.63±0.37
ANOVA (F value)	115.97**	115.97**	32.62**	84.43**	71.34**	80.09**
CD5%	0.28	0.28	0.38	0.29	0.38	0.34
CD1%	0.38	0.38	0.51	0.39	0.51	0.46
CV	11.85	11.85	10.99	12.67	15.69	14.43

Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM. **significant at 0.01%, * significant at 0.05%

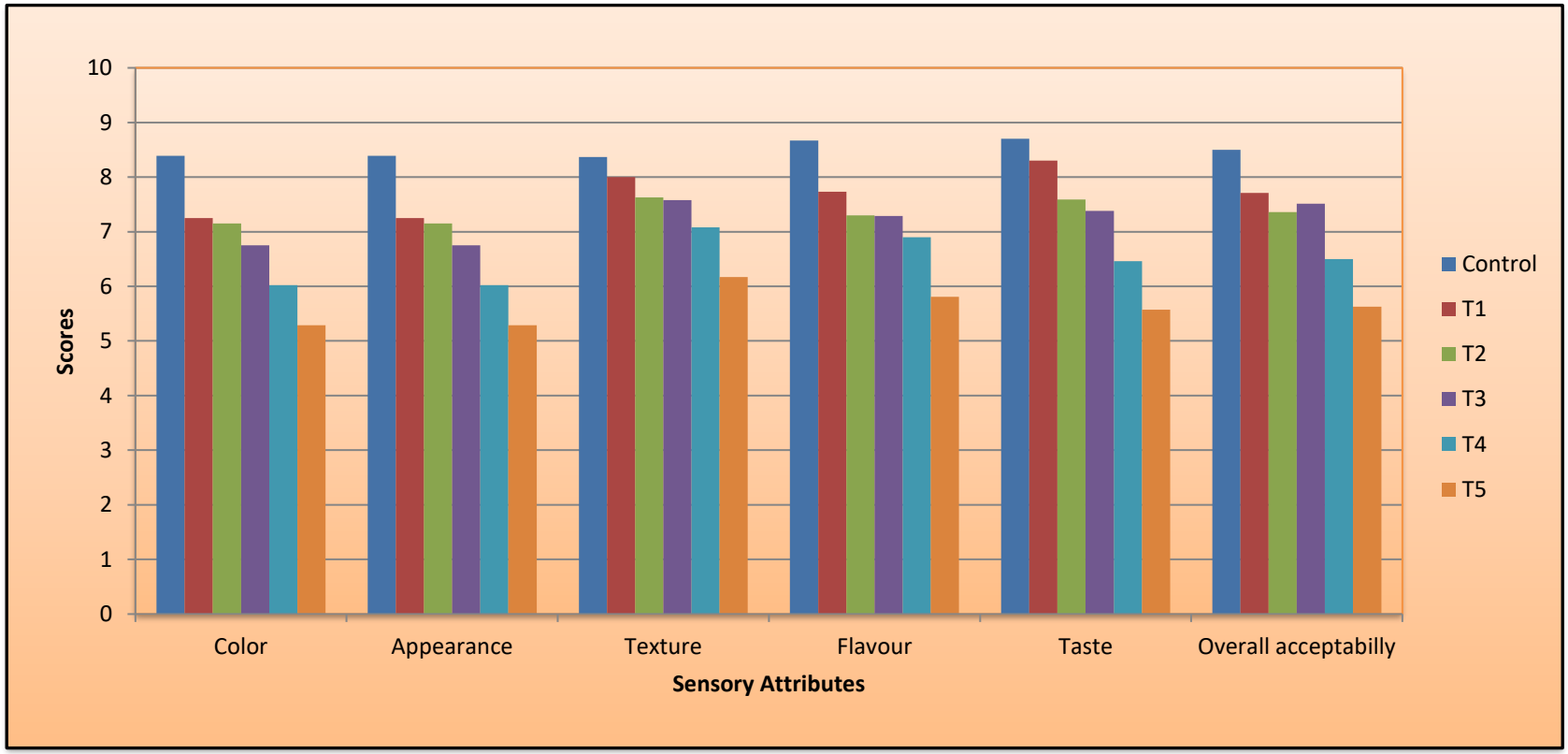
4.8.3. Quality assessment of developed IRFSM

Flour quality may be defined as the ability of the flour to produce an attractive end product at competitive cost under conditions imposed by the end product manufacturing unit. The concept of quality may refer to fitness of a raw material or a product for a particular process or for consumer (Kharker, 2013). The quality of developed IRFSM was assessed in the following terms:

4.8.3.1. Nutrient compositions:

The nutritional composition provides basic information about the components and quality of the products. Hence, proximate and mineral content was analyzed and discussed to evaluate the nutritional quality of the IRFSM. The statistical results of nutritional quality analysis were presented in Table-4.22.

Figure: 4.10 Mean sensory scores of Mathri



Where, Control= 100% refined wheat flour, T1=9:1, T2=8:2, T3= 7:3, T4=6:4, T5=5:5 of wheat flour:IRFSM

Moisture content

The moisture content is one of the most important and commonly measured properties of food products. It is measure for a number of reasons including legal and label requirement, economic importance, food quality, better processing operations and storage stability considerations. The dehydration process i.e. oven drying was used for drying the selected food ingredients, that works on the principle of removal of moisture by application of indirect heat under control conditions of temperature, humidity and air flow must have resulted in uniform dried food with low moisture content. The moisture content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 11.67g, 9.45g, 10.23g and 4.62g/100g respectively (Table-4.22). IRFSM had less amount of moisture content 9.54%. This could be explained by the subsequent drying of ingredients in order to prevent the growth of microorganism.

Table: 4.22 Nutritional composition of raw ingredients and formulated IRFSM (per 100g)

Constituents	Rice flakes	Lotus stem	Cauliflower leaves	Garden cress seeds	IRFSM
Moisture(g)	11.67±1.23	9.45±0.02	10.23±0.04	4.62±0.05	9.54±0.23
Ash(g)	10.24±0.42	12.67±0.83	13.32±0.12	7.79±0.85	8.63±0.46
Crude fibre (g)	0.68±0.08	24.8±0.16	8.68±0.12	6.92±0.83	8.86±0.45
Energy(Kcal)	342.62±4.23	236.76±0.82	267.32±1.32	452.67±3.23	323.97±0.67
Protein(g)	6.9±0.45	6.8±0.23	28.03±0.12	25.80±0.23	10.11±0.56
Fat(g)	1.25±0.48	1.26±0.01	1.76±0.08	23.64±0.04	3.37±0.4
Carbohydrate(g)	76.4±1.43	51.8±0.32	18.65±0.86	34.56±0.89	62.23±2.55
Iron((mg)	22.62±0.34	68.76±0.04	46.79±0.04	76.40±0.56	39.87±1.43
Calcium(mg)	20.56±0.08	402.65±0.06	682.05±1.78	365.58±1.54	236.5±1.28

Values represent Mean±Standard Deviation of triplicate determinations. Values expressed as percent dry weight

Table: 4.23 Nutritional composition of control and IRFSM Biscuits

Constituents	IRFSM Biscuits	Control Biscuits	t value
Moisture(g)	5.89±1.24	5.03±1.67	0.89ns p=0.42
Ash(g)	2.8±0.65	1.12±0.54	3.44**, p=0.026
Crude fibre(g)	3.59±0.92	0.99±0.87	3.56**, p=0.024
Energy(Kcal)	445.6±3.45	432.82±4.21	3.75**, p=0.02
Protein(g)	9.56±0.56	7.35±0.86	3.73**, p=0.02
Fat(g)	25.83±0.54	25.48±0.69	0.69ns, p=0.527
Carbohydrate(g)	56.34±1.58	55.02±1.87	0.93ns, p=0.40
Iron((mg)	16.86±0.08	4.42±0.64	33.41**, p=0.0001

Where, control Biscuits = 100% refined wheat flour, IRFSM Biscuit= Wheat flour:IRFSM (70:30) ,significant at 0.05%, * significant at 0.01%, ns= non significant**

Ash content

The ash content is the inorganic residue remaining after the removal of water and organic matter by heating in the presence of oxidizing agent, which provides a measure of the total amount of minerals in a food. The moisture content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 10.24, 12.67, 13.32 and 7.79g/100g respectively. IRFSM had ash content of 8.63g/100g.

While in another study, composite flour biscuits were prepared by Sharma et al. (2013) using barley, wheat flour and check pea flour in various preparation and wheat biscuits served as control. It was stated that the mean ash content of composite flour biscuits was significantly ($P<0.05$) higher than the control biscuits.

Jain et al. (2010) were prepared iron rich biscuits using refined wheat flour, defatted soya flour and niger seeds and wheat flour biscuits served as control. The ash content of control recipes was lower than their iron enriched variant. In present study, the ash content of IRFSM biscuits (2.8g/100g) was significantly higher than control biscuits (1.12g/100g) this could be due to the higher mineral content of mix biscuits.

Crude Protein

Proteins are polymers of amino acid and their amount in a sample represent its quality index. Crude protein is normally determined by measuring the amount of nitrogen in a sample. Fresh green leafy vegetable are generally poor source of protein but after drying of cauliflower leaves increase of protein was seen. The protein content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 6.9g, 6.8g, 28.03g and 25.80g/100 respectively. The protein content of IRFSM was 10.11g/100g. Biscuits prepared with IRFSM contain high protein (9.56g/100g) as compared to control biscuits (7.35g/100g) (Table-4.23). This protein content of IRFSM biscuits was high due to the incorporation of protein rich garden cress seeds and dry cauliflower leaves in the mix.

Similar result were reported by Wani and Sood (2013) in malted wheat flour and dry cauliflower leaves biscuits. Protein content was high (9.51%) in treated biscuits (70:30) as compared to control biscuits (7.30%).

Patil et al. (2015) reported in their study that garden cress seeds supplementation wheat flour significantly increased the protein content of garden cress seeds biscuits as compared to control biscuits. Mathri prepared with dry vegetable powder contain high protein (7.44 g) as compared to fresh mathri (3.5g) (Verma and Jain, 2012).

Crude fiber

Crude fiber is the residues of plant based food left after extraction with solvent, dilute acid and dilute alkali (William and Olmstead, 1935). It is a measure of the quantity of indigestible cellulose, pentasans, lignins of foods. Fiber has little food value but give bulk to the food and also helps in regulate certain physiological functions. The perusal of the data in table-4.22 revealed that the fibre content of cauliflower leaves and lotus stem was 8.68g and 24.8g/100 respectively, as both are rich source of dietary fibre. Rice flakes and garden cress seeds had fibre content 0.68g and 6.92g/100g respectively. Crude fiber content of IRFSM was 8.86g/100g.

Fiber content of IRFSM biscuits was significantly higher (3.59g/100g) than control wheat flour biscuits (0.99g/100g). This could be due to incorporation of fiber rich dry lotus stem and cauliflower leaves powder in the IRFSM.

Wani and Sood (2013) reported that fiber content of cauliflower leaves mix biscuits (8.39%) was significantly higher as compare to wheat flour biscuits (6.12%). Similar results have been reported by Zanvar and Devi (2007) in garden cress seeds biscuits and Sivakami and Sarojani (2013) in defatted coconut oilcake biscuits.

Carbohydrate

Carbohydrate is compounds made up of sugar and source of energy for vital metabolic process. They add flavor to the diet. The carbohydrate content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 76.4g, 51.8g, 18.65g and 34.56g/100g respectively.

The carbohydrate content was found to be 62.23g/100g in IRFSM. A glance of data in Table-4.23 reveals that carbohydrate content of IRFSM biscuits was 56.34 %and wheat flour biscuits was 55.02% respectively. The results were supported by the finding of Sivakami and Sarojani (2013) in defatted coconut oilcake biscuits.

Crude fat

Lipid including fats and oils are one of the major constituent of food are important in our diet for number of reasons. They are major source of energy and provide essential lipid nutrients. In many foods, lipid components play a major role in determining the overall physical characteristics, such as flavor, texture, mouth feel and appearance. The fat content of rice flakes, lotus stem and cauliflower leaves was 1.25g, 1.26g and 1.76g/100g respectively. Garden cress seed are oil seeds so its fat content was high (23.64g/100g).The results have been presented in Table-4.22 shows that the fat content of IRFSM was 3.37g/100g. Data in Table-4.23 depicts that the fat content of IRFSM biscuits and wheat flour biscuits was 25.83% and 25.48% respectively.

These finding are in accordance with the finding of Zanvar and Devi (2007); Sivakami and Sarojani (2013); Wani and Sood (2013) and Patil et al. (2015).

Energy

Energy of IRFSM is derived from three major nutrient i.e. fat, protein and carbohydrate. It is apparent from the data given in Table- 4.22 that energy value of rice flakes, lotus stem, cauliflower leaves and garden cress seeds were 342.62kcal, 236.76kcal, and 267.32kacl and 452.67kcal/100 g respectively. The energy value of IRFSM was 323.97kcal. Data in Table-4.23 depicts that the energy value of IRFSM biscuits and wheat flour biscuits was 445.6kcal/100g and 432.82kcal/100g respectively.

Mineral composition

Mineral are inorganic substances present in all living and non living things including man, animal, rock and soil. Their presence in living things is necessary for the maintenance of certain physiochemical processes essential to life. Mineral can be divided into two parts i.e. macro and micro minerals. Macro or major minerals like calcium (Ca), magnesium (Mg) and phosphorus (P) are essential mineral found in the body in abundance. Micro or trace element, such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu), in small amount are needed but are highly significant in the body. Result regarding mineral composition of developed IRFSM was presented in Table-4.22.

Iron

The iron content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 22.62g, 68.76g, 46.79g and 76.40g/100g respectively. The calcium content of rice flakes, lotus stem, cauliflower leaves and garden cress seeds was 20.56mg, 402.65mg, 682.05mg and 365.58mg/100 respectively. The calcium content of IRFSM was 236.5mg/100g.

The iron content of IRFSM was 39.87mg/100g. The IRFSM was found to be rich source of iron as this was made of iron rich indigenous food ingredients. Fatza et al. (2014) reported that the iron content of premixes made up of ameranthe leaves, cauliflower leaves, fenugreek, flax seeds and wheat flour was 27mg/100g. Similar findings also reported by Jain et al. (2010).

Biscuits prepared from IRFSM had significantly higher iron content (16.86mg/100g) as compare to control biscuits (4.42mg/100g). This may be due to incorporation of IRFSM in biscuits. IRFSM supplementation in wheat flour significantly increased the iron content of IRFSM biscuits in comparison to wheat flour biscuits. Addition of dehydrated leaves greens has been reported to increase the nutrient density of products remarkably (Gupta and Prakash, 2011).

The same result was found in the study conducted by Zanvar and Devi (2007) that garden cress seeds biscuits containing 13.13% iron. In another study Patil et al. (2015) reported that wheat flour and garden cress seeds biscuits contain 22.05% iron. Garden cress seeds supplementation in wheat flour biscuits significantly increased the iron content in comparison to wheat flour biscuits.

While in another study biscuit were prepared by Wani and Sood (2013) using malted wheat flour and dry cauliflower leaves in various proportions and wheat flour biscuits served as control. It was stated that iron content of cauliflower leaves mixed biscuits was significantly higher as compared to control biscuits.

Biscuits prepare from defatted coconut oilcake and rice flakes contained 18.34% iron and defatted coconut oilcake, rice flakes and garden cress seeds contained 18.48% iron respectively (Sivakami and Sarojani , 2013).

A study on Udaipur ACRIP mix a home stead technology to prevent iron and vitamin-A deficiency were conducted by Jain et al. (2010). Four commonly consumed recipes were selected to fortify with iron and vitamin-A rich mix. The standardized powder mix was incorporated in the basic recipes of four traditional products i.e. biscuits, mathri, laddo and kasar, which were prepared using 22g of ACRIP mix along with other ingredients. All the products evaluated at laboratory level indicate the acceptance at higher level for texture, taste and flavor but the appearance and colour was liked slightly due to the dark colour contribution in products by niger seeds in the ACRIP mix.

Drumsticks (Maringa olifera) pod powder was used to develop biscuits and mathri by Joshi and Jain (2011). Acceptability of products was assessed on 9 point hedonic scale by a group of 10 penal members. Scores of drumstick biscuits and mathri were graded as 7 and 8, respectively indicating that both products were highly acceptable by the panel members.

4.8.3.2. Physical and functional properties

In addition to nutrient content, the functional properties of value added food ingredients also play a key role for their successful incorporation in conventional food formulations. Several physical and functional properties are carried out to predict the end use quality of flour for making various food products from it. These properties are classified physical properties of flour like particle size, bulk density, wet gluten, SDS-sedimentation volume and functional properties such as water absorption capacity, swelling power, solubility and foaming capacity are performed to judge the quality of raw material particularly flour to get best potential of a flour when processed at industrial level. These properties are useful in making compatible application of flour for a quality product. This reduces processing losses and helps in improving the overall quality of product.

4.8.3.2.1. Bulk density

Bulk density is a measure of heaviness of flour. It is very important in determining the packaging requirement, material handling and application in wet processing in the food industry (Adebowale et al., 2005). The higher the bulk density is desirable for greater ease for dispersibility of flour and is a good physical attribute when determining the mixing quality of a particular matter. Higher values of bulk density provide packing advantage and make its use in the preparation of high nutrient density weaning food. The bulk density of IRFSM was 0.82±0.04g/ml (Table-4.24).

Table: 4.24 Physical and functional properties of IRFSM

Properties	Bulk Density g/ml	Water Absorption Capacity g/g	Water Solubility capacity g/g	Swelling Capacity %
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
IRFSM	0.82±0.04	5.97±0.05	4.30±0.02	63.3±0.04

Shad et al. (2011) reported that the bulk density of lotus stem flour was 0.59±0.035g/ml. Chandra et al. (2015) reported the bulk density of composite flour (rice, green gram dal, potato flour and wheat flour) was 0.82g/ml. The low values of bulk densities make the flour suitable for high nutrient density formulation of foods.

4.8.3.2.2. Water absorption capacity (WAC) and water solubility capacity (WSC)

Water absorption capacity is important in bulking and consistency of product as well as in baking application and WAC gives an indication of the amount of water available for gelatinization (Edema et al., 2005). Good SC, WAC and WSC make it useful to be used as a thickener in liquid and semi liquid foods i.e. gravies soups and bakery products.

Water absorption capacity of IRFSM was 5.97g/g while water solubility capacity of IRFSM was 4.30 g/g (Table-4.24). The higher water absorption capacity of IRFSM may be due to the higher polar amino acid residues of protein having an affinity for water molecules (Yusuf et al., 2008). The major chemical compositions that enhance the water absorption capacity of flour are proteins and carbohydrate, since these constituents contain hydrophilic parts, such as polar or charged side chains. Nasir (2009); Yaseen et al. (2010) and Ei-Demery (2011) reported that proteins are responsible for higher WAC.

4.8.3.2.3. Swelling Capacity

Swelling Capacity is the volume of expansion of molecule in response to water uptake which it possessed until a colloidal suspension is achieved or until further expansion and uptake is prevented by intermolecular force in the swelled particle. Solubility and swelling power increased with increase in temperature. The swelling capacity was used in determining the quantity of water the grain could absorb and the degree of swelling with in specified time (Ikujenlola and Fashakin, 2005).

The increase in the swelling capacity may be attributed to the fact that the outer membranes of the starch granules present in the flour are ruptured during the milling process and swell up in the form of a gel by absorbing water at low temperature i.e. 40-50˚C. A remarkable increase in swelling power may be observed between 60-90˚C (Hoover and Sosulki, 1996).The swelling capacity of IRFSM was 63.3% at 30 to 35˚C (Table-4.24).

4.8.4. Keeping quality assessment of the developed IRFSM

4.8.4.1. Sensory quality

The overall acceptability of a product is a composite effect of different sensory attributes viz. color, appearance, taste, flavor and texture. The sensory quality of the stored IRFSM was assessed in the form of Chapati. It was subjected to sensory analysis by a selected group of panelist for their individual sensory attributes. The sensory scores assigned by the panel members during storage of the product were statistically analyzed using analysis of variance.

