DOI:https://doi.org/10.54393/pbmj.v5i3.336

PAKISTAN BIOMEDICAL JOURNAL

https://www.pakistanbmj.com/journal/index.php/pbmj/index

Volume 5, Issue 3 (March 2022)

Review Article

Iron Deficiency Anemia: Cause, Plant Based Iron, Fortification and Impact on Lifestyle and Socioeconomic Parameters

Saira Ahmad[1], Huma Bader Ul Ain[1*], Tabussam Tufail[1], Makia Nasir[2], Aiza Qamar[3] and Zunaira Mushtaq[4]

[1]University Institute of Diet and Nutritional Sciences, The University of Lahore, Lahore, Pakistan
[2]College of Nutrition, Multan Medical Dental College, Multan, Pakistan
[3]Department of Nutrition and Health Promotion, University of Home Economics, Lahore, Pakistan
[4]Department of Human Nutrition and Dietetics, Riphah International University Faisalabad, Pakistan

ARTICLE INFO

Key Words:
Anemia, Iron Deficiency Anemia, Iron, Plant-Based Foods, Fortification

How to Cite:
Ahmad, S., Bader Ul Ain, H. ., Tufail, T. ., Nasir, M. ., Qamar, A. ., & Mushtaq, Z. . (2022). Iron Deficiency Anemia: Cause, Plant Based Iron, Fortification and Impact on Lifestyle and Socioeconomic Parameters: Plant-Based Iron, Fortification and Impact on Lifestyle and Socioeconomic Parameters. Pakistan BioMedical Journal, 5(3). https://doi.org/10.54393/pbmj.v5i3.336

***Corresponding Author:**
Huma Bader Ul Ain
University Institute of Diet and Nutritional Sciences, The University of Lahore, Lahore, Punjab-Pakistan
huma.badar@dnsc.uol.edu.pk

ABSTRACT

Micronutrient deficiency is prevelant in both high income and low-income countries globally causing major health issues, especially iron deficiency which causes hypoproliferative microcytic anemia. Iron deficieny anemiais effecting more than two billion population on earth especially pregnant woman, infants and woman of reproductive. Iron plays a key role in the formation of red blood cells and reactions occurring in the human body. Food is one of the best and safe options to prevent and cure iron deficiency anemia. In the present study, we highlighted different foods with special reference to plant-based foods for the treatment and prevention of iron deficiency anemia. Literature revealed that major cereal flours, cumin seeds, green leafy vegetables, moringa leaves, papaya with supplements, beet root, apples, pomegranate, bael, sugar molasses and berries are best sources of iron due to presence of ascorbic acid. Prebiotics and probiotics fortification can also increase the iron absorption in the gut by providing optimum pH for absorption. In addition to change in dietary patterns, fortification of major crops, flours and salt should be made mandatory by as in many countries. Moreover, Iron fortified formulas, complementary food, beverages, baked items (cookies) and confectionary are best ways to prevent and cure iron deficiency anemia in children and adults. Similarly, sugar molasses from sugar industry is one of the superabundant sources of iron which can be used as supplement for value addition. However, human research is required to check the efficacy of fortified products to prevent iron deficiency anemia in future generations.

INTRODUCTION

Micronutrient deficiency creates a significant public health problem that hinders growth and development processes in humans that weaken the body's immune system, ultimately causing death [1]. Mineral nutrients are inorganic compounds or metals. Their primary source is soil which provides nutrients for plant growth that plants and animals consume, hence becoming part of animal diet [2]. Vitamins and minerals are necessary micronutrients mandatory in minute amounts to guarantee ideal health and efficient body working. Iron serves many essential biologic functions in the human body, such as oxidation/reduction reactions, gene regulation, immune function, neurotransmitter synthesis, DNA synthesis, the cofactor for enzymes, and other metabolic responses [3, 4]. Iron, an element, superabundantly found on Earth that is an important component for every living organism, de facto, a growth-limiting factor in the environment [5]. Anemia is originated from the Greek word anemia, meaning "lack of blood." Anemia is when the quantity of red blood cells (RBC), hematocrit, and hemoglobin count is low in the blood. There are numerous types of anemia, for instance, normocytic anemia, microcytic anemia, and macrocytic anemia [6,7]. Aplastic anemia and renal failure cause lymphoproliferative normocytic anemia, while alcohol consumption and vitamins deficiency like B12 and folate cause hypoproliferative macrocytic anemia. In contrast, iron deficiency causeshypoproliferative microcytic anemia [8, 7]. According to WHO [9], Iron deficiency is the