Perusal of average color scores as evident from Table-4.25 reveals striking features for maintaining consistency in the visual appeal of the chapatti prepared from packaged IRFSM during entire storage period of three month. Exactly same trend was exhibited for the appearance because the two parameters (color and appearance) are interlinked and interrelated. Observations on taste and flavour scores reveals that decline of slightly high magnitude which became significant ($P<0.05$) after second month of storage. Table-4.25 shows a gradual but non- significant reduction in the texture quality of chapati prepared using packed IRFSM.

Overall acceptability is reflection of the combined effect of the individual sensory traits. The trend displayed by the samples for all five sensory characteristics are visible here (Table-4.25) where even after slight (significant at 5% level) decline, the product could maintain its liked moderately status, at the end of the three months storage period.

Table: 4.25 Effect of storage (days) on the sensory scores of Chapati

Storage (days)	Color	Appearance	Texture	Flavour	Taste	Overall acceptabilly
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
0 day	7.24±0.10	7.36±0.03	7.85±0.02	7.48±0.05	7.28±0.06	7.67±0.10
30 day	7.24±0.05	7.34±0.05	7.82±0.06	7.44±0.01	7.25±0.10	7.63±0.05
60 day	7.21±0.05	7.32±0.01	7.80±0.02	7.40±0.10	7.16±0.01	7.58±0.15
90 day	7.20±0.01	7.31±0.10	7.78±0.10	7.15±0.05	7.00±0.10	7.36±0.10
ANOVA (F value)	1.13 ns	1.46 ns	2.48 ns	58.52**	26.71**	17.01**
CD5%	0.06	0.05	0.06	0.06	0.07	0.1
CD1%	0.08	0.07	0.08	0.08	0.09	0.13
CV	7.92	8.01	7.05	8.95	9.52	8.65

****significant at 0.05%, * significant at 0.01%, ns=Non significant**

4.8.4.2. Microbial load

Microbial load is another determinant indicative of quality of any food product. Every step in handling and preparation of food may be a potential source of examination. In the course of three month of storage, ordinary heated sealed IRFSM was examined to the presence of total viable organisms, yeast and molds and coliforms at monthly intervals

Microbial examination revealed that the total number of surviving microbes (TVC) and yeast and molds counts in the IRFSM were nil prior to their storage (0 day). After that, packaged IRFSM showed significant increase ($P<0.01$) at second and third month of storage as can be seen in table-4.26 and 4.27. This increase may be due attributed to the permeability of packaging material to water and air in ordinary heat sealing.

Table: 4.26 Effect of storage on Total Viable Count(cfu/g) of IRFSM

Storage (days)	Total Viable Count(cfu/g)				
	Mean±SD	F Value	CD (5%)	CD (1%)	CV
0 Day	Nil	50.5*	430.48	652.24	38.3
30 Day	2424±259.08				
60 Day	3294±506.1				
90 Day	5551±375.50				

****significant at 0.05%, * significant at 0.01%, ns=Non significant**

Table: 4.27 Effect of storage on Yeast and Mold count(cfu/g) of IRFSM

Storage (days)	Yeast and Mold count(cfu/g)				
	Mean±SD	F Value	CD (5%)	CD (1%)	CV
0 Day	Nil	196.93*	5.05	7.59	35.33
30 Day	53±4.36				
60 Day	95±2.64				
90 Day	127±6.08				

****significant at 0.05%, * significant at 0.01%, ns=Non significant**

During the entire storage period, the enumerated values of TVC and yeast and molds count i.e. 0 to 5200 cfu/g and 0 to 122 cfu/g, respectively were found, which are much lower than the wheat flour specification given by Kenya standard (2009) of maximum permissible level of TVC (10^5 per gram) and Y& M count (10^4 per gram). Moreover, the findings of the present study depicts that coliform count was not detected in package IRFSM throughout the storage.

Because for the growth of coliform bacteria the maximum moisture content in a food should be 18% (Ballogou et al., 2011) and in the present study maximum moisture content of the IRFSM was 9.54% (refer in table-4.22) which was unfavorable for the growth of coliforms.

In the present investigation, the result of microbial examination revealed that the developed IRFSM was safe for human consumption as all the indicators of microbial load were within permissible limit. Low moisture, the hygienic condition maintained during preparation and storage of sample were the reason behind the observations.

In a recent study, Munasinghe et al. (2013) prepared a composite flour of mong bean (Vigna radiate), soyabean (Glycine max) and brown rice (Oryza sativa). They also reported nil detection of coliform count in the composite flour while TVC was quite higher than the present study i.e. 2.75x 10^6 cfu/g. Similar to the finding of the present study, Compaore et al. (2011) observed nil growth of coliforms in pearl millet and maize based complementary flours. Further, comparable findings were observed by Ojure and Quadri (2012) regarding the microbial flora of plantain flour. It was reported that the coliform counts was nil and the TVC and yeast and molds counts were found to be 2.1x 10^2cuf/g and 1.1x10^2cuf/g respectively.

4.8.4.3. Moisture

Moisture being one of the important determinants of shelf life of dried product was mentioned at regular intervals during storage period of three months. The mean value of moisture content from the three replicates of the flour stored in HDPE bags in ordinary heat sealing have been presented in Table-4.28 and Fig-4.11.

Table-4.28 shows that the average mean values of moisture content of ordinary heat sealed packed IRFSM were 9.98% at 30 day, 10.82% at 60 day and 11.7% at 90 day. The table further depicts significant increase ($P<0.05$) at 2nd and 3rd month of storage period.

A significant increase in the moisture content of IRFSM was recorded during the entire storage span which might be attributed to absorption of moisture from atmosphere due to permeability of high density polythene bags to water vapour and hygroscopic properties of the IRFSM.

Figure: 4.11 Effect of storage on moisture content (%) of the developed IRFSM

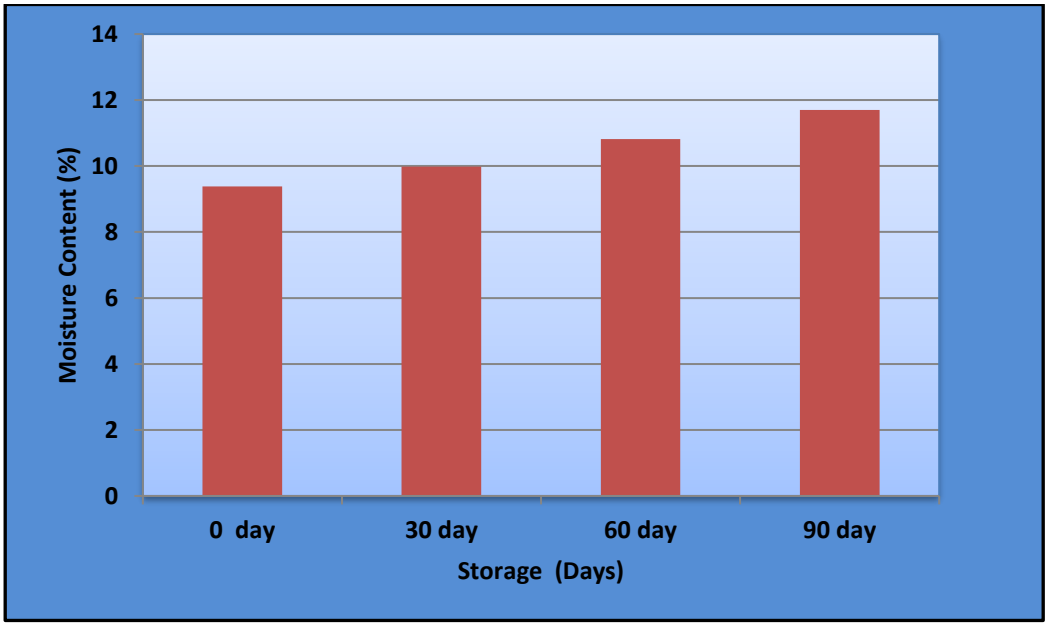


Table: 4.28 Effect of storage on moisture content (%) of the developed IRFSM

Storage (days)	Moisture content (%)				
	Mean±SD	F Value	CD (5%)	CD (1%)	CV
0 Day	9.38±0.4	10.1**	0.57	0.83	9.8
30 Day	9.98±0.64				
60 Day	10.82±0.06				
90 Day	11.7±0.80				

****significant at 0.05%, * significant at 0.01%, ns=Non significant**

Alike the present study, Khan et al.(2009) observed through gradual but significant increase in the moisture content of four different composite flours using wheat and soy flour packed in polypropylene bags during storage period of two months. The moisture content in the composite flours ranged from 8.04% to 9.04% during entire storage period of 60 days. Increase in the moisture of various composite flour samples may be again due to the hygroscopic nature of flour and change in relative humidity during storage.

4.8.4.4. Insect infestation

Detection of insect infestation is an important quality parameter of the flour in the present investigation, there was no infestation observed in the flour by visual perception and sieving method performed at monthly interval during the entire storage period. The reason behind this may be low moisture, proper packaging material and technique, storage environment etc.

Equivalently, Sharma (2005) observed no infestation in the composite flour of wheat, pearl millet, bengal gram, barley maize and foxtail millet packed in polythene bags during its storage of three months.

In contrast, Nasir et al. (2003) noticed the insect infestation in the wheat flour during the 60 days storage period. They stated that insect infestation was more in the sample having higher moisture (13.5%) during storage while the sample with lower moisture content (9%) showed no infestation.

In the present study, the findings regarding the insect infestation showed that the developed IRFSM would be well accepted for the use of food preparation as it free from insects as per visual perception.

4.8.5. Cost analysis of IRFSM

Cost is an important criteria to be considered for any supplementation. The cost incurred in the preparation of IRFSM is given in Table-4.29.

The total cost in the preparation of IRFSM was rupee 5.2/100g. It is evident that the IRFSM are far more economical, affordable and can be easily prepared at home compared to commercial Iron rich health supplements.

Table: 4.29 Cost analysis of IRFSM

Category	Quantity (g)	Cost (Rupee)
Raw material		
Rice flakes	50	1
Lotus stem	30	3
Cauliflower leaves	10	0
Garden cress seeds	10	1
Processing charges	100	0.2
Total	100	5.2

4.9. Impact of nutrition intervention package in improving the iron status of adolescent girls

4.9.1. Impact of nutrition education on the nutritional knowledge of the subjects

After imparting nutrition education, the knowledge scores increased in all four experimental groups while in control group there was no increase in scores (Table-4.30 and 4.31). Nutrition education was given to experimental group III and IV. In experimental group I and II more than 50% adolescent girls gained medium scores with MPS 57.49% and 54.04% respectively while in experimental groups III and IV, 62.86% and 53.12 % girls had medium scores and 37.14% and 46.87% gained high nutrition knowledge scores. The MPS was highest (80.67%) in experimental group IV and lowest in control group. Gain in knowledge scores was 27.91%, 23.73%, 40.78% and 51.2% in experimental group I, II, III and IV respectively. Increase in nutrition knowledge scores after imparting nutrition education was found significant ($P<0.05$). ANOVA values depict a significance difference between experimental groups and control group. Gain in nutrition knowledge reflects that adolescent girls are potential learners and crucial asset for nation building.

Table: 4.30 Mean scores of nutrition knowledge test before and after intervention

Study group	Number of subjects	Pre test	MPS	Post test	MPS	Mean difference±SD	Gain%	t value	F value	CD5%	CD1%
Control group	30	12.56±1.99	27.91	13.26±2.15	29.51	0.7±1.53	1.6	0 ns	**72.891****	2.8	3.7
Experimental group I	32	13.31±3.91	29.58	25.87±7.87	57.49	12.56±7	27.91	8.09**		2.71	3.58
Experimental group II	31	13.64±3.70	30.31	24.32±4.42	54.04	10.67±6.09	23.73	10.31**		2.75	3.64
Experimental group III	35	14.25±3.88	31.62	32.6±4.01	72.4	18.34±5.96	40.78	19.43**		2.59	3.42
Experimental group IV	30	13.26±3.68	29.47	36.33±4.30	80.67	23.07±4.92	51.2	22.33**		2.8	3.7

**** Significant at p< 0.05, * Significant at p< 0.01, ns = Non significant.**

Figure: 4.12 Nutrition knowledge test scores before and after intervention

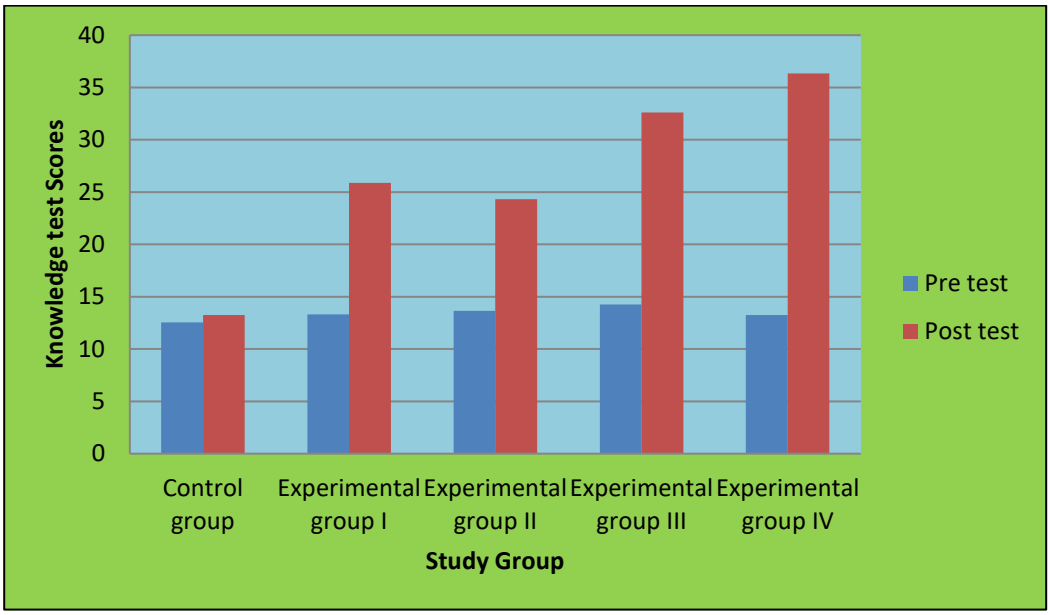


Table: 4.31 Nutritional knowledge of the respondent

Study Group	Test	Low		Medium		High	
		N	%	N	%	N	%
Control Group N=30	Pre test	26	86.67	4	13.33	0	0
	Post test	25	83.33	5	16.67	0	0
Experimental Group I N=32	Pre test	26	81.25	6	18.7	0	0
	Post test	11	34.37	21	65.62	0	0
Experimental Group II N=31	Pre test	28	90.32	3	9.68	0	0
	Post test	9	29.03	22	70.97	0	0
Experimental Group III N=35	Pre test	29	82.86	6	17.14	0	0
	Post test	0	0	22	62.86	13	37.14
Experimental Group IV N=32	Pre test	24	75	8	25	0	0
	Post test	0	0	17	53.12	15	46.87

Aspect wise mean scores Table-4.32 depicts that after imparting nutrition education the knowledge of all the aspects of nutrition education package was highest in experimental group III and IV.

Table: 4.32 Aspect wise mean scores

Aspects	Control Group N=30		Experimental Group I N=32		Experimental Group II N=31		Experimental Group III N=35		Experimental Group IV N=30	
	Pre test	Post test	Pre test	Post test	Pre test	Post test	Pre test	Post test	Pre test	Post test
Food group and nutrients	2.23±0.98	2.25±1.23	2.5±1.26	5.56±1.90	2.6±1.19	4.56±1.26	2.14±1.83	4.75±1.23	2.25±1.23	6.78±1.67
Iron rich food and their function	3.3±1.28	3.32±1.27	3.1±1.38	4.19±123	2.9±1.6	4.2±1.38	3.5±1.26	4.52±1.27	3.0±1.82	4.67±1.23
Food favouring iron absorption and inhibition	2.0±1.83	2.34±1.63	1.9±1.32	3.23±1.50	2.1±1.18	3.89±1.32	1.9±1.72	4.9±1.63	2.26±1.43	5.43±1.20
Hemoglobin and its function	0.5±0.6	0.7±0.72	0.9±0.8	2.46±1.23	0.6±0.9	1.2±0.8	0.52±0.78	2.6±1.23	0.82±0.56	2.67±1.65
Iron deficiency anemia, its causes and preventive measures	1.5±1.72	2.02±1.78	2.29±1.63	4.86±1.45	2.2±1.72	5.9±1.63	2.8±0.92	8.86±1.45	1.9±1.82	8.89±1.34
Role of ICDS to control anemia	1.4±1.3	2.45±1.43	2.6±1.8	5.56±1.60	3.24±1.8	4.5±1.8	3.4±1.62	6.86±1.60	3.02±2.16	7.86±1.24

The highest knowledge scores were observed in “iron deficiency anemia and its causes and preventive measures” and lowest retention in gain was found about “hemoglobin and its function”.

Various other studies also show that nutrition education intervention resulted in improvement of nutritional knowledge as well as increase in consumption of nutrition rich foods. Saibaba et al. (2002); Sharma and Chawla (2005); Kaur et al. (2011); Meg et al. (2012) and Ambre and Sengupta (2015) also observed highly significant gain in nutrition knowledge of adolescent girls after imparting nutrition education.

Kaur et al. (2007) reported the impact of nutrition education on nutrient adequacy of adolescent girls of village Shousha district Solan, Himachal Pradesh. Nutrition education was imparted to the subjects after assessing their basic nutrition knowledge.

Nutrition education improved their mean nutrition knowledge scores significantly ($P<0.01$). Before imparting nutrition education, majority (46%) of the respondents had obtained the scores pertaining to nutrition knowledge between 10-15 followed by 5-10 (40%) and 15-20 (13%). After imparting nutrition education, most of the respondents (53.3%) were able to get higher scores from 15-20 and 13.3% of the respondents were able to get the scores up to 25-30. Thus nutrition education was effective in increasing the level of nutrition knowledge.

Abrahme (2015) assessed the knowledge regarding anemia of adolescent girls attending high schools in Pune city. They also found that in pre-test, majority (51.3%) of the adolescent girls had average knowledge regarding anemia and its prevention. 38.8% of them had poor knowledge and 10% of them had good knowledge regarding anemia and its prevention. Whereas in post test, majority (53.8%) of them had good knowledge, most of them (45%) had excellent knowledge and only few of them had average knowledge regarding prevention of anemia. The study significantly proved that there is a remarkable improvement in the knowledge of adolescent girls after teaching program.

4.9.2. Impact of nutrition intervention package on hemoglobin status of the subjects

The impact of nutrition intervention package on hemoglobin status of selected anemic adolescent girls is shown in Table-4.33 and Figure-4.13. After intervention the mean Hb increment among all the four experimental groups was significantly higher ($p<0.01$) than control group. Experimental group IV showed highest increment (1.52g/dl) followed by experimental group II (1.14g/dl) when IRFSM biscuits and lemon/amla were supplemented daily. Further, though the gain was relatively less, even though anemic girls, who were supplemented only IRFSM biscuits without vitamin C (EG I), gained about 0.86 g/dl of Hb and those anemic girls who were intervened through only nutrition education (EG III), gained about 0.43 g/dl of Hb.