DOI:https://doi.org/10.54393/pbmj.v5i3.336

chiefcausative factor of 50 % of all kinds of anemia. Nutritional Anemia is a worldwide health issue in emerging countries and developed countries having advanced health facilities. It affects people of all age groups, irrespective of gender, including babies, children, youngsters, pregnant and lactating women, and men [10]. It is conspicuous that iron-deficiency anemia (IDA) is the significant limiting factor for the growth and development of children that affects cognitive performance, immune status, physical capability, and sexual performance, particularly in developing countries encompassing middle-income populations [11,12]. Most issues of anemia are instigated by discrepancies of iron homeostasis, and iron is critical for hemoglobin development. The difficulty occurs due to the inadequate amount of iron that is required for erythropoiesis that can be triggered by two different process, absolute or functional iron deficiency (ID). Absolute iron deficiencyroots iron deficiency anemia (IDA), the most common form of anemia. However, functional iron deficiency, the second most frequentreason of anemia globally that causes anemia of chronic disease (ACD)[13-15]. Consumption of food rich in micronutrients showed a reduction in anemia in adolescents in Indonesia, especially iron and vitamin A. Therefore, there is a strong relationship between dietary intake and nutritive status of a body [16]. Iron (Fe) is acritical component for life that shows a vital role in numerous physiological processes, namely cellular propagation and metabolic actions, such as mitochondrial catabolic and anabolic reactions (energy production), immune surveillance, and oxygen transportation [17, 15]. So, it is essential to meet the requirements of spongy tissues inside the bone for erythropoiesis [18,19]. The human body cannot synthesize iron; therefore, it meets its requirement from food that is the only natural source. Even though the human body recovers and recycles this mineral, one way or another, it loses some iron daily though needing replacement. Macrophages recycle most iron from senescent erythrocytes, managing body needs; only 5 to 10% of iron comes from the food [20,21]. Iron is crucial for the maturation and development of the brain and spinal cord growth and development during infancy, especially around the age of six months, because iron stores are exhausted. Hence complementary diets are introduced for preventing iron deficiency anemia [11, 22]. In 2016, over 1.2 billion people were iron deficient, among which 89 percent were from developing countries [14, 31-35]. In Africa, 16% of children younger than five years suffer from iron deficiency [46, 47].The pervasiveness of iron shortage in female athletes is greater than their males.Athletes require a tremendous amount of iron for well-being throughout the season; predominantly female athletes, especially during periods, are at higher risk of developing IDA because ofextreme blood loss. Almost 15-50% percent of athlete women are iron deficient and 29% suffer from IDA [48-52]. According to the statistics one in two children unders five years of age are suffering from the hidden micronutrient deficiency and almost two billion population of the world is iron deficient [53]. Conferring to nutritional surveys such asthe feeding infants and toddlers study and the national health and nutrition examination survey, iron consumption is reduced over twenty years among 6-12-month-old infants [54-56]. As reported by a recent survey of the United States, exclusive breastfeeding rates are estimated at 47% at three months and 25% at six months. Most breastfed infants are supplemented with iron-fortified baby formula recommended by DGA to avoid iron deficiency [57,58]. Information shared by UNICEF mentions that 55% of South Asian teenage girls of 15–19 years age is anemic, 11% are underdeveloped, and 39% are thin [59]. Iron deficiency anemia is quite prevalent in Pakistan due to bad socioeconomic conditions and lack of nutrition knowledge. Almost 65-78% of children are suffering from it though 39%of adolescents are affected, and yet 50%, of women of child-bearing age are bearing its consequences; nevertheless, 90.5% of pregnant ladies are anemic and iron deficient [60-62]. However, only 20% of women had average hemoglobin levels [64]. IDA can be due to iron malabsorption because of celiac disease, atrophic gastritis, reduced acidity in stomach (H2 blockers, antacids, and protein-pump inhibitors), and iron refractory iron deficiency anemia [68-70]. Iron deficiency disturbs the accuracy of the cognitive skill in a varied sort of dailychoresvia different processes by prompting nerve myelination; formation and regulation of neurotransmitters; synaptogenesis and neurogenesis [65-71]. Iron is found principally in two readily reversible oxidation conditions in ferric (Fe3+) or ferrous (Fe2+) in foods. Iron is a transition metal that displays properties of oxo- and lipophilicity and are able to form complex compounds by combining with O-, N- and S- atoms on donor ligands [82]. Heam iron is the superabundant source of iron as it has the highest tendency to pass through the gut. These factors promote the absorption present in animal sources are collectively known as "meat factors," Almost 40% of the iron found in animal foods as organic Fe (haem iron). It is ingested in minor amount but shows two to threefold more bio-availability than nonheme iron [79-84].