Figure: 4.13 Change in mean Hemoglobin of the adolescent girls of different groups after intervention

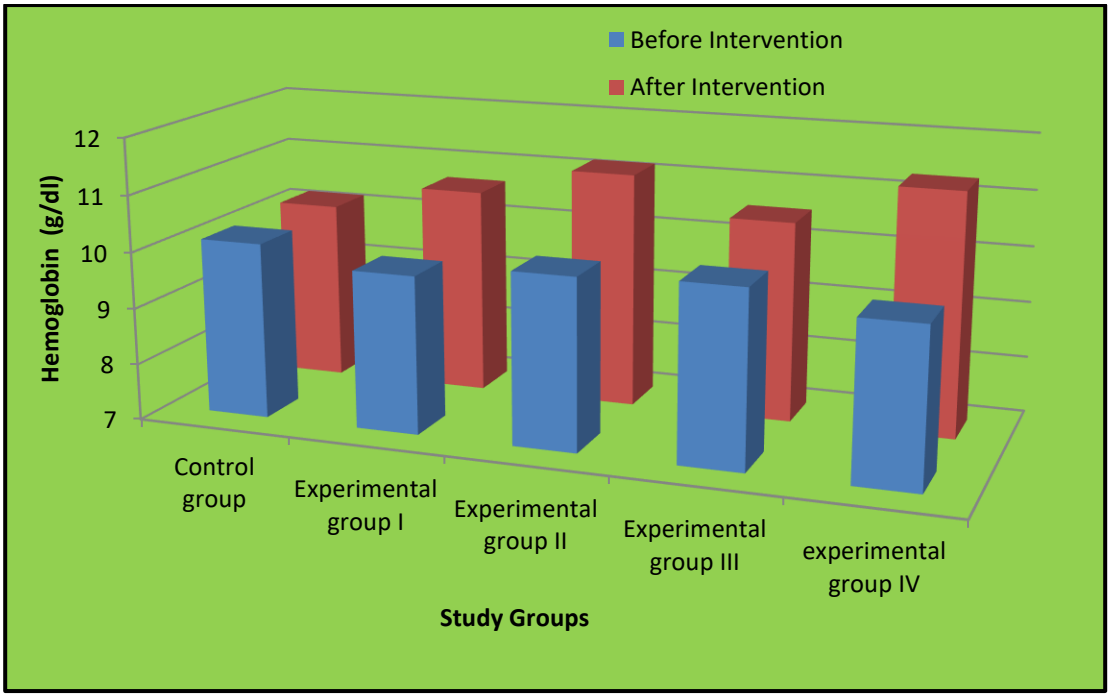


Table: 4.33 change in mean Hemoglobin of the adolescent girls of different groups after intervention

Study group	Number of subjects	Mean Hemoglobin(g/dl)			t value	F value	CD5%	CD1%
		Before Hb±SD	After Hb±SD	Difference±SD				
Control group	30	10.12±1.28	10.19±1.37	0.06±0.59	0.20 ns	**18.874****	0.37	0.49
Experimental group I	32	9.8±1.46	10.66±1.27	0.86±0.87	-2.61*		0.36	0.48
Experimental group II	31	10.04±1.3	11.181.23	1.14±0.75	-3.54 *	p<0.00001	0.37	0.49
Experimental group III	35	10.12±1.2	10.55±1.14	0.43±0.83	-1.47*		0.35	0.46
Experimental group IV	30	9.79±1.26	11.31±0.99	1.52±0.53	5.18*		0.37	0.49

**** Significant at p< 0.01, * Significant at p< 0.05, ns = Non significant.**

Table: 4.34 Change in severity of anemia in adolescent girls of different groups after intervention

Study group	Intervention	Mild Anemia	Moderate Anemia	Severe Anemia	Non-Anemic
	%	%	%	%	%
Control group	Pre Test	33.33	53.33	13.33	0
N=30	Post Test	26.67	60	13.33	0
Experimental group I	Pre Test	50	40.62	9.37	0
N=32	Post Test	40.62	25	0	34.37
Experimental group II	Pre Test	58.07	32.26	9.68	0
N=31	Post Test	38.71	19.35	0	41.93
Experimental group III	Pre Test	45.71	40	14.28	0
N=35	Post Test	37.14	28.57	0	34.28
Experimental group IV	Pre Test	50	40	10	0
N=30	Post Test	26.67	20	0	53.33

Though EG I and III were significantly better in Hb gain than control group, the gain was not as high as EG II and IV. No significant change was recorded in Hb level of control group ($p>0.05$). ANOVA points out to a significant difference in the mean Hb of all five groups (Annexure-XIV).

Daily intake of lemon/amla with IRFSM biscuits by EG II and IV group girls resulted in a significant increase in Hb level. In a community based study, anemic school children were given supplements of 100 mg of synthetic ascorbic acid at each of their two daily meals for a period of two months. This improved their iron levels significantly and the prevalence of anemia was reduced from 96 to 26 percent (Seshadri, et al., 1985).

These observations are in conformation with those reported from rural Mexico, showing that better iron status was associated with higher intake of non-heam iron and foods that contain ascorbic acid (Backstrand et al., 2012).

Jain (2013) also reported that iron rich food supplementation improves the hematological profile of anemic adolescent girls. While other studies conducted by Kowsalya and Shimpray (2008) and Singh (2013) had strongly supported that food based iron supplementation positively improves the iron status of the anemic adolescent girls.

Sheeba and Sabita (2016) also reported that the supplementation of garden cress seeds incorporated chikkies had a significant effect on the hematological parameters of the anemic girls. They assessed the effect of garden cress seeds (Lepidium sativum) incorporated chikkies on the selected anemic adolescent of the age group (12-18 years). A chikkie of twenty grams containing garden cress seeds (3g), groundnut (10g) and jaggery(7g) was supplemented to fifty selected moderately anemic adolescent girls in the experimental group daily for a period of 3 months. The chikkie contained 3.5mg of iron. . The hematological parameters namely Hb and RBC count gradually increased from 9.624g/dl to 12.14gdl and 3.207 million cells/mm3 to 4.044 million cells/mm3 respectively. There was significant improvement in parameter of experimental group and there was no specific change in control group.

Shah (2015) reported a positive and significant improvement in blood hemoglobin level of the anemic adolescent girls of Mehsana city, as an effect of intervention program i.e. garden cress seeds supplementation, iron tablets and nutrition knowledge intervention.

Garden cress seeds powder was supplemented with lemon juice to anemic college girls. It showed that before supplementation the mean blood hemoglobin of girls was 8.99g/dl and after supplementation, it was 10.29g/dl and increment in hemoglobin was 10.92%.

4.9.3. Impact of nutrition intervention on the nutrient intake of adolescent girls

Mean nutrient intake

Mean daily nutrient intake of all the four experimental groups and control group are presented in Table-4.35- 4.39.

As seen in the table-4.35 to 4.39 prior to intervention the energy consumption was only 48% to 54% of RDA in all the subjects of five groups. After intervention the energy intake was increased by 20-30% in all the four experimental group while there was no change observed in control group. The mean energy intake was highest (83.96% and 84.66% of RDA) in 13-15 year and 16-19 years of age girls of experimental group IV respectively. This improvement can be attributed to an increased consumption of cereal, pulses and fat in their daily diet.

The mean intake of protein was increased by 10-30 % in all the four experimental groups while control group showed no change in the intake of protein. The improvement in protein was comparatively higher (88.24% in 13-15 years and 89.73% in 16-19 years of age girls) in experimental group IV.

Table: 4.35 Mean nutrient intake of adolescent girls in control group before and after intervention

Nutrient	Control group (13-15 years)					Control group (16-19 years)				
	pre test		post test		Percent difference of RDA	pre test		post test		Percent difference of RDA
	Mean	% of RDA	Mean	% of RDA		Mean	% of RDA	Mean	% of RDA	
Energy	1245.5±98.3	53.4	1236.4±102.2	53.07	-0.33	1420.8±156.2	58.28	1460.8±172	59.89	1.61
Protein	30.5±16.6	58.77	31±17.5	59.73	0.96	34.5±18.58	62.16	33.6±19.56	60.54	-1.62
Fat	21.5±26.5	53.75	20.5±21.4	51.25	-2.5	21.5±26.8	61.43	21±24.5	60	-1.43
Carbohydrate	189.5±24.5	54.22	184.6±20.8	52.81	-1.41	192.8±23.56	52.68	200±22.56	54.64	1.96
Calcium	402±169.4	50.25	410±142.3	51.25	1	412±185.2	51.5	405±198	50.62	-0.88
Iron	10.6±11.2	39.26	11.6±10.3	42.96	3.7	11.2±13.4	43.08	10.5±13.2	40.38	-2.7
Vitamin A	275.63±95.24	45.94	279.24±84.56	46.54	0.6	292.82±101.5	48.8	289.56±105.6	48.26	-0.54
Thiamin	0.59±0.43	49.17	0.56±0.32	46.67	-2.5	0.62±0.32	56.36	0.59±0.56	59	2.64
Riboflavin	0.76±0.24	54.28	0.73±0.24	52.14	-2.14	0.69±0.54	57.5	0.72±0.34	60	2.5
Niacin	7.89±3.24	56	7.65±4.32	54.64	-1.36	7.9±5.23	57	7.8±5.43	55.86	-1.14
Vitamin C	19.67±12.64	49.17	18.78±18.96	46.95	-2.22	18.89±14.56	47.22	19.27±13.48	48.17	0.95

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Table: 4.36 Mean nutrient intake of adolescent girls in Experimental group I before and after intervention

Nutrient	Experimental group I (13-15 years)					Experimental group I (16-19 years)				
	pre test		post test		Percent difference of RDA	pre test		post test		Percent difference of RDA
	Mean	% of RDA	Mean	% of RDA		Mean	% of RDA	Mean	% of RDA	
Energy	1226.9±129.2	52.66	1706.5±105.2	73.24	20.58	1287.2±119.2	52.75	1806.5±145.2	74.04	21.29
Protein	32.56±15.6	62.74	36.5±12.8	70.33	7.59	33.6±16.3	60.54	41.6±17.23	74.77	14.23
Fat	20±17.8	50	31.5±16.8	78.75	28.75	22.5±17.9	64.28	32.5±17.32	85.88	21.6
Carbohydrate	184.8±28.5	52.87	242.5±25.6	69.38	16.51	198.5±20.8	54.23	275.5±21.5	75.27	21.04
Calcium	390.78±126.2	48.85	525.8±16.2	65.72	16.87	425.65±172.82	53.21	588.8±112.5	73.6	20.39
Iron	11.8±12.5	43.7	20.8±14.5	77.04	33.34	10.9±12.3	41.92	21.6±12.8	83.07	41.15
Vitamin A	284.23±9.52	48.75	392.5±112.5	65.42	16.67	283.56±92.8	45.59	402.5±95.6	67.09	21.5
Thiamin	0.61±0.42	50.83	0.89±0.65	74.17	23.34	0.6±0.56	58	0.76±0.45	76	18
Riboflavin	0.69±0.64	48.29	0.83±0.43	59.28	10.99	0.74±0.54	61.67	0.89±0.63	74.17	12.5
Niacin	7.56±6.57	54	9.82±6.45	70.14	16.14	6.84±5.43	48.86	9.95±7.65	71.07	22.21
Vitamin C	21.63±16.87	54.07	26.73±16.84	66.82	12.75	22.82±12.32	57.05	27.52±15.82	68.8	11.75

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Table: 4.37 Mean nutrient intake of adolescent girls in experimental group II before and after intervention

Nutrient	Experimental group II(13-15 years)					Experimental group II(16-19 years)				
	pre test		post test		Percent difference of RDA	pre test		post test		Percent difference of RDA
	Mean	% of RDA	Mean	% of RDA		Mean	% of RDA	Mean	% of RDA	
Energy	1148.51±135.23	49.29	1725.5±118.32	74.06	24.77	1225.8±126	50.24	1816.8±182	74.58	24.34
Protein	33.8±12.21	65.12	37.5±13.5	72.25	7.13	35.6±11.5	64.14	40.05±13.5	72.16	8.02
Fat	22.5±12.5	56.25	30.5±14.5	76.25	20	21.5±12.5	61.42	30.5±16.7	87.14	25.72
Carbohydrate	178.5±18.5	51.07	288.8±25.6	69.38	18.31	198.5±20.8	54.23	297.5±21.5	81.28	27.05
Calcium	468.5±126.5	58.56	528.8±157.	66.1	7.54	450.8±115	56.35	590.8±153	73.85	17.5
Iron	10.6±12.9	39.26	23.8±13.6	88.14	48.88	10.2±15.6	39.23	22.8±14.6	85.77	46.54
Vitamin A	292.5±99.52	48.75	403.8±85.62	67.3	18.55	283.53±112.8	47.25	399.5±108.9	66.58	19.33
Thiamin	0.61±0.52	50.83	0.79±0.56	65.83	15	0.58±0.53	58	0.82±0.43	82	24
Riboflavin	0.69±0.48	48.57	0.84±0.65	60	11.43	0.62±0.53	61.67	0.92±0.51	74.67	13
Niacin	7.47±5.72	53.28	9.82±6.05	70.14	16.86	6.84±5.46	48.86	9.82±4.89	70.14	21.28
Vitamin C	20.94±16.87	52.35	41.5±11.93	103.75	51.4	21.47±16.84	53.67	42.6±12.83	106.5	52.83

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Table: 4.38 Mean nutrient intake of adolescent girls in experimental group III before and after intervention

Nutrient	Experimental group III (13-15 years)					Experimental group III (16-19 years)				
	pre test		post test		Percent difference of RDA	pre test		post test		Percent difference of RDA
	Mean	% of RDA	Mean	% of RDA		Mean	% of RDA	Mean	% of RDA	
Energy	1150.8±142	49.39	1650.8.2±115	70.82	21.43	1340.8±128.4	54.95	1750.8±115.2	71.75	16.8
Protein	30.8±11.5	59.34	39.514.2±	76.1	16.76	31.93±10.5	61.52	37.53±14.2	67.62	6.1
Fat	22±12.5	55	30.5±16.3	76.25	21.25	24.5±12.56	70	26.5±16.3	75.71	5.71
Carbohydrate	189.25±24.5	54.12	237.8±28.5	68.04	13.92	190.8±22.8	51.91	295±28.5	80.6	28.69
Calcium	346.8±156.5	43.35	520.5±162.8	65.06	21.71	465.8±165.8	58.22	579.6±162.8	72.45	14.23
Iron	11.7±15.5	43.33	18.5±11.5	68.51	25.18	10.8±12.6	41.54	17.8±11.5	68.46	26.92
Vitamin A	278.32±105.6	46.39	423.35±96.85	70.56	24.17	294.32±98.62	49.53	406.24±96.85	67.71	18.18
Thiamin	0.63±0.54	52.5	0.94±0.47	78.33	25.83	0.58±0.42	58	0.89±0.47	89	31
Riboflavin	0.73±0.34	52.14	0.98±0.87	70	17.86	0.71±0.67	59.17	0.93±0.87	77.5	18.33
Niacin	7.45±7.62	53.21	9.62±5.87	68.71	15.5	6.84±5.54	48.86	9.89±5.87	70.64	21.78
Vitamin C	20.02±11.56	50.05	29.63±12.62	74.07	24.02	19.82±12.89	49.55	33.84±12.63	70.65	21.1

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Table: 4.39 Mean nutrient intake of adolescent girls in experimental group IV before and after intervention

Nutrient	Experimental group IV(13-15 years)					Experimental group IV(16-19 years)				
	pre test		post test		Percent difference of RDA	pre test		post test		Percent difference of RDA
	Mean	% of RDA	Mean	% of RDA		Mean	% of RDA	Mean	% of RDA	
Energy	1195.8±112	51.32	1956.8±123	83.96	32.64	1456.6±135	59.69	2065.84±185	84.66	24.97
Protein	30.23±16.8	58.24	45.8±17.9	88.24	30	32.68±17.5	58.89	49.8±18.5	89.73	30.84
Fat	20.5±22.8	51.25	32.5±21.5	81.25	30	21.5±25.8	61.43	31±26.6	88.57	27.14
Carbohydrate	191.5±23.67	54.79	292.8±24.56	83.78	28.99	199.6±16.92	54.53	296.5±15.34	81.01	26.48
Calcium	410±102	51.25	520±108	65	13.75	395±186	49.36	585±145	73.12	23.76
Iron	11.6±12.2	42.96	25.8±13.4	95.56	52.6	10.6±13.6	40.78	24.8±11.6	95.38	54.6
Vitamin A	282.56±85.2	47.09	476.84±92.53	79.47	32.38	284.63±98.56	47.43	486.23±124.63	80.54	33.11
Thiamin	0.63±0.54	52.5	0.94±0.56	78.33	25.83	0.58±0.41	52.73	0.89±0.65	89	36.27
Riboflavin	0.72±0.67	51.43	1.12±0.98	80	28.57	0.79±0.59	65.83	0.93±0.54	77.5	11.67
Niacin	7.94±6.45	56.71	11.4±7.89	81.42	24.71	6.98±4.98	49.8	11.9±5.67	85	35.2
Vitamin C	18.24±15.64	45.6	46.35±12.38	115.87	70.27	20.82±14.58	52.05	49.34±15.96	123.35	71.3

*** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Figure: 4.14 Mean percent difference of nutrient intake of 13-15 years of age adolescent girls

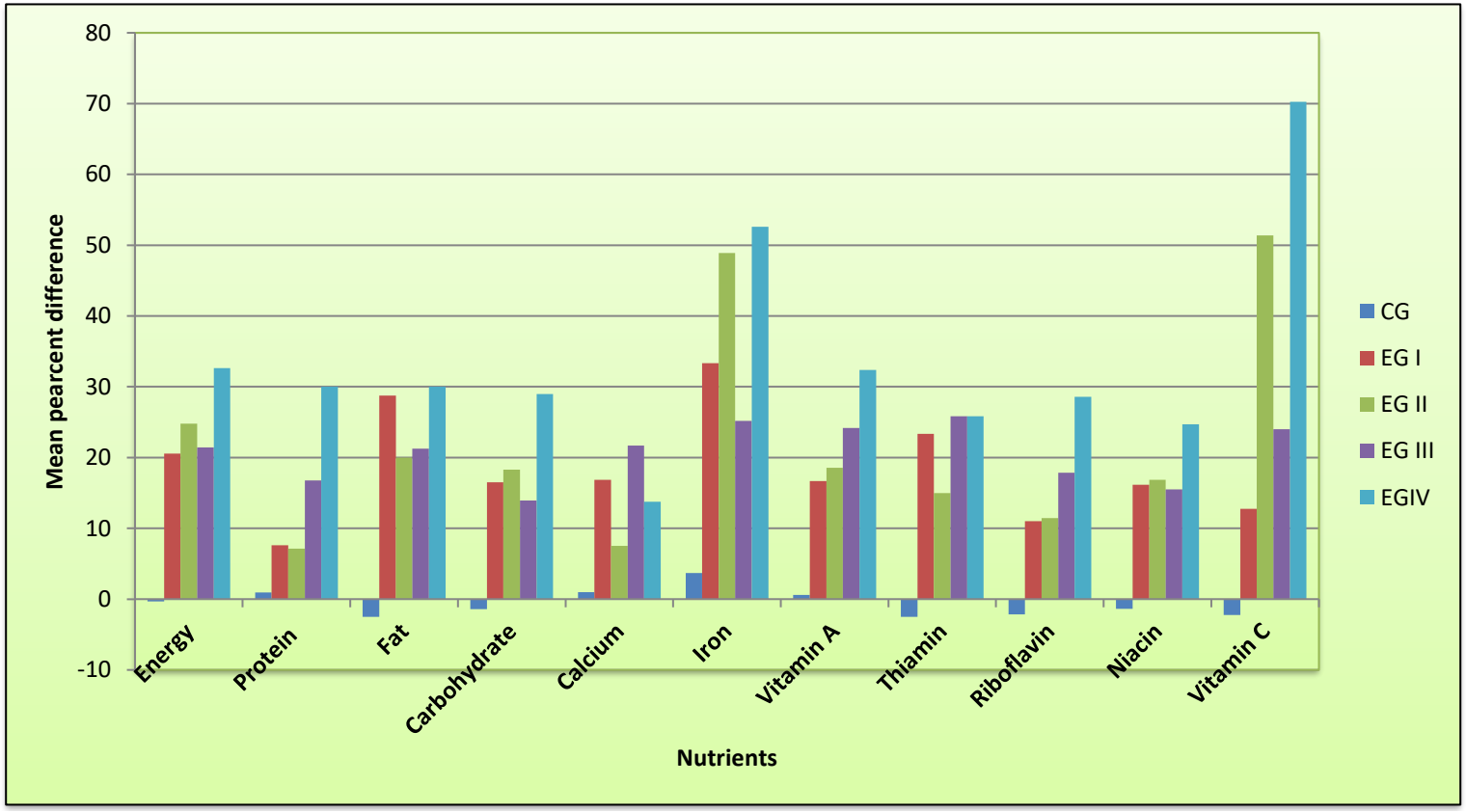


Figure: 4.15 Mean percent difference of nutrient intake of 16-18 years of age adolescent girls

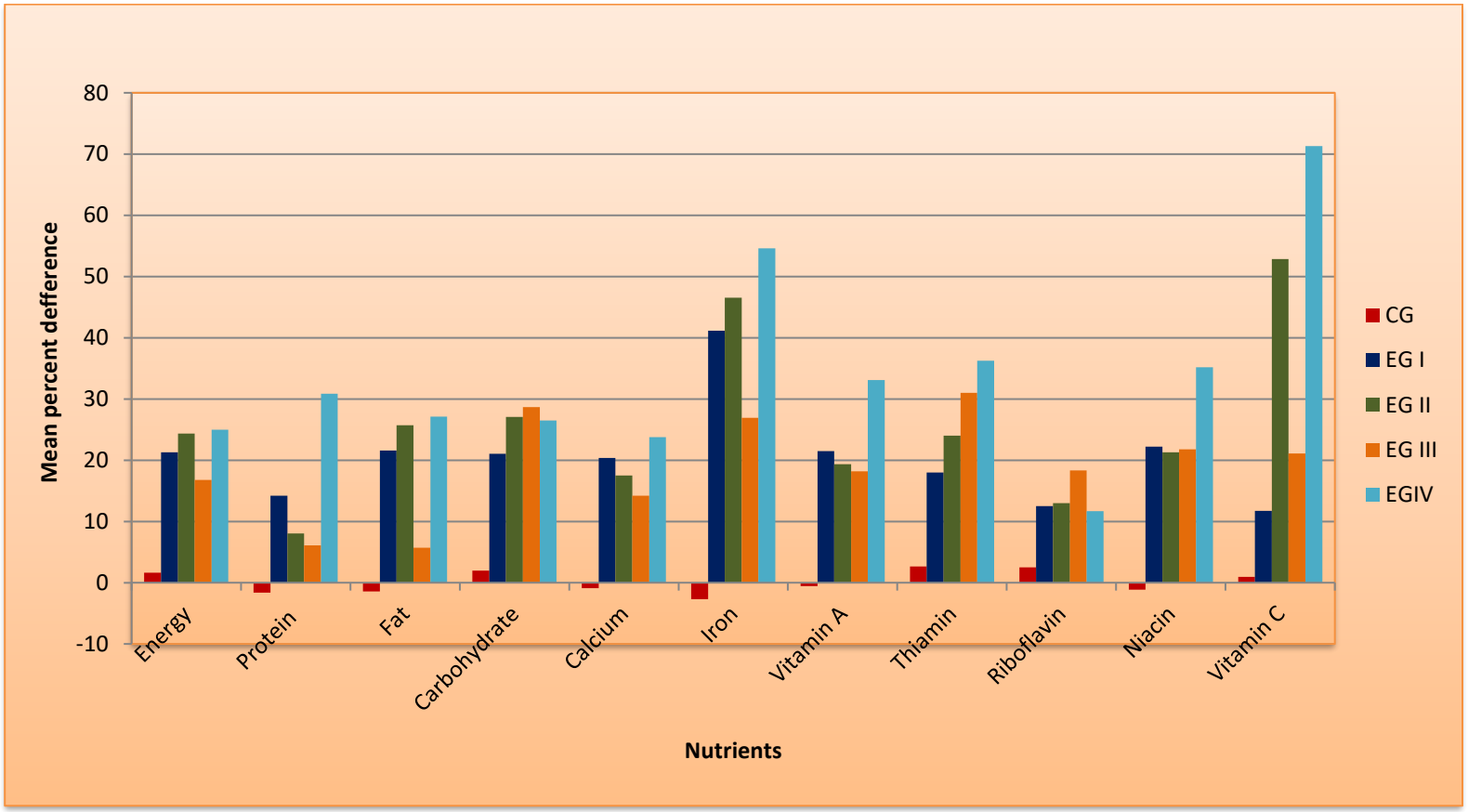


Table: 4.40 Mean difference of nutrient intake of adolescent girl (13-15 years) in five groups

Nutrient	Control group	Experiment group I	Experiment group II	Experiment group III	Experiment group IV	ANOVA (F Value)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Energy	9.1±5.45	479.6±174.67	577±163.42±	500±147.45	761±216.4	92.53**
Protein	0.5±1.2	3.94±2.8	3.7±2.4	8.7±6.5	15.57±12.3	25.39**
Fat	1±1.3	11.5±10.3	8±5.9	8.5±7.6	12±9.8	10.73**
Carbohydrate* **	4.9±1.2	57.7±40.3	110.3±98.3	48.55±35.4	101.3±79.8	15.00**
Calcium	8±3.9	135.02±98.63	60.3±40.87	173.7±112.98	110±89.03	20.15**
Iron	1±0.34	9±3.6	13.2±6.23	6.8±2.98	14.2±8.92	31.50**
Vitamin A	3.61±2.87	108.27±102.98	111.3±102.76	145.03±112.8	194.28±143.3	13.58**
Thiamin	0.03±0.32	0.28±0.45	0.18±0.12	0.31±0.09	0.31±0.07	6.71**
Riboflavin	0.03±0.04	0.14±0.06	0.15±0.16	0.25±0.08	0.4±0.62	7.29**
Niacin	0.24±0.12	2.26±0.65	2.35±1.65	2.17±0.65	3.46±0.99	44.97**
Vitamin C	0.89±0.32	5.1±1.56	20.56±9.87	9.61±4.98	28.11±11.67	75.61**

**** Significant at p< 0.01, * Significant at p< 0.05, NS = Non significant. *** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

Table: 4.41 Mean difference of nutrient intake of adolescent girl (16-19 years) in five groups

Nutrient	Control group	Experiment group I	Experiment group II	Experiment group III	Experiment group IV	ANOVA (F Value)
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
Energy	40±54.5	519.3±121.87	591±214.65	410±184.54	609.24±221.32	55.97**
Protein	0.9±2.8	8±4.8	4.45±3.6	5.6±5.3	17.12±12.3	25.72**
Fat	0.5±1.32	10±12.16	9±5.6	2±6.3	9.5±10.6	9.85**
Carbohydrate* **	7.2±6.87	77±45.32	99±63.6	104.2±87.65	96.9±70.6	12.84**
Calcium	7±5.87	163.15±85.32	140±93.6	113.8±87.65	190±170.6	14.44**
Iron	0.7±1.87	10.7±8.32	12.6±13.6	7±7.65	14.2±10.6	10.30**
Vitamin A	3.26±2.96	118.94±98.85	115.97±104.7	111.92±98.86	201.6±109.87	17.38**
Thiamin	0.03±0.24	0.16±0.11	0.24±0.13	0.31±0.25	0.31±0.24	10.42**
Riboflavin	0.03±0.2	0.15±0.09	0.3±0.12	0.22±0.21	0.14±0.12	12.61**
Niacin	0.1±0.2	3.11±2.22	2.98±1.57	3.05±2.32	4.92±2.65	22.38**
Vitamin C	0.38±1.2	4.7±3.5	21.13±16.65	14.02±12.65	28.52±21.45	22.54**

**** Significant at p< 0.01, * Significant at p< 0.05, NS = Non significant. *** RDA for carbohydrate calculated assuming at least 60% of energy should come from carbohydrate. The Value are Mean ± SD; #RDA : Recommended Dietary allowances by ICMR 2010**

The mean intake of fat was more than 75% to 85% of RDA in the four experimental groups whereas in control group there was no change observed after intervention. After intervention calcium intake was less than 70% of recommended allowances in the entire four experimental groups. This may be due to less consumption of milk and milk products. Mostly girls consumed milk in tea only.

A significant improvement in the mean iron intake was observed with increase of 26-56 % in all the four experimental groups. The maximum improvement was observed in experimental group IV (95.56% in 13—15 years and 95.38% in 16-19 year of age girls), it was due to the combined effect of nutrition education and supplementation in this group. While in experimental group II it was 88.14% in 13-15 years and 85.77% in 16-19 year old girls respectively. β-carotene intake was also more than 75% of RDA in experimental group IV whereas in other groups it was 60-70%of RDA. It is fascinating to observe that the initial intake of vitamin C was below 50% of the RDA whereas after intervention program it was raised to 103-123%of RDA in experimental group II and IV. Mean vitamin C intake was increased by11-71 % in all the four experimental groups.

With regard to thiamine, riboflavin and niacin, before intervention the intake was less than 50% of RDA in control and experimental groups but after intervention the intake was as close as ICMR recommendation in the four experimental groups.

A significant increase in all the nutrients was observed (Table-4.40 and 4.41) in all the four experimental groups after intervention. This change was mainly due to the increased knowledge, regarding food groups and nutrients in experimental group III and IV and effect of IRFSM supplementation in experimental group I, II and IV. The differences of intake of nutrients before and after intervention program were found to be significant at one percent level of significance indicating the efficacy of the nutrition intervention package. Thus the daily supplementation of IRFSM was beneficial with respect to rise in hemoglobin level and maintaining adequate iron status of the anemia girls. These efforts improve the nutritional status of anemic adolescent girls.

Padmavati and Saradha (2015) also reported that the mean intake of food groups and nutrients of anemic adolescent girls (13-15 years and 16-17 years) were increased after health and nutrition intervention program. The‘t’ valued showed that the improvement of intake by both experimental group A and B was significant at 1% level.

Kaur et al., (2007) reported that the mean intake of energy, protein, fat and carbohydrates of anemic adolescent girls was increased to 59.5, 51.9, 13.23 and 52.2 per cent of the respective RDA after imparting nutrition education. Before imparting nutrition education the average daily intake for β-carotene, thiamine, folic acid, vitamin-B 12, vitamin C, iron and calcium was 31.59, 70, 85.6, 85, 201.25, 33.96 and 74.60 per cent of the RDA by the subjects respectively. However, after imparting nutrition education intake of respective nutrients increased to 65.65, 106, 104.6, 90, 225.15, 47.25 and 84.22 per cent of corresponding RDA.

4.9.4. The impact of nutrition intervention on growth of the subjects

The impact on growth with regards to gain in height for age, weight for age and body mass index of selected anemic adolescent girls. This section presents data related to height, weight and BMI of girls in various groups.

Height

Data on table-4.42 depicts that the mean increment in height was almost same in all the four intervened groups after intervention. The highest mean increment in height was 1.83 cm in EG IV but difference in mean height in all the groups was non significant ($p>0.05$). The mean height after the intervention ranged from 149cm to 152cm.

Weight

With regard to weight, overall the mean weight after the intervention ranged from 42.27kg to 44.52kg, with the mean increment in weight being about 1.06 to 2.18kg in all the four experimental groups compared to 0.91kg in control group (Table-4.43). Among all the experimental four groups, girls of EG II and EG IV had relatively better weight gain (2.12 kg and 2.18kg) than EG I and EGIII(1.17kg and 1.06kg).

Figure: 4.16 Mean height of the respondent before and after intervention

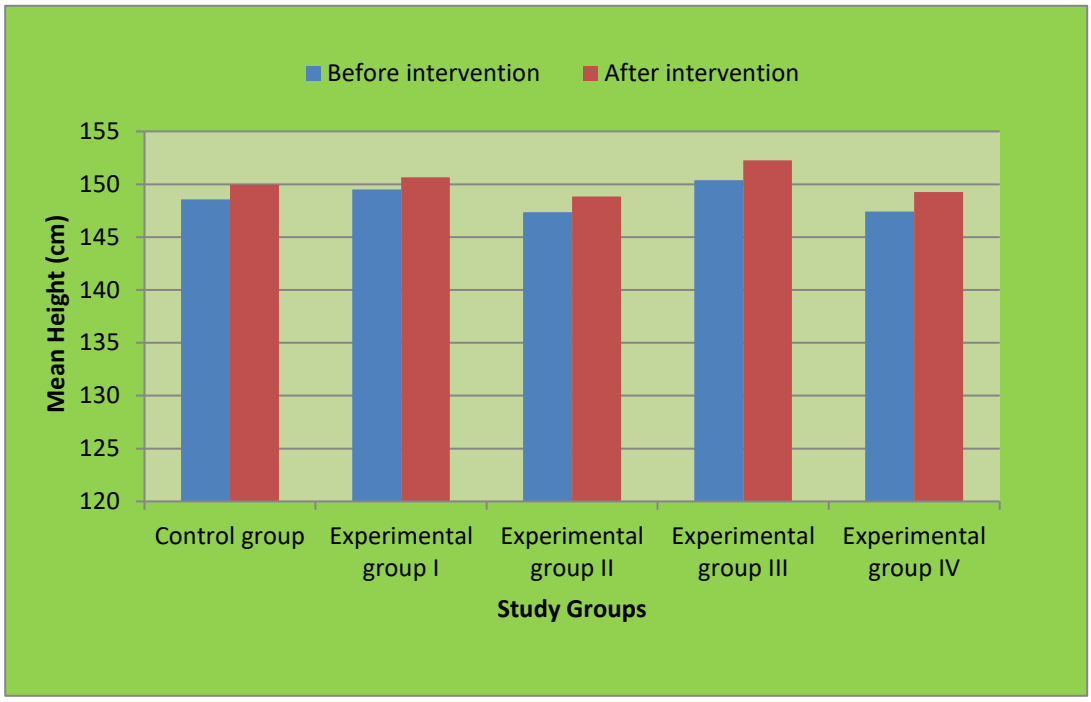


Figure: 4.17 Mean weight of the respondent before and after intervention

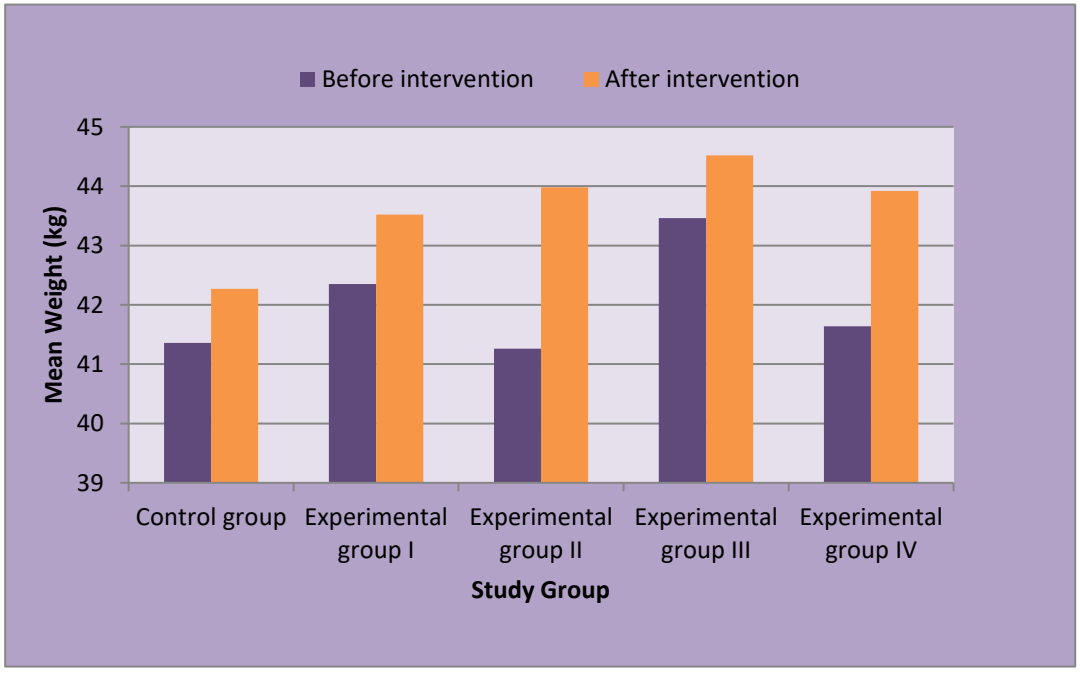


Table: 4.42 Change in mean height of the girls of different groups after intervention

Study group	Number of subjects	Mean Height		Mean difference±SD	t value	F value	CD5%	CD1%
		Before	After					
Control group	30	148.56±4.56	149.96±5.86	1.4±1.3	1.03ns	**1.389 ns**	0.78	1.04
Experimental group I	32	149.52±5.36	150.67±4.35	1.15±1.01	0.94ns	p=0.24	0.75	1
Experimental group II	31	147.36±4.82	148.85±6.34	1.49±1.52	1.04 ns	p>0.01	0.76	1.02
Experimental group III	35	150.37±3.67	152.27±5.78	1.9±2.11	1.64 ns		0.72	0.96
experimental group IV	30	147.43±5.9	149.26±4.67	1.83±1.23	1.33 ns		0.78	1.04

**** Significant at p< 0.01, * Significant at p< 0.05, ns = Non significant.**

Table: 4.43 Change in mean weight of the girls of different groups after intervention

Study group	Number of subjects	Mean Weight		Mean difference±SD	t value	F value	CD5%	CD1%
		Before	After					
Control group	30	41.36±3.45	42.27±4.85	0.91±1.4	0.8374 ns	**20.121****	0.53	0.7
Experimental group I	32	42.35±3.89	43.52±4.64	1.17±0.78	1.0889 ns		0.51	0.68
Experimental group II	31	41.26±5.64	43.98±4.44	2.72±1.2	2.108**		0.52	0.69
Experimental group III	35	43.46±4.34	44.52±3.65	1.06±0.69	1.1058 ns		0.49	0.65
experimental group IV	30	41.64±3.56	43.92±4.45	2.28±0.89	2.1914**		0.53	0.7

**** Significant at p< 0.01, * Significant at p< 0.05, ns = Non significant.**

Table: 4.44 Change in mean BMI of the girls of different groups after intervention

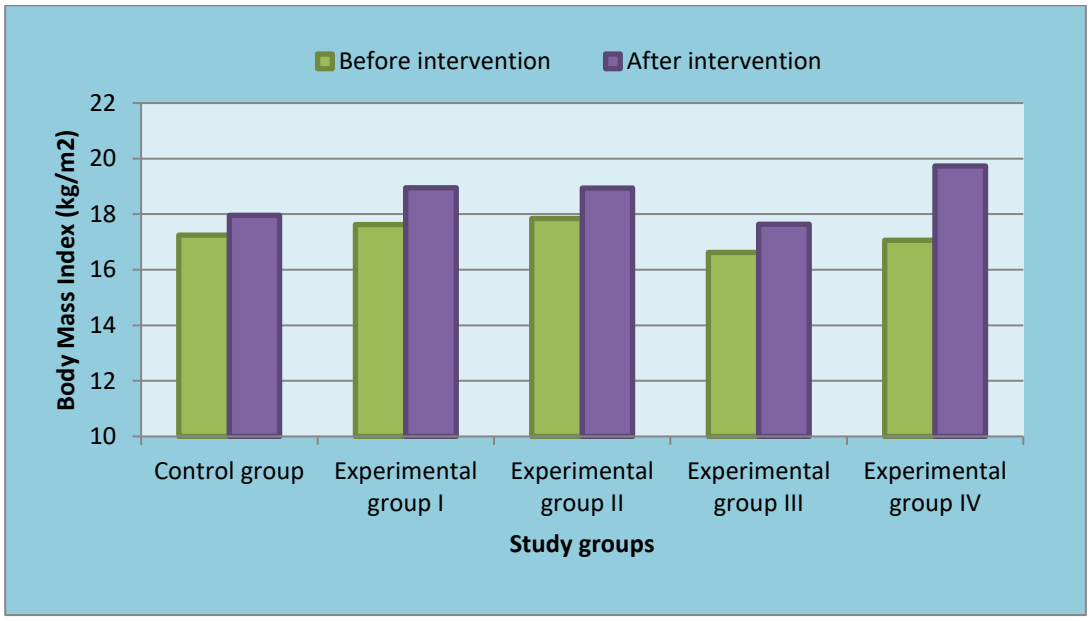
Study group	Number of subjects	Mean BMI		Mean difference±SD	t value	F value	CD5%	CD1%
		Before	After					
Control group	30	17.25±4.63	17.96±3.56	0.71±1.07	0.6658 ns	10.372**	0.67	0.9
Experimental group I	32	17.62±5.67	18.95±4.56	1.33±1.11	1.0340 ns		0.65	0.87
Experimental group II	31	17.85±3.45	18.94±5.63	1.09±2.18	0.9191 ns		0.66	0.88
Experimental group III	35	16.62±3.69	17.64±4.68	1.02±0.99	1.0125 ns		0.62	0.83
Experimental group IV	30	17.06±4.68	19.73±5.34	2.67±0.66	2.0596**		0.67	0.9

**** Significant at p< 0.01, * Significant at p< 0.05, ns = Non significant**

BMI

BMI is the recommended indicator for nutritional status in adolescents. The impact on growth in terms of BMI gain in the girls was measured after the intervention and all the groups were compared. Overall, in the mean BMI increment was from 16-17kg/m² before the intervention to 17-19kg/m² after intervention (Table-4.44). The mean increment in BMI was significantly higher ($p<0.05$) in experimental groups compared to control group. In the intervened groups, the girls in EG IV had relatively better BMI gain (1.97kg/m²) than other experimental groups.