CONCLUSION

Iron deficiency anemia is one of the most abundant disease in the world which demands implementation of efficient

DOI:https://doi.org/10.54393/pbmj.v5i3.336

and effective strategies globally. Food plays a vital role in maintaing the nutritional balacnce in human body. By monitoring lifestyle and changing dietary patterns IDA can be prevented and cured easily which cause major problems and delays growth and development of human body.

REFERENCES

[1] Bailey RL, West Jr.KP and Black RE. The epidemiology of global micronutrient deficiencies. Ann Nutr Metab. 2015. 66(2).doi.org/10.1159/000371618

[2] Gupta UC and Gupta SC. Sources and deficiency diseases of mineral nutrients in human health and nutrition: a review.Pedosphere. 2014. 24(1): 13-38. .doi.org/10.1016/S1002-0160(13)60077-6

[3] Spengler RN. Origins of the apple: The role of megafaunal mutualism in the domestication of Malus and rosaceous trees. Frontiers in plant science, 2019. 10: 617.doi.org/10.3389/fpls.2019.00617

[4] Patocka J et al. Malus domestica: A Review on Nutritional Features, Chemical Composition, Traditional and Medicinal Value. Plants.2020.9(11): 1408.https://www.mdpi.com/2223-7747/9/11/1408#

[5] Abbaspour N, Hurrell R and Kelishadi R. Review on iron and its importance for human health. Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences.2014. 19(2):164. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999603/

[6] Johnson-Wimbley TD and Graham DY. Diagnosis and management of iron deficiency anemia in the 21st century. Therapeutic advances in Gastroenterology.2011. 4(3): 177-184. doi.org/10.1177/1756283X11398736

[7] Turner J, Parsi M and Badireddy M. Anemia. StatPearls. 2021. NCBI PMID: 29763170https://www.ncbi.nlm.nih.gov/books/NBK499994/

[8] Usuki K. Anemia: From Basic Knowledge to Up-to-Date Treatment. Topic: IV. Hemolytic anemia: Diagnosis and treatment. Nihon Naika Gakkai Zasshi. 2015. 104(7):1389-96 doi: 10.2169/naika.104.1389

[9] WHO, The Global Prevalence of Anaemia in 2011, World Health Organization, Geneva, 2015. https://apps.who.int/iris/bitstream/handle/10665/177094/9789241564960_eng.pdf

[10] Elmaghraby DA et al. Assessment of community awareness of the possible relationship between black tea consumption and iron deficiency anemia. Clinical Nutrition ESPEN.2021. doi.org/10.1016/j.clnesp.2021.04.018

[11] Bukva M et al. Iron content in fruits, vegetables, herbs and spices samples marketed in Sarajevo, Bosnia and Herzegovina. Kemija u industriji: Časopis kemičara i kemijskih inženjera Hrvatske.2019. 68(7-8): 281-287. doi.org/10.15255/KUI.2019.001

[12] Paulino CTD, Nishijima SM and Sarti FM. Association of Iron Supplementation Programs with Iron-Deficiency Anemia Outcomes among Children in Brazil. Nutrients.2021. 13(5): 1524. https://www.mdpi.com/2072-6643/13/5/1524#

[13] Camaschella C. New insights into iron deficiency and iron deficiency anemia. Blood Rev. 2017.31(4):225–233.doi.org/10.1016/j.blre.2017.02.004

[14] Kassebaum NJ et al. A systematic analysis of global anemia burden from 1990 to 2010. Blood.2014.123(5):615–624. doi.org/10.1182/blood-2013-06-508325

[15] Sonnweber, T., et al., Anaemia, iron homeostasis and pulmonary hypertension: a review. Internal and emergency medicine. 2020. 1-13.doi.org/10.1007/s11739-020-02288-1

[16] Knijff M, et al., Frequent Consumption of Micronutrient-Rich Foods Is Associated With Reduced Risk of Anemia Among Adolescent Girls and Boys in Indonesia: A Cross-Sectional Study. Food and Nutrition Bulletin. 2021;42(1_suppl):S59-S71. doi:10.1177/0379572120977455

[17] Muckenthaler MU, Rivella S, Hentze MW, Galy B, A red carpet for iron metabolism. Cell.2017. 168(3):344–361. doi.org/10.1016/j.cell.2016.12.034

[18] Muñoz M, Villar I and García-Erce JA. An update on iron physiology. World J Gastroenterol. 2009. 15(37):4617-26. doi: 10.3748/wjg.15.4617

[19] Clifford J, Niebaum K and Bellows L. Iron: an essential nutrient (Doctoral dissertation, Colorado State University. Libraries). 2015. https://extension.colostate.edu/docs/pubs/foodnut/09356.pdf

[20] Coad J and Pedley K. Iron deficiency and iron deficiency anemia in women. Scand J Clin Lab Invest Suppl. 2014.244: 82-9; discussion 89. doi.org/10.3109/00365513.2014.936694

[21] Moustarah F & Mohiuddin SS. Dietary Iron. In StatPearls. StatPearls Publishing. 2020. https://pubmed.ncbi.nlm.nih.gov/31082013/

[22] Basrowi RW & Dilantika C. Optimizing iron adequacy and absorption to prevent iron deficiency anemia: The role of combination of fortified iron and vitamin C. World Nutrition Journal. 2021, 5(1-1), 33-