Figure: 4.18 Mean BMI of the respondent before and after intervention



Sen and Kanani (2007) also reported that after nutrition intervention the mean height and weight gain among the supplemented girls (anemic adolescent girls) were significantly higher ($p<0.001$) compared to the non-supplemented counterparts (control group). With regards to BMI, all the supplemented group had significantly higher increment compared to the control group.

CHAPTER-5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The world's adolescent population is facing a series of serious nutritional challenges, which are not only affecting their growth and development but also their livelihood as adults. Yet, adolescents remain a largely neglected, difficult-to-measure and hard-to-reach population, in which the needs of adolescent girls in particular, are often ignored. This period is very crucial, since these are the formative years in the life of an individual, when major physical, psychological and behavioral changes take place. The nutritional and the health need of the adolescents are also more because of the growth spurt and the increase in the physical activity in them (Chatterjee, 2008).

Anemia is currently one of the most common and intractable nutritional problem globally. It is a global public health problem that affects both developing and developed countries with major consequence of for human health as well as social and economic development. WHO estimates the number of anemic people worldwide to be a staggering two billion with approximately 50% of all anemia attributable iron deficiency (Murray et al., 2000).

Many more adolescents are in fact suffering from iron deficiency with its adverse effects on health and physical stamina, than are frankly anemic. Iron deficiency and iron deficiency anemia (IDA) in adolescence is a major public health problem. Studies indicate than the incidence of anemia in adolescents tends to increase with age and corresponds with the highest acceleration of growth during adolescence. The highest prevalence is between the ages of 12-15 years when the requirement are at peak. More than 50% in this age group have been reported to be anemic. UNICEF/UNU/WHO/MI

Keeping in view, the importance of adolescent period in human life and nutritional problem of adolescent girls, the present investigation has been planned to assess the prevalence of anemia among adolescent girls who belong to rural community. To combat iron deficiency anemia among rural adolescent girls, nutrition education material and food products rich in iron using food-to-food fortification was developed. The study also attempted to assess the efficacy of nutrition education package and iron rich food supplement in affecting the hematological parameters and nutritional status of rural adolescent girls.

Objective of the Study

1. To assess the nutritional status of adolescent girls (10 -19 yr.)

2. To estimate the prevalence of anemia among adolescent girls.

3. To study the socio-economic factors associated with anemia among adolescent girls.

4. To assess the nutrition knowledge of adolescent girls.

5. To develop nutrition intervention package including development of iron rich food supplement powder and nutrition education package.

6. To assess the efficacy of the nutrition intervention package in improving the iron status of adolescent girls.

In order to fulfill these objectives the present study was carried out in three phases. In Phase I phase nutritional status of adolescent girls and prevalence of anemia was assessed using cross-sectional survey design. Multistage sampling method was used for sample selection. The nutritional assessment was conducted through anthropometric measurements such as height, weight and body mass index, clinical examination using a clinical schedule, dietary survey by 24 hour dietary recall method and biochemical analysis using standard procedures.

The socio economic features and nutrition knowledge were also assessed. Valid and reliable instrument were developed for assessing food and nutrient intake, nutrition knowledge and socio economic features.

In phase II nutrition intervention package was developed including development of iron rich food supplement powder and nutrition education package for adolescent girls to overcome the prevalence of anemia. Iron rich food supplement mix was developed using locally available iron rich foods and nutritional educational material was developed based on current food and nutrient intake, food selection and traditional practices (based on the finding of phase I of the study). IRFSM was formulated, standardized and acceptability of the best combination of mix was identified by sensory evaluation with the help of 10 panelists. The nutrient contents were analyzed to find out the nutritional composition of mix.

Phase III was focused to assess the impact of nutrition intervention program. Pre and post experimental design was used for the efficacy assessment of nutrition intervention package. Pre and post experimental design was used for the efficacy assessment of nutrition intervention package. Adolescent girls suffering from anemia but not requiring hospitalization were considered eligible for intervention. Iron rich food product was fed to the girls in addition to the ICDS food supplement so that in each group food supplement given by ICDS is common. The educational program for girls was in addition to the routine approach adopted in the Anganwadi's under the ICDS program. Five group of girls was studied viz. control group, the intervention supplementation group without vitamin-C source (Experimental group I), the intervention supplementation group with vitamin-C source (Experimental group II), the intervention nutrition education group (Experimental group III) and the intervention nutrition education cum supplementation group with vitamin C (Experimental group IV).

The results of the present study are presented under the following heads:

Phase I

General information and Socio-demographic characteristic of the adolescent girls

The findings related to general information of the subjects reveals that that majority of the subjects (42.86%) were on the age group of 14-16 years, 34.28 percent belonged to age group of 10-13 years. Rest of them (22.86 %) was in the age group of 17-19 years.

Majority of the subjects (78.57%) belonged to Hindu religion while 17.44 percent were Muslim. 36.43 percent of the subjects were from backward caste, while 24.29% and 16.20% belonged to SC and ST caste respectively. Most of the mothers of the subjects (49.39%) were illiterate. Only 21.41% were educated up to primary level and 6.60 percent were educated up to secondary level. In case of fathers, 25.85% had primary education and 18.36%, 11.6% and 75 had secondary education, higher education and graduation respectively. Majorities (57.86%) of families were nuclear and 42.14 percent were joint. 55.24% families had 5-8 members residing in the house hold, 27.38% had more than 8 members and 17.38% had up to 4 members. More than half (54.29%) of the subjects belonged to lower middle class, 16.19% belonged to middle class. Very few (3.09%) subjects were in upper middle class and none of the subjects were in upper class.

Nutritional status of the adolescent girls

Nutritional status is the state of our body as a result of the foods consumed and their use by the body. Nutritional status can be good, fair and poor. Nutritional status was measured by anthropometry i.e weight, height and BMI, dietary survey, clinical signs and symptoms, biochemical parameters i.e. blood hemoglobin level.

Anthropometric measurements of the subjects

The overall mean weight, height and BMI of the study population were 39.13±8.99 (SE 0.43, 95%CI 38.28-39.98), 147.03±7.18 (SE 0.35, 95%CI 146.34-147.72) and 16.83±6.73 (SE 0.32, 95%CI 16.18-17.47) respectively. The adolescent of the present study had lower mean height and weight. Anthropometric measurement and indicators found in the present study were compared with reference standards including WHO growth standards ((2007) and IAP growth standards (2015). On comparison of mean height of the girls in the present study with the reference standards it was observed that the girls had lower value of height and weight. The values of BMI for age were also lower in the present study as compared to WHO and IAP standards.

Prevalence of mal-nutrition (under nutrition and over nutrition)

The overall prevalence of underweight (low weight for age) was 29.52% with reference to IAP (2015). The overall prevalence of stunting was found 30.71 % as compared to height-for-age z scores (HAZ scores)(WHO, 2006). Similarly 32.38 % of the adolescent girls were found too thin as describe by WHO (2006) criteria(BMI for age Z scores).

Dietary and nutrient intake of the subjects

Thus, the mean intake of various food groups and nutrient intake of the subjects were calculated over a period of three consecutive days. Mean nutrient intake of adolescent girls was calculated by using Food Composition Tables (Gopalan et al., 1989). Mean nutrient intake of was compared with recommended dietary allowances (RDA) (ICMR,2010).

Intake of various food groups

The nutritional status of any individual is directly affected by food intake. Men need a wide range of nutrient to lead a healthy and active life and these are derived through the diet that person consumed daily.

The mean intake of cereals among the subject was found to be 152.68±101.5g/day,168.02±98.24g/day and 166.72±112.8g/day in 10-12 year, 13-15 year an 16-19 year of age group respectively. It was 63.62%, 50.92% and 50.52% of the balanced diet suggested by RDI (2011). The mean intake of pulses was 44.38%, 47.33% and 51.41% of the RDI, which is a lower consumption of pulses than recommended. Mean intake of green leafy vegetables among subject was found to be lower. This may be attributed to low preference for green leafy vegetables by study subjects. The mean intake of roots and tuber was deficient by 31.44%, 34.58% and 54.23% of recommended intake for the respective age group . Among fruits apple, banana, grapes and mango were commonly consumed by the subjects. The mean intake was deficient by 79.44%, 77.36% and 79.28% of RDI among all the group of adolescent girls. All the subjects consumed milk and its products in the form of butter milk, curd, ghee etc. Mostly was consumed milk in tea preparation. Intake of fat was almost 50-60% in comparison with the suggested quantity. Mean intake of sugar and jiggery was found to be 66.07%, 74.68% and 79.28% of balanced diet.

Nutrient intake by the subjects

The mean intake of energy among 10-12 year of age was 1205±236.52 kcal/day, 13-15 year of age was1355.5±242.60 kcal/day and 16-19 year of age was1426.5 ±383.77 kcal/day respectively. The mean intake of protein was 60.89%, 63.05% and 54.95% of RDA (ICMR, 2010) in the age group of 10-12 years, 13-15 years and 16-19 years respectively. Majority of subject had protein intake less than 65%.

Fat intake was deficient by 44.19%, 46.25% and 42.86% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively. Intake of calcium was less; it may be due to low inclusion of calcium rich food in daily diet and majority (75%) of subject included tea in morning. Intake of iron was deficient by 60%, 57.03% and 55.77% of RDA in the age group of 10-12 years, 13-15 years and 16-19 years respectively. The mean intake of ascorbic acid, beta carotene, thiamine, riboflavin and niacin in all the age group were lower than the recommended value.

Frequency of consumption of iron and vitamin-C rich food

All the subjects consumed wheat flour daily in the form of chapatti and bati (traditional recipe of Rajasthan) but the consumption of whole wheat was very low among the subjects. Pulses consumption was seen in majority as bi weekly (28.57%) and once a week (21.9%) while 20.48% consumed daily. Majority of the girls did not consume green leafy vegetables regularly. The overall consumption of green leafy vegetables was only 9.29% as daily basis and 10.24% on alternate days where another 21.19% and 22.86% subjects consumed as biweekly and once a week respectively. Daily fruits consumption was reported by only 17.38% subject and 18.10% subjects reported consumption on alternate days. Consumption of non-vegetarian food was reported by only 16% subjects and they were not consumed regularly. Overall the adolescent girls did not frequently consume iron and vitamin-C rich foods and those that did consumed it in inadequate amount.

Clinical signs and symptoms of anemia

According to clinical signs of anemia 43.33% of subjects had pallor skin, followed by 24.52% had pallor tongue. One third of the subjects had bleeding gums followed by 22.86% subjects had angular stomatitis. Conjunctiva pallor was the most common ocular manifestation of anemia seen in 23.33% subjects. Only very small numbers of subjects (5%) had spoon shaped and 7.86% had brittle nails. Oedema on leg was present in 15.95% subjects.

Clinical symptoms of anemia in adolescent girls reveals that more than half of the subjects reported weakness always while 35.95% subjects felt weakness sometimes. Fatigue was reported by nearly half of the subjects followed by lethargy (58%) and fainting episodes (16%). Lack of concentration was reported by 49.95% subjects always and by 29.05% sometimes. More than one-fourth of the subjects reported symptom of breathlessness always whereas 30% reported sometimes. Headache and body ache were the common symptoms present mostly in girls. Coldness of hands and feet were present in 22%always whereas another 19.56% felt it sometimes.

Menstruation history

Out of 420 adolescent girls 314 had attained menarche. The mean age of menarche was 13.4±1.2 years with 10 and 17 years being the lowest and highest age of menarche respectively. Most of them (66.24%) had regular menstrual cycle and 33.76% had irregular cycle. The most common menstrual pattern found among girls was >30daysfollowed by 28-30 days. Most of them (74.8%) had 3-5 days duration of flow and16.2 % had 5-7 days. Irregular menstruation means cycle less than 20 days (Polymenorrhea) was found in10 % girls and cycle greater than 40 days (Oligomenorrhea) was found in23.90 %. Oligomenorrhea was the most frequently reported problem (23.90%) and polymenorrhea was much less prevalent (10%).

Prevalence of anemia

Among 420 rural adolescent girls 334 were found to be anemic with prevalence of 79.52% and remaining 86 (20.48%) were non anemic. In the present study, the mean hemoglobin level among adolescent girls was 11.15+1.07g/dl and the range varies from 6.8-13.6 g/dl. The prevalence of mild, moderate and severe anemia among total participated (420) adolescent girls was 44.29%, 29.52% and 5.71 % respectively.

Socio-demographic correlates of nutritional anemia in study subjects

Various socio-demographic factors viz: caste, education of mother, family type and family size, parents occupation, diet and socio-economic status, which were found to be significantly associated with anemia in adolescent girls.

Nutrition Knowledge of Adolescent Girls related to Anemia

To know the overall knowledge of respondents their knowledge categories were made i.e. low, medium and high on the basis of the score obtained by respondent in the knowledge test. Majority (80%) of the adolescent girls had low level of knowledge and very few (14.76%) had medium knowledge. None of them exhibited good knowledge about nutrition. Nutrition knowledge was low in rural adolescent girls in pre-test, due to lack of knowledge regarding the importance of nutrition

especially during this period of life. They are unaware about the health problems of this age group and their consequences.

Phase II Development of nutrition intervention package including iron rich food supplement mix and nutrition education package

Development of Iron Rich Food Supplement Mix (IRFSM)

Iron rich food Rice flakes, Lotus stem (Nelumbo nucifera), Cauliflower leaves (Brassica Oleracea) and Garden cress seeds (Lepidium sativum) were selected for the preparation of IRFSM

Flours (rice flakes, lotus stem, cauliflower leaves and garden cress seeds) were mixed in different ratio for the development of IRFSM. Different proportions of iron rich food powder used for the preparation of IRFSM.

Standardization of Iron Rich Food Mix (IRFSM)

IRFSM standardization was done by preparing food products and for selecting the best acceptable ratio nine point hedonic scale was used. Sensory evaluation of three common products viz. chapatti, mathri and biscuits was done which were prepared using various proportion of IRFSM and wheat flour.

Chapatti is Indian unleavened flat bread which accounts for the cereals group in a balanced diet. Chapatti was prepared from wheat flour (80%) and different ratio of rice flakes, lotus stem, and cauliflower leaves and garden cress seeds (20%). The score assigned by the panel members for individual sensory attributes of chapatti were found as follows, values in the range of 8.00 to 8.33 for control (100% wheat flour) and 6.96 to 8.30 for IRFSM flour (T1-T5) chapatis. The nutritional value of T3 ratio was higher as compare to T1 and T2 and ratio of T3 was in acceptable range. Hence, IRFSM with ratio (T3) of rice flakes, lotus stem, cauliflower leaves and garden cress seeds (50:30:10:10) were selected for further study of quality evaluation and storage of IRFSM, as it increases nutritional aspect especially iron and fibre content of chapatti as compared to control.

In the present study Biscuits were prepared from various proportions of IRFSM (10%, 20%, 30%, 40% and 50%) and wheat flour (T1-T5) and served along with a control prepared from refined wheat flour. Mathri was prepared with incorporation of various percent of IRFSM (10%, 20%, 30%, 40% and 50%) and wheat flour (T1-T5) and served along with a control prepared from refined wheat flour. The iron content of T3 biscuits was higher as compare to T1 and T2, hence 30% IRFSM incorporated biscuits were selected for intervention.

In present study mathri was prepared with incorporation of various percent of IRFSM (10%, 20%, 30%, 40% and 50%) and wheat flour (T1-T5) and served along with a control prepared from refined wheat flour. The results revealed that all the treatment (T1-T5)were not liked extremely as compared to control, yet treatment (T1-T3) were in acceptable range but T4 and T5 were not liked by the panel members.

Quality assessment of the developed IRFSM

Flour quality may be defined as the ability of the flour to produce an attractive end product at competitive cost under conditions imposed by the end product manufacturing unit. The concept of quality may refer to fitness of a raw material or a product for a particular process or for consumer (Kharker, 2013). The quality of developed IRFSM was assessed in the following terms:

Nutrient compositions:

The nutritional composition provides basic information about the components and quality of the products. Hence, proximate and mineral content IRFSM was analyzed. The energy value of IRFSM was 323.97kcal. Moisture, ash, crude fiber, protein, carbohydrate and fat content of IRFSM was 9.54g, 8.63g, 8.86g, 10.11g, 62.23g and 3.37g/100g respectively. The iron and calcium content of IRFSM was 43.45mg and 236.5mg/100g.

Keeping quality assessment of the developed IRFSM

Sensory quality

The overall acceptability of a product is a composite effect of different sensory attributes viz, color, appearance, taste, flavor and texture. The sensory quality of the stored IRFSM was assessed in the form of Chapati. It was subjected to sensory analysis by a selected group of panelist for their individual sensory attributes. The sensory scores assigned by the panel members during storage of the product were statistically analyzed using analysis of variance

Microbial load

During the entire storage period, the enumerated values of TVC and yeast and molds count i.e. 0 to 5200 cfu/g and 0 to 122 cfu/g, respectively were found, which are much lower than the wheat flour specification given by Kenya standard, (2009) of maximum permissible level of TVC (10^5 per gram) and Y& M count (10^4 per gram).

Moisture

Moisture being one of the important determinants of shelf life of dried product was mentioned at regular intervals during storage period of three months. The mean value of moisture content from the three replicates of the flour stored in HDPE bags in ordinary heat sealing were 9.98% at 30 day, 10.82% at 60 day and 11.7% at 90 day. The moisture content was significant increase ($P<0.05$) at 2^{nd} and 3^{rd} month of storage period.

Insect infestation

Detection of insect infestation is an important quality parameter of the flour in the present investigation, there was no infestation observed in the flour by visual perception and sieving method performed at monthly interval during the entire storage period.

Cost analysis of IRFSM

The total cost in the preparation of IRFSM was rupee5.20/100g. It is evident that the IRFSM are far more economical, affordable and can be easily prepared at home compared to commercial Iron rich health supplements.

Phase III Efficacy assessment of nutrition intervention package in improving the iron status of adolescent girl

Impact of nutrition education on the nutrition knowledge of the subjects

After imparting nutrition education, the knowledge scores increased in all four experimental groups while in control group there was no increase in scores. Nutrition education was given to experimental group III and IV. In experimental group I and II more than 50% adolescent girls gained medium scores with MPS 57.49% and 54.04% respectively while in experimental groups III and IV, 62.86% and 53.12 % girls had medium scores and 37.14% and 46.87% gained high nutrition knowledge scores. The MPS was highest (80.67%) in experimental group IV and lowest in control group. Gain in knowledge scores was 27.91%, 23.73%, 40.78% and 51.2% in experimental group I, II, III and IV respectively. Increase in nutrition knowledge scores after imparting nutrition education was found significantly ($P<0.05$) higher in experimental group III and IV. ANOVA values depict a significance difference between experimental groups and control group. Gain in nutrition knowledge reflects that adolescent girls are potential learners and crucial asset for nation building.

The impact of nutrition intervention package on hemoglobin status of the subjects

After intervention the mean Hb increment among all the four experimental groups was significantly higher ($p<0.001$) than control group. Experimental group IV showed highest increment (1.52g/dl) followed by experimental group II (1.14g/dl) when IRFSM biscuits and lemon/amla were supplemented daily. Further, though the gain was relatively less, even though anemic girls, who were supplemented only

IRFSM biscuits without vitamin C (EG I), gained about 0.86 g/dl of Hb and those anemic girls who were intervened through only nutrition education (EG III), gained about 0.43 g/dl of Hb. Though EG I and III were significantly better in Hb gain than control group, the gain was not as high as EG II and IV. No significant change was recorded in Hb level of control group ($p>0.05$). ANOVA points out to a significant difference in the mean Hemoglobin of all five groups.

Impact of nutrition intervention on the nutrient intake of the subjects

A significant increase in all the nutrients was observed in all the four experimental groups after intervention. This change was mainly due to the increased knowledge, regarding food groups and nutrients in experimental group III and IV and effect of IRFSM supplementation in experimental group I, II and IV. The differences of intake of nutrients before and after intervention program were found to be significant at one percent level of significance indicating the efficacy of the nutrition intervention package. Thus the daily supplementation of IRFSM was beneficial with respect to rise in hemoglobin level and maintaining adequate iron status of the anemia girls. These efforts improve the nutritional status of anemic adolescent girls.

The impact on growth of the subjects

The mean increment in height was almost same in all the four intervened groups after intervention. The mean increment in weight after intervention was about 1.06 to 2.18kg in all the four experimental groups compared to 0.91kg in control group. The mean increment in BMI was significantly higher ($p<0.05$) in experimental groups compared to control group. In the intervened groups, the girls in EG IV had relatively better BMI gain (1.97kg/m^2) than other experimental groups.

Conclusion

The high prevalence of mild and moderate anemia demands due emphasis on food based approaches, iron and folic acid supplementation and the health education on the consumption of iron rich food, so as to bring down the total prevalence of anemia among the adolescent girls. Health and nutrition education along with good quality iron rich nutritious food and anti-anemic drugs can prevent the prevalence of anemia. Nutrition education and supplementation of indigenous food like green leafy vegetables, lotus stem, gingely seeds, roasted Bengal gram, jeggary, rice flakes and puffed rice, Garden cress seeds helps in prevention of anemia. Supplementations of locally available foods helps reduce the prevalence of anemia at lower cost and useful to the community for combating anemia. It is also necessary to educate the adolescent girls on the importance of family spacing, literacy, small family norms and the prevention of childhood marriages.

Even though various national programs exist in our country since decades, problems of anemia in adolescent girls still persists. A number of strategies are available for dietary modifications based either on promoting the intake of iron, absorption enhancers, including heam iron or on reducing the ingestion of absorption inhibitors (such as phytates and tannins) to double the bioavailability of iron. A significant association of anemia with the low socio-economic status suggested a need to develop strategies to improve the socio-economic status of the population through poverty alleviation programs. This should be supported by programs for the prevention of anemia among adolescent girls through nutrition education and prophylaxis with iron and folic acid supplementation with deworming.

The intervention program helped the adolescent girls to understand the need for healthy balanced diet to promote health which in turn made them to practice a wise dietary pattern and promoted nutritional contribution thus all the nutrients are significantly increased at one percent level to live a healthy life among the anemic adolescent girls in the age group of 13-18 years.

Interventions to prevent and correct iron deficiency anemia must include measures to increase iron intake through food-based approaches, namely dietary diversification and food fortification with iron; iron supplementation and by improved health services and sanitation. In countries where anemia prevalence exceeds 40% in pregnant women, universal iron supplements for adolescent girls (particularly those aged 12 to 16 years) and women of childbearing age is necessary. Adherence to the daily regime, however, is frequently poor. In view of this, weekly administration of iron-folic acid supplementation (WIFS) has been successfully tried as a public health approach in several countries.

We conclude that adolescent girls have tendency to consume junk food and not enough food rich in iron sources. Growth spurt and menarche increase iron requirements with poor diet and no added iron supplementation puts them into the high risk category for iron deficiencies. Thus increasing awareness and knowledge among adolescent girls will improve anemia in long run and potential of applying these experience (present study) through anganwadies, schools, colleges and other organizations reaching adolescent girls provides an existing and feasible opportunity. Hence nutrition education and supplementation should be a part of education system to improve iron status of adolescent, so that after marriage they can enter pregnancy with no serious iron deficiency handicaps. This will be decreased the poorly nourished mothers in future, who are more likely to give to low birth- weight babies, perpetuating a cycle of health problems which pass from one generation to another.

Implication of the study

It is evident from the study that majority of the adolescent girls parents were illiterate or educated up to primary and secondary level, hence they require special training on diet and nutrition and care of common diseases

Health and nutritional status of the adolescent girls was not found to be satisfactory in relation to anthropometric indices i.e. height, weight and BMI and biochemical parameter (Hemoglobin). These facts pertains that the parents of the girls are careless they did not coup up with the anemic condition poor awareness and poor health and nutrition knowledge. Hence, government should extend medical facilities at the door of the people of the rural areas.

The parents of the adolescent girls of the study area should be inform about the importance of follow healthy dietary habits which could improve the nutritional status in parallel with overcoming the devastating economic conditions.

Morbidity pattern showed greater prevalence of cold and cough, fever, headache and seasonal infection etc, were found among the adolescent girls of rural area. These results indicate the urgent need to deliver basic health and nutrition services to enormous number of vulnerable and largely inaccessible girls. Such responsibility could be given to several non government organizations (NGOs) those who were working in remote areas.

The prevalence of anemia was significantly higher in girls. This facts demands urgent attention of the parents and medical services provided as it will affect badly when she become pregnant. Therefore, the mother of the girls and the girls herself should be trained in respect of balance diet to combat iron deficiency.

People should be acknowledged about low cost and highly nutritious food items to ensure balance diet through nutrition education. Mass media can play a vital role to educate the people in these respects.

The nutrients intake was lower than the RDA in adolescent girls indicates that the required daily intake of protein and iron are low. The government schemes should be implemented properly to needy people i.e. adolescent girls.

In addition, series of workshops, demonstration of nutrient rich recipes, seminars and lectures of eminent workers and scientists on nutrition as awareness may be organized for parents, teachers, students and health workers

Recommendations

The present study was confined to rural area of Bhilwara district of Rajasthan state. A similar study could be replicated in other part of the state for the better health improvement of adolescent girls

The study concentrated on the nutritional status, anemia prevalence, dietary pattern, nutrient intake of rural adolescent girls. Future studies can be implemented to investigate the correlation and impact of socio-economic factors on health and nutritional status of adolescent girls

The variable other than those included in the present investigation might be influencing on nutritional status of adolescent girls. Such variables could be included in future research study.

During the course of the study, it was felt that health check up programs needs more efforts to disseminate the knowledge of nutrition, care of common diseases, low cost food items. A training module can be developed to fulfill the educational needs of girls.

Adolescent girls should be encourage to develop a good regimen of personal health and hygiene to prevent diseases, build up health reserves and help maintain a fit and

decent appearance. Such a regimen should include personal cleanliness, dental and gum care, cleanliness of dress and surrounding, getting sufficient hours of sleep, recreation and exercising and routine medical care and immunization. These are the body's rights, which must be respected by all people so as to protect health and maintain strength.

Adolescent girls may feel shy and embarrassed to discuss aspects of menstruation like dysmenorrhoea consequently leading to ill health. It was suggested that a strong need exists for strong health educational activities among the adolescent girls for effective management of menstrual problems.

Education regarding reproductive health and hygiene should be included as a part of school curriculum. Better hygienic practices can be adopted by making sanitary pads available at affordable prices.

Extensive and persuasive efforts are required to bring behavioral changes in the community for people to adopt dietary diversification. Ultimately, the only sustainable solution to IDA is to help the communities to consume regularly foods that are rich in iron, to encourage intake of promoters of iron absorption such as vitamin C and to discourage high consumption of inhibitory factors.

In order to further solidify the scientific basis for implementing large scale food-based programs to reduce IDA in India, the following area of research are needed:

Long term effects of the addition of food source containing 50 mg and 100mg of ascorbic acid to the existing meals and of meals providing 12-15mg of iron towards improving bioavailability of iron and the iron status in the anemic adolescent girls.

Determination of quantities of inhibitory and enhancing factors present in individual diets as consumed by the different socio-economic groups in anemic and non-anemic population, and their iron status

Determination of the total and bio-available iron in the existing meal of anemic and non anemic population.

Determinant of bio-available iron in the diet of anemic and non- anemic women in relation to menstrual loss, infection and infestation such as hookworm and malaria.

Study the availability of iron from fortified foods coming from the market

Genetically modified (GM) foods use biotechnological techniques to increase the micro nutrients content of food by genetic manipulation. Food such as carotene-rich canola oil and vitamin A rich golden rice are being produced in some countries. A similar strategy would help to increase production of iron rich food in the countries where per capita availability iron rich foods is very low. Multi-sectoral and integrated approach will be required to eliminate anemia in the poorer communities. The cooperation of the sectors of health, education, agriculture and industry is essential

CHAPTER 6

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ANNEXURES

Annexure I

Interview Schedule

Section: A General information

Name: Address:

Father's name:

Mother's name:

Date of birth: Village:

Age: Anganwadi Name:

Class:

School dropout: Yes/No

Marital status: Married / Unmarried/ Widow /Divorced

Religion: Hindu / Muslim / Christian/ Other

Section: B Socio Economic Background (Modified Pareek and Trivedi scale)

Caste

Caste	Score	
Schedule caste	1	
Schedule Tribe	2	
OBC	3	
General	4	
Total score =		

Occupation

Occupation	Score	Father	Mother
Labour	1		
Caste occupation	2		
Business	3		
Independent profession	4		
Cultivation	5		
Service	6		
Total score			

Education

S.No.	Family member(include respondent)	1	2	3	4	5	6	7
	Illiterate	0						
	Can read only	1						
	Can read and write	2						
	Primary	3						
	Middle	4						
	High school	5						
	Graduate	6						
Average score								

Social participation

Organizational Membership	Score	
No Membership	0	
Member of one organization	1	
Member of more than one organization	2	
Office holder	3	
Wider public leader	6	
Total score		

Land holding

Land	Score	
No Land	0	
<1 acre	1	
1- 5 acres	2	
5- 10 acres	3	
10-15 acres	4	
15—20 acres	5	
>20 acres	6	

House

Housing	Score	
No Home	0	
Hut	1	
Kaccha house	2	
Mixed house (Partially Kaccha +Pucca)	3	
Pucca house	4	
Mansion	5	

Farm power

Livestock	Score	
No draught animal	1	
1-2 draught animal	2	
3-4 draught animal	4	
5-6 draught animal	6	

Material Possession

Material Possession	Score	
Bullock-cart	1	
Cycle	1	
Chairs	2	
Radio	2	
Mobile phone	4	
Television	5	
Refrigerators	6	
Total score		

Family structure

Family type	Score	
Nuclear	1	
Joint	2	
Family size		
Small (upto 4 members)	1	
Medium (5to7 members)	2	
Large (more than 8 members)	3	
Total no. of siblings		
Total score		

Section-C Assessment of Nutritional Status

1. Anthropometric measurements

Height _____ cm

Weight _____ Kg

BMI _____ Kg/(m)²

2. Clinical Examination

Clinical signs of Anemia

Eye	Normal/ Watery/Dry/Pale conjunctiva
Lip	Normal/Angular stomatitis
Tongue	Normal/Pale/Red
Skin	Normal/Pale/Dry and rough
Gum	Normal/Bleeding
Nails	Normal / Brittle nails / Koilonychia
Leg	Normal / Oedema

Clinical symptoms of Anemia

Feels Weakness	a)Always b)Sometimes c)Rarely d)Never
Feels Fatigue	a)Always b)Sometimes c)Rarely d)Never
Feels Dizziness	a)Always b)Sometimes c)Rarely d)Never
Feels like Fainting	a)Always b)Sometimes c)Rarely d)Never
Feels Lethargic	a)Always b)Sometimes c)Rarely d)Never
Feels Breathlessness	a)Always b)Sometimes c)Rarely d)Never
Lack of concentration	a)Always b)Sometimes c)Rarely d)Never
Headache	a)Always b)Sometimes c)Rarely d)Never
Body ache	a)Always b)Sometimes c)Rarely d)Never
Leg Pain	a) Always b) Sometimes c) Rarely d) Never

3. Biochemical Examination

Hemoglobin …….. g/dl

4. Dietary survey Performa for 3 days 24- hour dietary recall method

Meal Time	Menu	Ingredients	Raw amount (g/ml)	Total cooked quantity (g/ml)	Consumption of food by subject (g/ml)	Intake of raw ingredients (g/ml)
Breakfast						
Lunch						
Evening Tea						
Dinner						
Late Night						

Performa of food frequency for iron and vitamin-C rich foods

Food item	Daily	Alternately	Twice a week	Once a week	Every 15^{th} day	Once a month	Rarely	Never
Cereals:								
Wheat Flour								
Whole Wheat								
Rice								
Rice flakes								
Puffed rice								
Bajra								
Pulses and Legumes								
Black gram								
Greengram								
Bengalgram								

Roasted Bengalgram								
Lentil								
Rajmha								
Red gram								
Soya been								
Horse gram								
Cowpea								
Moth been								
Sprouts of Pulses								
Green Leafy Vegetable								
Coriander Leaves								
Fenugreek Leaves								
Colocasia Leaves								
Radish Leaves								
Amaranth Leaves								
Mint Leaves								
Spinach								
Mustard Leaves								
Cauliflower leaves								
Bengal gram Leaves								
Cabbage								
Onion Stalk								
Other Vegetables								
Cucumber								
Drumstick								
Kanroda								
Lotus stem								
Cluster beans								
Roots and Tubers								
Beet root								
Carrot								
Fruits								

Guava								
Amla								
Zizyphus								
Lemon								
Orange								
Papaya								
Tomato								
Dates								
Ripe Mango								
Watermelon								
Pomegranate								
Sapota								
Custard Apple								
strawbarry								
Oil seeds								
Garden cress seeds								
Niger seeds								
Sesame seeds								
Dryfruits								
Tender Coconut								
Dry Coconut								
Cashew nut								
Pistachio								
Almond								
Roasted Groundnut								
Rasine								
Water melon seeds								
Jaggery								
Jaggery								
Honey								
Non-vegetarian								
Egg								
Meat								
Fish								

Section –D

Menstrual History

Age of menarche

Menarcheal status Premenarcheal/ postmenarcheal

Is your menstrual cycle Regular/Irregular

Duration of Blood flow 2-3 days/3-4 days/4-5 days/>5 days

Duration of menstrual cycle <28 days/28 days/>28 days

Are you having Dysmenorrhoea Yes/No

Do you avoid some foods during these days Yes/No

If yes specify Pickles/Curd/Lassi/Other

Do you have any type of illness during menstruation:

Irritation/Headache/chest pain/Abdominal blotting/Abdominal pain/constipation/back ache/ Tightness of chest

Section E

Morbidity Profile

Morbidity	Yes	No
Malaria		
Fever		
Diarrhoea		
Constipation		
Cold/cough		
Headache		
Vomiting		
Stomach ache		

Annexure II

Nutrition knowledge questionnaire

1. Knowledge regarding Food group and nutrients

1. Which nutrient present in food?

a) Carbohydrate b) Protein c) Vitamin and minerals d) All of above e) Don't know

2. Cereals and pulses are good source of which nutrient?

a) Calories and Protein b) Vitamin C c) Fat d) Minerals e) Don't know

3. Vegetable and fruits are good source of which nutrient?

a) Calories b) Protein c) Fat d) Vitamin and minerals e) Don't know

4. Sugar and jaggery are good source of which nutrient?

a) Calories b) Protein c) Fat d) Vitamins and minerals e) Don't know

5. Milk and milk products are good source of which nutrient?

a) Calories b) Protein and calcium c) Vitamin d) Iron e) Don't know

6. Oil seeds are good source of which nutrient?

a) Vitamin b) Protein c) Fat d) Minerals e) Don't know

7. Which group of food provide energy to our body?

a) Cereals, ghee/oil, sugar b) Milk, egg, meat c) Vegetable and fruits d) Pulses

e) Don't know

8. Which group of food provide protein to our body?

a) Cereals, ghee/oil, sugar b) Milk, egg, meat and pulses c) Vegetable and fruits

d) Biscuits and chocolates e) Don't know

9. Primary function of protein in our body?

a) Provide energy b) Body building and tissue repairing c) Protection from disease d) All of above e) Don't know

10. Function of vitamin and minerals in our body?

a) Provide energy b) Body building and tissue repairing c) Protection from disease and regulatory function d) All of above e) Don't know

2. Knowledge regarding iron rich food and their functions in our body

1. Which nutrient helps in blood formation in our body?

a) Carbohydrate b) Fat c) Iron d) Vitamin A e) Don't know

2. What is the colour given by dietary iron to blood?

a) Red b) Pale c) yellow d) white e) Don't know

3. Which of the following food groups, when eaten, will help to make blood in the body?

a) Milk, curd, cheese b) Fruits and vegetables c) Cereals ,potato, fats and oil

d) Green leafy vegetable, pulses, flesh food and jaggery e) Don't know

4. Which are iron rich foods?

a) Milk, curd, cheese b) Fruits and vegetables c)Cereals ,fats and oil

d) Green leafy vegetable, pulses, flesh food, jaggery e)Don't know

5. Lack of iron in the body causes which of the following disease?

a) Hepatitis b) Diarrhoea c) Fever d) Anemia e) Don't know

3. Knowledge regarding foods favouring iron absorption and inhibition

1. Foods that taste acidic contain one of the following nutrient?

a) Carbohydrate b) Protein c) Iron d) Vitamin C e) Don't know

2. Which of the following food groups provide maximum amount of vitamin C?

a) Milk, curd, paneer b) Rice, sugar, fats/oil c) Amla, orange, lemon, gvava

d) Pulses, flesh food e) Don't know

3. Is there any harmful effect caused by excess drinking of tea and coffee? Yes / No

4. Which food inhibits absorption of iron in body?

a)Tea/ Coffee b) Sugar/ jaggery c) Orange/ Lemon d) Ghee/oil e) Don't know

5. Intake of which of the following food groups prevent the formation of blood?

a)Tea/ coffee b) Sugar, jaggery, sugar syrup c) Orange, lemon , sprouted pulses

d) Fats and oils, butter e) Don't know

6. Antinutritional factors which inhibit the absorption of iron?

a) Phytate b) Tannin c) Caffine d) All of above e) Don't know

7. Do you have habit of eating of non- nutritional substances like?

a) Roasted soil /clay b) Chalk c) Ice d) Plaster chips e) Don't know

4. Knowledge about functions of Hemoglobin and cut off values

1 .What is the function of blood in our body?

a) Carrying Oxygen and nutrients to each cell of our body b) Fight against diseases
c) Remove toxic substance from the body d) All of above e) Don't Know

2. What is Hemoglobin?

a) Iron containing pigment b) Enzyme c) Hormone d) All of above e) Don't know

3. What is the function of Hemoglobin ?

a) Give red colour to RBC b) Carry oxygen in blood c) Associate and disassociate with oxygen and carbon di-oxide d) All of above e) Don't know

4. What is the normal Hemoglobin level for adolescent girls?

a)12-15 g/dl b)8 – 10 g/dl c)13- 16 g/dl d)All of above e)Don't know

5. Knowledge about causes, signs /symptoms and prevention of anemia

1. Deficiency of which nutrient causes anemia?

a) Carbohydrate b) Protein c) Fat d) Iron e) Don't know

2. What are the causes of anemia?

a) Iron deficient diet b) Poor absorption of iron in body c) Loss of blood

d) All of above e) Don't know

3. Is there any relation between anemia and excess drinking of tea and coffee? Yes / No

4. Which of the following is the sign of anemia?

a) Diarrheoa b) Blindness c) Obesity d) Pallor of skin and conjunctiva

e) Don't know

5. Which of the following is the symptom of anemia?

a) Fatigue / breathlessness b) Lack of concentration c) Poor working capacity

d) All of above e) Don't know

6. Is there any relation between menstrual bleeding and anemia? Yes / No

7. Is unhygienic practice is responsible for anemia? Yes/ No

8. Should we wash hand before/after using toilet?

a) Always b) Sometimes c) Rarely d) Never e) Don't know

9. Worms can cause which of the following illness?

a) Vomiting b) Hepatitis c) Fever d) Anemia e) Don't know

6. Knowledge regarding role of agencies /institution to control anemia

1 .Do you get information related to health and nutrition? Yes/ No

2. From where do you get information?

a) Print media b) Electronic media c) Personal and group interaction

d) All the above e) Don't know

3. Do you have any knowledge of ICDS and anganwadi? Yes /No

4. What are the functions of lady supervisor and anganwadi worker?

a) To give knowledge of health b) To give knowledge of personal hygiene

c) To give knowledge of nutrition d) All the above e) Don't know

5. Do you have knowledge of iron folic acid weekly supplementation (IFWS) program?

Yes/ No

6. What is the distribution pattern of Iron folic acid (IFA) tablets?

a) Daily b) Alternates days c) Twice a week d) Once a week e) Don't know

7. Do you take IFA tablets? Yes / No

8. How many time do you take IFA tablets in a month?

a) Daily b) Alternates days c) Twice a week d) Once a week e) Don't know

9. Do you take Albenzadole tablets? Yes / No

10. How many time do you take Albenzadole tablets?

a) Daily b) Weekly c) Monthly d) Six monthly e) Don't know

Annexure III

Score card for sensory evaluation of Iron Rich Food Supplement Mix Product

Date:

Code No. of product	Sensory Characteristics					
	Color	Taste	Flavor	Texture	Appearance	Overall acceptability

Please give scores to the product using nine point hedonic rating scale given below:

Quality description	Score	Quality description	Score
Liked extremely	9	Nor liked neither disliked	5
Liked very much	8	Disliked slightly	4
Liked moderately	7	Disliked moderately	3
Liked slightly	6	Disliked very much	2
		Dislike extremely	1

Remarks if any:

Signature

Name of panel member

Annexure IV

Permission Letter

To,

CDPO

Suwana Panchayat Smiti

Bhilwara

Subject: Permission for conducting research work on rural adolescent girls.

Respected sir,

I, Dr. Deepa Swamy, Senior Lecturer, Department of Home Science, JDB Govt. Girls College, Kota. Ms Jyoti Sachan is my PhD research student doing research work under my guidance on "*Development of Nutrition Intervention Package and It`s Efficacy Assessment in Improving the Iron Status of Rural Adolescent Girls of Bhilwara District in Rajasthan*". We would like to assess the nutritional status and estimate prevalence of anemia among rural adolescent girls of selected anganwadis of Suwana Panchayat Smiti. For this porpuse, I request you to allow her to do the following work:

- To assess the nutritional status of adolescent girls.
- To find out the prevalence of anemia among adolescent girls.
- To assess the impact of nutrition intervention package in improving the iron status of selected adolescent girls.

We assure you that the data collection will be solely used for the research purpose. Kindly grant me permission for the same.

Thanks and regards

Research Guide

Dr Deepa Swamy

JDB Govt. Girls College, Kota

Annexure V

Consent latter for the parents

Dear Parents

I, Dr. Deepa Swamy, Senior Lecturer, Department of Home Science, JDB Govt. Girls College, Kota. Ms Jyoti Sachan is my PhD research student doing research work under my guidance on "*Development of Nutrition Intervention Package and It`s Efficacy Assessment in Improving the Iron Status of Rural Adolescent Girls of Bhilwara District in Rajasthan*". We would like to assess the nutritional status and estimate prevalence of anemia among rural adolescent girls of selected anganwadis of Suwana Panchayat Smiti.

Therefore, we would like to screen your daughter to know whether she is anemic or not. For this purpose we need to collect 2-3 drops of blood from the index finger, using prick method. Sterilized and new lancets will be used for each girl. Thereafter, your daughter will be given iron rich food supplement for a period of three months to improve her iron status. Required permission has been taken from CDPO, Suwana Panchayat Smiti, Bhilwara. We will be thankful if you kindly give your consent for the hemoglobin estimation and allow your child to consume iron rich food supplement.

Looking forward for your support and co-operation,

Thanking You,

With warm regards,

Dr. Deepa Swamy — Jyoti Sachan

(Research Supervisor) — Research Scholar

Department of Home-science

JDB Govt. Girls P.G. College, Kota

To be filled by the parents: (Tick any one)

_ Yes, I give permission to conduct hemoglobin test on my daughter and allow her to consume iron rich food supplement.

_ No, I don't give permission to conduct hemoglobin test on my daughter and don't allow her to take iron rich food supplement.

Name: Signature:

Annexure VI

List of selected Anganwadi of Suwana Panchayt Samiti

S.No.	Name	S.No.	Name
1	Palri I	15	Akola
2	Palri II	16	Rajola
3	Govindpura	17	Agarpura
4	Arjiya I	18	Roopaheli
5	Bhdalikheda	19	Danthal
6	Jhodhas	20	Khayra
7	Taswariya	21	Kumariya
8	Chhapri	22	Nowgawan
9	Haled II	23	Sundarpura
10	Suwana II	24	Mahuwa Khurd
11	Suwana IV	25	Pondras
12	Atoon II	26	Harni Kurd
13	Mandapiya	27	Pondras
14	Pansal I	28	Pansal II

Annexure VII

Analysis of variance for sensory scores of Chapati

Analysis of variance for color scores of Chapati

Source of variation	Sum of squares	Df	Mean squares	F value
Between:	48.233	5	9.647	53.943
Within:	9.657	54	0.179	
Total:	57.89	59		

Analysis of variance for texture scores of Chapati

Source of variation	Sum of squares	Df	Mean squares	F value
Between:	29.393	5	5.879	47.20
Within:	6.726	54	0.125	
Total:	36.119	59		

Analysis of variance for flavor scores of Chapati

Source of variation	Sum of squares	df	Mean squares	F value
Between:	52.957	5	10.591	43.616
Within:	13.113	54	0.243	
Total:	66.07	59		

Analysis of variance for taste scores of Chapati

Source of variation	Sum of squares	df	Mean squares	F value
Between:	55.106	5	11.021	58.064
Within:	10.25	54	0.19	
Total:	65.356	59		

Analysis of variance for appearance scores of Chapati

Source of variation	Sum of squares	df	Mean squares	F value
Between:	47.332	5	9.466	61.612
Within:	8.297	54	0.154	
Total:	55.628	59		

Analysis of variance for overall acceptability scores of Chapati

Source of variation	Sum of squares	df	Mean squares	F value
Between:	50.885	5	10.177	68.085
Within:	8.072	54	0.149	
Total:	58.957	59		

Annexure VIII

Analysis of variance for sensory scores of Mathri

Analysis of variance for color scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	57.437	5	11.487	115.971
Error	5.349	54	0.099	
Total	62.786	59		

Analysis of variance for Texture scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	29.707	5	5.941	32.622
Error	9.835	54	0.182	
Total	39.542	59		

Analysis of variance for Flavour scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	44.403	5	8.881	84.432
Error	5.68	54	0.105	
Total	50.083	59		

Analysis of variance for taste scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	67.423	5	13.485	71.314
Error	10.211	54	0.189	
Total	77.634	59		

Analysis of variance for appearance scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	57.437	5	11.487	115.971
Error	5.349	54	0.099	
Total	62.786	59		

Analysis of variance for overall acceptability scores of Mathri

Source of variation	Sum of squares	Df	Mean squares	F value
Between	58.519	5	11.704	80.093
Error	7.891	54	0.146	
Total	66.41	59		

Annexure IX

Analysis of variance for sensory scores of Biscuits

Analysis of variance for color scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
between	56.81	5	11.36	69.84
Error	8.785	54	0.1627	
Total	65.60	59		

Analysis of variance for flavor scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
Between	66.621	5	13.324	92.117
Error	7.811	54	0.145	
Total	74.432	59		

Analysis of variance for taste scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
Between	76.904	5	15.381	85.092
Error	9.761	54	0.181	
Total	86.665	59		

Analysis of variance for appearance scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
Between	56.812	5	11.362	67.574
Error	9.08	54	0.168	
Total	65.891	59		

Analysis of variance for overall acceptability scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
Between	54.803	5	10.961	67.614
Error	8.754	54	0.162	
Total	63.557	59		

Analysis of variance for texture scores of Biscuits

Source of variation	Sum of squares	Df	Mean squares	F value
between	35.31	5	7.063	60.09
Error	6.347	54	0.1175	
Total	41.66	59		

Annexure X

Analysis of variance for sensory scores of Chapati during storage

Analysis of variance for color scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.013	3	0.004	1.126
Error	0.136	36	0.004	
Total	0.149	39		

Analysis of variance for appearance scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.015	3	0.005	1.457
Error	0.122	36	0.003	
Total	0.136	39		

Analysis of variance for texture scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.027	3	0.009	2.477
Error	0.13	36	0.004	
Total	0.156	39		

Analysis of variance for flavour scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.663	3	0.221	58.521
Error	0.136	36	0.004	
Total	0.799	39		

Analysis of variance for taste scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.475	3	0.158	26.709
Error	0.213	36	0.006	
Total	0.688	39		

Analysis of variance for overall scores of Chapati during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	0.574	3	0.191	17.007
Error	0.405	36	0.011	
Total	0.979	39		

Annexure XI

Analysis of variance for moisture content of IRFSM during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	9.191	3	3.064	10.101
Error	2.426	8	0.303	
Total	11.617	11		

Annexure XII

Analysis of variance for Total Viable Count of IRFSM during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	15,629,078.00	2	7,814,539.00	50.497
Error	928,519.81	6	154,753.30	
Total	16,557,597.81	8		

Annexure XIII

Analysis of variance for Yeast and Mold count of IRFSM during storage

Source of variation	Sum of squares	Df	Mean squares	F value
Between	8,264.00	2	4,132.00	196.932
Error	125.891	6	20.982	
Total	8,389.89	8		

Annexure XIV

Analysis of variance for change in the Hemoglobin of the adolescent girls of different groups after intervention

Source of variation	Sum of squares	Df	Mean squares	F value
Between:	40.463	4	10.116	18.874
Within:	82.003	153	0.536	
Total:	122.465	157		

Annexure XV

Analysis of variance for change in the nutrition knowledge of the adolescent girls of different groups after intervention

Source of variation	Sum of squares	Df	Mean squares	F value
Between:	48.936	4	12.234	0.983
Within:	1,904.05	153	12.445	
Total:	1,952.99	157		

Annexure XVI

Analysis of variance for change in height of the adolescent girls of different groups after intervention

Source of variation	Sum of squares	Df	Mean squares	F value
Treatmant	12.532	4	3.133	1.389
Error	345.191	153	2.256	
Total:	357.723	157		

Annexure XVII

Analysis of variance for change in weight of the adolescent girls of different groups after intervention

Source of variation	Sum of squares	Df	Mean squares	F value
Between	83.145	4	20.786	20.121
Error	158.059	153	1.033	
Total	241.203	157		

Annexure XVIII

Analysis of variance for change in BMI of the adolescent girls of different groups after intervention

Source of variation	Sum of squares	Df	Mean squares	F value
Between	70.48	4	17.62	10.372
Error	259.925	153	1.699	
Total	330.405	157		

Annexure- XIX

Educational Material

Flash Cards - Food Groups

PowerPoint Presentation on Balance Diet

किशोरावस्था में सन्तुलित आहार

किशोरावस्था में सन्तुलित आहार

➢ सन्तुलित आहार वह भोजन होता है जिसमें सभी पौष्टिक तत्व व्यक्ति विशेष की मांग,आयु,वजन, एवं क्रियाशीलता , अवस्था, आदि के अनुसार उचित मात्रा एवं अनुपात में मौजूद हो।

➢ किशोरावस्था में आहार का सन्तुलित एवं उचित मात्रा में होना अत्यन्त आवश्यक है।

➢ किशोर में निरन्तर विकास के कारण शरीर में पोषक तत्वों की मांग भी बढ़ जाती है।

➢ यदि आवश्यकता के अनुसार पोषक तत्व उपलब्ध ना हो तो किशोर अनेक रोगों से ग्रस्त हो जाता है।

अनाज समूह

आहार में ऊर्जा का मुख्य स्रोत अनाज होते हैं लगभग 70-80% तक ऊर्जा 1 दिन में अनाजों से प्राप्त होती है इसके अतिरिक्त अनाज - प्रोटीन , कैल्शियम,लौह तत्व एवं B-काम्प्लेक्स विटामिन के भी अच्छे स्त्रोत होते हैं

गेहूं, मक्का, बाजरा,जौ,रागी आदि भी अनाज समूह के उदाहरण हैं।

दालें

दालें प्रोटीन का अच्छा स्रोत होती है । शाकाहारी व्यक्तियों के आहार में दालें प्रोटीन का अच्छा स्रोत होती है इसके अतिरिक्त दालों में कार्बोहाइड्रेट, अदृश्य वसा, विटामिन-B तथा B12, फोलिक अम्ल, कैल्शियम एवं लौह तत्व भी पाए जाते हैं।

मूंग, चना, मटर, राजमा, उड़द, सोयाबीन, मसूर आदि।

दूध व दूध से बने पदार्थ

दूध व दूध से बने पदार्थ प्रोटीन (उच्च गुणवत्ता) वसा, कैल्शियम, विटामिन B12 एवं विटामिन A के उत्तम स्त्रोत होते हैं।
दूध, दही, छाछ, पनीर, मावा आदि इस समूह के उदाहरण हैं

मांस, मछली, अण्डा :- प्रोटीन, वसा, विटामिन - B12 के अच्छे स्त्रोत हैं।

फल व सब्जियाँ

फल:-फल कैरोटिन, विटामिन A, विटामिन -C, रेशे एवं खनिज लवण के अच्छे स्त्रोत होते हैं। आम,अमरूद,केला,पपीता,संतरा, सेब, अंगूर, आदि।

हरी पत्तेदार सब्जियाँ :- हरी पत्तेदार सब्जियां लौह तत्व, कैल्शियम,बेना, फोलिक अम्ल आदि के अच्छे स्रोत होती हैं उदाहरण :- पालक, मेथी चौलाई ,सरसों, बथुआ, बने का साग,हरा धनिया आदि।

वसा व शक्कर

वसा :- वसा ऊर्जा का अच्छा स्रोत हैं। 1ग्राम वसा से 9किलो कैलोरी ऊर्जा प्राप्त होती है। उदाहरण :-घी, मक्खन, वनस्पति तेल, मूंगफली का तेल,तिल का तेल आदि।

शक्कर व गुड :- खून में मुख्य रूप से कार्बोहाइड्रेट पाई जाती है इसका मुख्य कार्य ऊर्जा प्रदान करना है

PowerPoint Presentation on Nutritional Requirements of Adolescent

किशोरावस्था में पोषण सम्बन्धी मांग

किशोरावस्था

किशोरावस्था की अवस्थाएँ

पूर्व किशोरावस्था
मध्य किशोरावस्था
उत्तर किशोरावस्था

वयस्क व्यक्ति की लम्बाई का 25%

वयस्क व्यक्ति के भार का 50%

वयस्क व्यक्ति के बोन मास का 40%

किशोर किशोरावस्था में प्राप्त कर लेता है

किशोरावस्था में पोषण सम्बन्धी मांग

ऊर्जा :- किशोरावस्था में शरीर में ऊर्जा की मांग बढ़ जाती है। क्योंकि इस अवस्था में शारीरिक विकास एंव क्रियाशीलता में वृद्धि हो जाती है।

*10-12 वर्ष में ऊर्जा की मांग 2010 किलो कैलोरी
*13-15 वर्ष में ऊर्जा की मांग 2330 किलो कैलोरी
*16-17 वर्ष में ऊर्जा की मांग 2440 किलो कैलोरी

प्रोटीन

मॉसपेशियो का निर्माण, कोशिकाओ की टूट -फूट की मरम्मत हार्मोन्स का निर्माण आदि के लिए प्रोटीन की आवश्यकता होती है। यदि इस अवस्था में किशोर- किशोरियों को पर्याप्त मात्रा में प्रोटीन युक्त आहार नही दिया जाता है तो उनकी शारीरिक वृद्धि कम हो जाती है। और उनकी लम्बाई एंव वजन सामान्य से कम हो जाता है।

*10-12 वर्ष में प्रोटीन की मांग 40.4 ग्रा./ दिन
*13-15 वर्ष में प्रोटीन की मांग 51.9 ग्रा./ दिन
*16-17 वर्ष में प्रोटीन की मांग 53.5 ग्रा./ दिन

वसा:- वसा की मुख्य कार्य ऊर्जा प्रदान करना है। इसकी अधिक मात्रा शरीर के लिए हानिकारक है। इसलिए उचित मात्रा मे इसका सेवन करना चाहिए।

*10-12 वर्ष में वसा की मांग 35 ग्रा./ दिन
*13-15 वर्ष में वसा की मांग 40 ग्रा./ दिन
*16-17 वर्ष में वसा की मांग 35 ग्रा./ दिन

विटामिन:- ये सुरक्षात्मक भोज्य तत्व है जो शरीर को विभिन्न रोगों से सुरक्षा प्रदान करते है। कुछ विटामिन जल में घुलनशील (विटामिन B एंव B - काम्पलेक्स तथा विटामिन C) एंव कुछ वसा घुलनशील (विटामिन - A, D, E एंव K) होते है।

खनिज लवण

अस्थियों, दाँतो, रक्त, हार्मोन्स आदि के निर्माण के लिए खनिज लवण अत्यावश्यक होते है। ये सुरक्षात्मक भोज्य तत्व होते है जो शरीर को विभिन्न रोगों से सुरक्षा प्रदान करते है जैसे कैल्सियम, फास्फोरस, लौहतत्व, जिंक, आयोडीन आदि।

लौहलवण की दैनिक प्रस्तावित आहारीय मात्राएं (RDA) ICMR 2010

बालक आयु (वर्ष)	लौहलवण (मि.ग्रा./दिन)	बालिका आयु (वर्ष)	लौहलवण (मि.ग्रा./दिन)
10-12	27	10-12	21
13-15	32	13-15	27
16-18	28	16-18	26

PowerPoint Presentation on Anemia

कारण, लक्षण एवं उपचार

एनीमिया (रक्त अल्पता)

यह शरीर की वह स्थिति है जब रक्त में हीमोग्लोबिन का स्तर एक सामान्य स्तर से कम हो जाता है। हीमोग्लोबिन शरीर की सभी कोशिकाओं तक ऑक्सीजन का संवहन करता है। यह एक गम्भीर स्वास्थ्य समस्या है।

विश्व में एनीमिया की समस्या सर्वाधिक भारतीय किशोरियों (60-70%) एवं गर्भवती महिलाओं में पाई जाती है। राजस्थान राज्य की 75-85% किशोर बालिकाएँ एनिमिक पाई गई हैं । प्रतिवर्ष लगभग 20-40% मातृत्व मृत्यु एनीमिया के कारण होती है।

आयु एंव लिंग के अनुसार सामान्य हीमोग्लोबिन स्तर

आयु	हीमोग्लोबिन (ग्राम/ 100 मि.ली.)
बालक-बालिकाएँ 6माह- 6वर्ष	11-14
बालक-बालिका 6 वर्ष -14वर्ष	12-15
किशोर-बालक -बालिका 15-19वर्ष	12-15
वयस्क पुरुष	13-16
वयस्क महिला	12-15
गर्भवती महिला	11-14

एनीमिया के कारण

पौषणिक कारण

(1) आहार में लौह-लवण युक्त खाद्य पदार्थो का अभाव।

(2) आहार में विटामिन बी-6, बी-12 व फौलिक अम्ल युक्त खाद्य पदार्थो का अभाव

(3) आहार में विटामिन-C युक्त खाद्य पदार्थो का अभाव

(4) भोजन संबंधी गलत आदतें :-
- फास्ट फूड व जंक फूड्स - पिज्जा, बर्गर, वाऊमिन, चिप्स, कोल्ड ड्रिंक्स आदि का अधिक सेवन।
- आहार के साथ- साथ चाय, कॉफी आदि का सेवन।
- उत्तेजक व नशीले भोज्य पदार्थो चाय, कॉफी, बीयर, एल्कोहॉल, बीडी, सिगरेट, तम्बाकू, गुटखा आदि का अधिक सेवन।

(5) भोजन की अनियमितता।

गैर पौषणिक कारण

(1) किशोर वय में तीव्र विकास के कारण लौह-लवण की आवश्यकता बढ़ना।

(2) मासिकधर्मी के दौरान रक्त का अधिक स्त्राव।

(3) प्रसव के दौरान रक्त का अत्यधिक बहना।

(4) लम्बी बीमारी जैसे टीयफॉइड व मलेरिया का बार- बार- होना।

(5) पेट में कीडे व कृमि।

(6) किशोर वय में विवाह एंव गर्भधारण करना।

(8) गर्भावस्था में लौह-लवण की आवश्यकता बढ़ना।

एनिमिया के लक्षण एवं चिन्ह

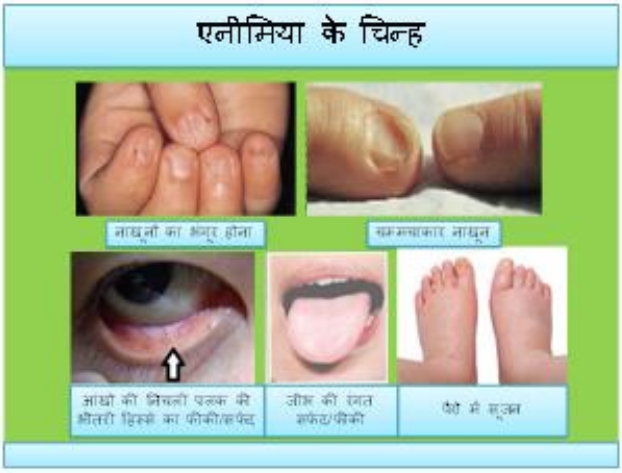
एनीमिया के लक्षण

1-कार्य में कमी
2-शारीरिक कमजोरी एवं थकान
3-सांस फूलना
4-सिर दर्द होना
5-कार्य में रुचि कम होना
6-सीखने एवं स्मरण करने की क्षमता कम होना

एनीमिया के चिन्ह

त्वचा की रंगत सफेद/पीली होना

नाखूनों की रंगत सफेद/पीली होना


एनीमिया के चिन्ह
नाखूनों का अंगूर होना
चम्मचाकार नाखून
आंखों की निचली पलक की भीतरी झिल्ली का फीकी/सफेद
जीभ की रंगत सफेद/फीकी
पैरों में सूजन


रोकथाम के उपाय
इनका सेवन अधिक करें
अनाज- चोकर/भूसा,मूंगफली,बाजरा
दलहन व तिलहन
अंकुरीकृत अनाज व दालों से बने व्यंजन


इनका सेवन अधिक करें
हरी पत्तेदार सब्जियां
विटामिन सी युक्त फल
गुड़ व गुड़ से बने व्यंजन
अंडा, मांस,मछली,मुर्गी, आदि


रोकथाम के उपाय
इनका सेवन कम से कम करें।
1- चाय, कॉफी, एवं कोको।
इनमें टेनिन एवं फाइटेड जैसे हानिकारक तत्व होते हैं जो शरीर में लौह लवण के अवशोषण को कम करते हैं।
2- लौह लवण युक्त खाद्य पदार्थों के साथ कैल्शियम युक्त खाद्य पदार्थों जैसे दूध वाले बुरे पदार्थों का सेवन नहीं करें।


कृमि संक्रमण से बचाव के लिए ध्यान दें


हर हफ़्ते
नीली गोली लेकर
हम बचे
सुस्त से चुस्त.
भोजन द्वारा खाद्य पदार्थों से लौह तत्वों की पूर्ति नहीं हो पाती इस हेतु आयरन की गोली लेना जरूरी है। जिससे शरीर में खून की कमी न हो सके।

बिस्किट

सामग्री:

मैदा = 30 ग्राम
मिक्स = 20 ग्राम
चीनी = 25 ग्राम
घी = 20 ग्राम
बेकिंग सोडा = 2 ग्राम
दूध = 10 मिली

विधि :

मैदा, मिक्स एवं बेकिंग सोडा को अच्छी तरह से मिलाएँ। इसमें घी एवं पीसी हुई चीनी मिलाकर दूध से आटा गूंद लें। 10 मिनट तक कपड़े से ढक कर रखें। सांचे से बिस्किट काट कर ओवन में 160°c पर 10 मिनट तक बेक करें।

मठरी

सामग्री :

मैदा = 35 ग्राम
मिक्स = 20 ग्राम
नमक = 1/3 चम्मच
अजवाइन = 2 ग्राम
तेल = मोयन व तलने के लिए

विधि : मैदा में मिक्स, नमक एवं अजवाइन अच्छी तरह से मिलाएँ। तेल का मोयन डालकर पानी से आटा गूंद लें। छोटी-छोटी लोइंया बनाकर उन्हें हाथ से थोड़ी चपाती कर लें। चाकू से गोद लें ताकि तलने पर फूले नहीं। गर्म तेल में धीमी आंच पर मठरियां सुनहरी होने तक तल लें।

चकली

सामग्री :

चावल का आटा= 30 ग्राम
मिक्स = 20 ग्राम
तिल = 5 ग्राम
नमक = 1/3 चम्मच
तेल = तलने के लिए

विधि :

चावल का आटा एवं मिक्स को मिलाकर मलमल के कपडे में बांध कर 20 मिनट के लिए भाप मे रखें। भाप लगे हुए मिश्रण में नमक एवं तिल मिलाकर आवश्यकतानुसार पानी से ढीला आटा गूँद लें। इस आटे को चकली बनाने वाली मशीन में भर कर प्लेट में सारी चकली बना लें। इन सभी चकालियों को गर्म तेल में तल लें।

इस तरह से लौह तत्व युक्त खाद्य मिश्रण को मिलाकर अन्य व्यंजन जैसे चपाती, परांठा, खाखरा, कसार, लड्डू आदि भी बनाये जा सकते हैं।

-: आलेख:-

श्रीमती ज्योति सचान (शोधार्थी)

डॉ दीपा स्वामी

व्याख्याता गृह-विज्ञान

जे. डी. बी. राजकीय कन्या महाविद्यालय, कोटा

लौह तत्व युक्त खाद्य मिश्रण

लौह तत्व कि कमी को रोकने का एक प्रभावी उपाय

गृह-विज्ञान विभाग

जानकी देवी बजाज राजकीय कन्या महाविद्यालय, कोटा (राजस्थान)

लौह तत्व रक्त की लाल रक्त कोशिकाओं का एक हिस्सा है । लाल रक्त कणिकाओं में हीमोग्लोबिन नामक एक तत्व होता है, जिसके निर्माण में लौह तत्व की आवश्यकता होती है । हीमोग्लोबिन का मुख्य कार्य शरीर की विभिन्न कोशिकाओं में ऑक्सीजन पहुँचाना है।

शरीर में लौह तत्व की कमी से एनीमिया (रक्त अल्पता) नामक रोग हो जाता है। विश्व में एनीमिया की समस्या सर्वाधिक भारतीय बच्चों, किशोरिओं, गर्भवती एवं धात्री माताओं में पाई जाती है। राजस्थान राज्य कि 75-85% किशोर बालिकाएं एनीमिया से ग्रसित पाई गई हैं।

शरीर में लौह तत्व की कमी से निम्न लक्षण दिखाई देते हैं:

1. शरीर में खून की कमी होना
2. शारीरिक कमजोरी एवं थकान
3. जल्दी-जल्दी साँस फूलना
4. भूख कम लगना
5. त्वचा तथा आँखों का पीला पड़ना एवं नाखूनों कि लालिमा का ख़त्म होना
6. लोह तत्व की अधिक कमी के कारण नाख़ून चपटे एवं चम्मचाकर होने लगते है

उपाय: सेठ मुरलीधर मानसिंहका राजकीय कन्या महाविद्यालय के गृह-विज्ञान विभाग में प्रान्त में आसानी से उपलब्ध होने वाली खाध्य सामग्री को सुखाकर लौह तत्व से भरपूर पाउडर तेयार किया गया । किशोर बालिकाओं पर किये गये अनुसंधान में इस मिश्रण के 100 दिन के सेवन पर बालिकाओं के हीमोग्लोबिन स्तर में लाभकारी प्रभाव देखे गए।

इस मिश्रण को बनाने कि विधि :

1. बाजार से कमल डंडी, फूलगोभी के पत्ते, पोहा तथा चंद्रसूर के बीज एकत्रित करें।
2. कमल डंडी एवं फूलगोभी के पत्तों को साफ पानी में साफ कर लें।
3. कमल डंडी को छोटे-छोटे टुकडों में काट लें एवं 15 मिनट तक गर्म पानी में उबालें।
4. कमल डंडी एवं फूलगोभी के पत्तों को छायादार जगह पर सुखा लें क्यूंकि सीधी कड़क धूप में सुखाने से पोषक तत्व नष्ट हो सकते हैं।
5. सभी सूखी हुई खाध्य सामग्री- कमल डंडी, फूलगोभी के पत्ते, पोहा तथा चंद्रसूर के बीज को अलग-अलग महीन पीस लें व निश्चत अनुपात में मिलाएँ।

100 ग्राम मिश्रण बनाने के लिए:

खाध्य सामग्री (पिसी हुई)	**मात्रा**	**घरेलू माप**
पोहा	50 ग्राम	15 छोटे चम्मच
चंद्रसूर के बीज	10 ग्राम	4 छोटे चम्मच
कमल डंडी	30 ग्राम	10 छोटे चम्मच
फूलगोभी के पत्ते	10 ग्राम	6 छोटे चम्मच

इन सभी खाध्य सामग्री को मिलाने के बाद 100 ग्राम मिश्रण तैयार होगा जिसे 5 बराबर भागों में बाँट लें। इस 20 ग्राम मिश्रण के प्रतिदिन सेवन से बच्चों एवं किशोर बालिकाओं की लौह तत्व की दैनिक आवश्यकता के एक तिहाई मात्रा की पूर्ति होती है। इस मिश्रण को अलग-अलग व्यंजनों के रूप में लौह तत्व की कमी से ग्रसित व्यक्तियों को खिलाया जा सकता।

नमकीन चिला

सामग्री :
बेसन = 40 ग्राम
मिक्स = 20 ग्राम
नमक = 1/3 चम्मच
तेल = तलने के लिए
प्याज = 10 ग्राम
हरी मिर्च = 5 ग्राम
हरा धनिया = 5 ग्राम

विधि:

बेसन एवं मिक्स को मिलाकर इसमें सारे मसाले अच्छी तरह से मिलाएँ। आवश्यकतानुसार पानी मिलाकर घोल बना लें। तवे पर तेल लगाकर चिले बना लें। हरी चटनी के साथ गर्म-गर्म परोसें।

नमकीन सेव

सामग्री :
बेसन = 30 ग्राम
मिक्स = 20 ग्राम
नमक = 1/3 चम्मच
तेल = तलने के लिए

विधि:

बेसन में मिक्स व नमक मिलाएँ एवं आवश्यकतानुसार पानी से ढीला आटा गूँद लें. इस आटे को सेव बनाने वाली मशीन में भर कर गर्म तेल में तल लें।

रोकथाम के उपाय :-

(अ) इनका सेवन अधिक करें

1-अनाज:- जैसे पोहा/चिवड़ा,मुरमुरा,बाजरा, गेहूं
2- दलहन व तिलहन:- भुना चना,साबुत चवले,कुलद, साबुत मसूर, सोयाबीन,काला तिल, सफेद तिल,गोला/सूखा नारियल,तरबूज के बीज।
3- हरी पत्तेदार सब्जियां:- पालक,मेथी,चौलाई, सरसों मूली एंव चने का साग, पुदीना, हरा प्याज।
4- फल व सब्जियां:- कमल ककड़ी, तरबूज, अनार, सीताफल, खजूर एंव छुआरा,दाख एंव किशमिश।
5-विटामिन सी युक्त फल व सब्जियां:- आंवला, अमरुद,नांरगी,व नींबू प्रजाति के फल ,टमाटर, पत्तागोभी।
6-अंकुरीकृत अनाज व दालों से बने व्यंजन।
7-गुड़ व गुड से बने व्यंजन।
8-अंडा, मांस, मछली, मुर्गी, आदि

(ब) इनका सेवन कम से कम करें।

1- चाय, काफी, एंव कोको।
इनमें टेनिन एंव फाइटेड जैसे हानिकारक तत्व होते हैं जो शरीर में लौह लवण के अवशोषण को कम करते है।
2- लौह लवण युक्त खाद्य पदार्थों के साथ कैल्शियम युक्त खाद्य पदार्थों जैसे दूध वाले दुग्ध पदार्थों का सेवन नहीं करें।

साप्ताहिक आयरन- फोलिक एसिड अनुपूरण कार्यक्रम (WFS)

यह कार्यक्रम भारत सरकार के राष्ट्रीय स्वास्थ्य मिशन के अंतर्गत स्वास्थ्य एंव परिवार कल्याण मंत्रालय द्वारा 25 जुलाई2013 को राजस्थान में प्रारम्भ हुआ।

राज्य के सभी राजकीय स्कूलों में कक्षा 6-12 तक के सभी छात्र- छात्रा-छात्राओ को तथा स्कूल नही जाने वाली किशोर बालिकाओ (10-19) वर्ष को (IFA) की गोली (100मि.ग्रा.) आण्विक आयरन एंव 500. माइक्रोग्राम फोलिक अम्ल एक वर्ष में 52 सप्ताह तक साप्ताहिक रुप में दिया जाना।
Albendazolo (400मि.ग्रा.) की एक खुराक हर छः माह में देना।

-: आलेख:-
श्रीमती ज्योति सचान (शोधार्थी)
डॉ दीपा स्वामी
व्याख्याता गृह-विज्ञान
जे. डी. बी. राजकीय कन्या महाविद्यालय, कोटा

किशोरियों को एनीमिया से बचाएँ उनका भविष्य स्वस्थ्य बनाएँ

गृह-विज्ञान विभाग
जानकी देवी बजाज राजकीय कन्या महाविद्यालय, कोटा (राजस्थान)

एनीमिया:-

यह शरीर की वह स्थिति है जब रक्त में हीमोग्लोबिन का स्तर एक सामान्य स्तर से कम हो जाता है। हीमोग्लोबिन शरीर की सभी कोशिकाओ तक ऑक्सीजन का संवहन करता है। यह एक गम्भीर स्वास्थय समस्या है।

विश्व में एनीमिया की समस्या सर्वाधिक भारतीय किशोरियों (60-70%) एंव महिलाओ में पाई जाती है। राजस्थान राज्य की 75-85% किशोर बालिकाएँ एनिमिक पाई गई हैं प्रतिवर्ष लगभग 20-40% मातृत्व मृत्यु एनीमिया के कारण होती है।

आयु एंव लिंग के अनुसार सामान्य हीमोग्लोबिन स्तर

आयु एंव लिंग	हीमोग्लोबिन(ग्राम/100 मि.ली)
बालक-बालिकाएँ 6माह-6वर्ष.	11-14
बालक-बालिका 6वर्ष-14वर्	12-15
किशोर-बालक -बालिका 15-19वर्ष	12-15
वयस्क पुरुष	13-16
वयस्क महिला	12-15
गर्भवती महिला	11-14

एनीमिया का वर्गीकरण:-

एनीमिया का प्रकार	हीमोग्लोबिन स्तर (ग्राम/100 मि.ली)
मृदु एनीमिया	10-11.9
मध्यम एनीमिया	7-9.9
तीव्र एनीमिया	<7
गर्भवती महिला में एनीमिया	<11
सामान्य महिला में एनीमिया	<12

दैनिक प्रस्तावित आहारीय मात्राएं (RDA)

बालक आयु(वर्ष)	लौहलवण (मि.ग्रा./दिन)	बालिका आयु(वर्ष)	लौहलवण (मि.ग्रा./दिन)
10-12	27	10-12	21
13-15	32	13-15.	27
16-18	28	16-18	26

एनीमिया के कारण:-

(अ) पौषणिक :-

1) आहार में लौह-लवण युक्त खाद्ध पदार्थो का अभाव
(2) आहार में विटामिन बी-6,बी-12 व फौलिक अम्ल युक्त खाद्ध पदार्थो का अभाव
(3) आहार में विटामिन 'सी' खाद्ध पदार्थो का अभाव
(4) भोजन संबंधी गलत आदतें:-
* फास्ट फूड व जंक फूड्स - पिज्जा, बर्गर,चाऊमिन, चिप्स, कोल्ड ड्रिंक्स आदि का अधिक सेवन।
* आहार के साथ- साथ चाय, कॉफी,आदि का सेवन।
* उत्जेक व नशीले भोज्य पदार्थो चाय, कॉफी, बीयर, एल्कोहॉल, बीडी,सिगरेट, तम्बाकू, गुटखा, आदि का अधिक सेवन।
(5) भोजन की अनियमितता।

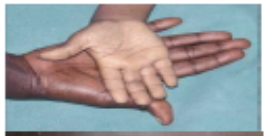
(ब) गैर पौषणिक:-

(1) किशोर वय में तीव विकास के कारण लौह-लवण की आवश्यकता की बढ़ना।
(2) माहवारी के दौरान रक्त का अधिक स्त्राव।
(3) अल्सर, अपरेशन, एक्सीडेंट, गहरी चोट, आदि में शरीर से रक्त की हानि।
(4) प्रसव के दौरान रक्त का अत्यधिक बहना।
(5) लम्बी बीमारी जैसे टीयफॉइड व मलेरिया का बार- बार होना।
(6) पेट में कीडे व कृमि।
(7) किशोर वय में विवाह एंव गर्भधारण करना।

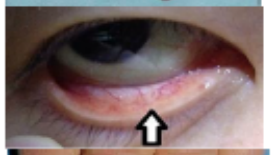
एनीमिया के लक्षण:-

1-भूख में कमी
2- शारीरिक कमजोरी वह थकान
3-सांस फूलना
4- सिर दर्द होना
5-कार्य में रुचि कम होना
6-सीखने वह स्मरण करने की क्षमता कम होना

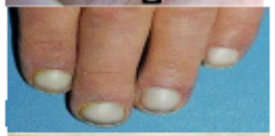
7-त्वचा की रंगत सफेद/फीकी होना



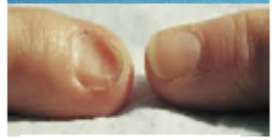
8-आंखो की निचली पलक की भीतरी हिस्से की चिंता

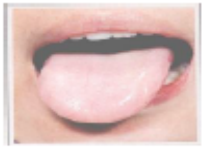


9-नाखूनो की रंगत सफेद/फीकी होना

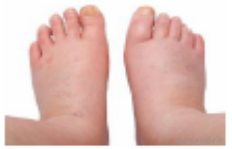


10-चम्मचाकार नाखून





11-जीभ की रंगत सफेद/फीकी होना



12-पैरो में सूजन