DOI:https://doi.org/10.54393/pbmj.v5i3.336

39doi.org/10.25220/WNJ.V05.S1.0005
[23] Sheldon JR, Laakso HA and Heinrichs DE. Iron Acquisition Strategies of Bacterial Pathogens. Microbiol. Spectr. 2016. 4(2): 4-2.doi.org/10.1128/microbiolspec.VMBF-0010-2015
[24] Fuqua BK, Vulpe CD and Anderson GJ. Intestinal iron absorption. J. Trace Elem. Med. Biol. 2012.26: 115–119. doi.org/10.1016/j.jtemb.2012.03.015
[25] West AR and Oates PS. Mechanisms of heme iron absorption: Current questions and controversies. World J. Gastroenterol. 2008.14: 4101–4110. doi.org/10.3748%2Fwjg.14.4101
[26] Gomme PT and McCann KB. Transferrin: Structure, function and potential therapeutic actions. Drug Discov. Today. 2005. 10: 267–273. doi.org/10.1016/S1359-6446(04)03333-1
[27] Anderson ER and Shah YM. Iron homeostasis in the liver. Compr. Physiol. 2013. 3: 315–330. 10.1002/cphy.c120016
[28] Przybyszewska J and Zekanowska E. The role of hepcidin, ferroportin, HCP1, and DMT1 protein in iron absorption in the human digestive tract. Prz. Gastroenterol. 2014.9: 208–213. doi.org/10.5114%2Fpg.2014.45102
[29] Verna G et al. Iron-Enriched Nutritional Supplements for the 2030 Pharmacy Shelves. Nutrients. 2021. 13(2): 378. https://www.mdpi.com/2072-6643/13/2/378#
[30] Sangeetha T et al. Siginificance of serum hepcidin as a novel biomarker for the assessment of iron status in pregnant women. International journal of scientific research. 2019.8(10): 2277 - 8179. doi.org/10.36106/ijsr
[31] World Health Organisation. Worldwide prevalence of anaemia 1993-2005, Who vitamin and mineral nutrition information system. Geneva: WHO.2008. doi: 10.1017/S1368980008002401
[32] Kassebaum NJ and GBD 2013 Anemia Collaborators. The global burden of anemia. Hematology/oncology clinics of North America. 2016. 30(2):247-308. doi.org/10.1016/j.hoc.2015.11.002
[33] Shah T, Warsi J and Laghari Z. Effect of Maternal Anemia on the Anthropometric Indices of Newborn. JLUMHS.2020a. 19(3): 191–194. https://www.lumhs.edu.pk/jlumhs/Vol19No03/10.pdf
[34] Didzun O. et al. Anaemia among Men in India: A Nationally Representative Cross-Sectional Study. Lancet Global Health.2019.7(12): e1685–e1694.doi.org/10.1016/S2214-109X(19)30440-1
[35] Pasricha SR et al., Iron deficiency. Lancet. 2021. 397:233–48.doi.org/10.1016/S0140-6736(20)32594-0
[36] Guralnik JM et al. Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood. 2004. 104:2263–8.doi.org/10.1182/blood-2004-05-1812
[37] Lopez A et al. Iron deficiency anaemia. Lancet 2016. 387:907–16.doi.org/10.1016/S0140-6736(15)60865-0
[38] Snook J et al. British Society of Gastroenterology guidelines for the management of iron deficiency anaemia in adults. Gut.2021. 70(11): 2030-2051.doi.org/10.1136/gutjnl-2021-325210
[39] Zaman B et al. Hepcidin as a diagnostic biomarker of iron deficiency anemia during pregnancy. J Matern Fetal Neonatal Med. 2021.34(8):1288-1296. doi.org/10.1080/14767058.2019.1635112
[40] Nusrat FP et al. Assessment of the Patterns of Exercise and Diet Intake among the Pregnant and Pre-Pregnant Women Reported at Gynae OPD Civil Hospital Khairpur, Sindh, Pakistan. J. Pharmaceut. Res. Int. 2021. 33(12): 51–58. doi.org/10.9734/jpri/2021/v33i1231254.
[41] Shah T et al. Gestational Anemia and its effects on neonatal outcome, in the population of Hyderabad, Sindh, Pakistan. Saudi Journal of Biological Sciences. 2021. doi.org/10.1016/j.sjbs.2021.08.053
[42] Shah T, Warsi J and Zulfiqar L. Anemia and Its Association with Parity. Profess. Med. J. 2020b. 27(5): 968–972. doi.org/10.29309/TPMJ/2020.27.05.3959
[43] Hercberg S, Preziosi P and Galan P. Iron Deficiency in Europe. Public Health Nutr. 2001.4(2B): 537–545. doi:10.1079/PHN2001139
[44] Navas-Carretero S et al. Oily Fish Increases Iron Bioavailability of a Phytate Rich Meal in Young Iron Deficient Women, Journal of the American College of Nutrition.2008. 27(1); 96-101. doi: 10.1080/07315724.2008.10719680
[45] Center for Disease Control: Morbidity and Mortality Weekly report. Current version November 2005. www.cdc.gov/mmwr (Last access 20 September 2005).
[46] Black RE. Global distribution and disease burden related to micronutrient deficiencies.Nestle Nutr Inst Workshop Ser. 2014. 78:21–28. doi.org/10.1159/000354932
[47] Ryckman T et al. Affordability of nutritious foods for complementary feeding in Eastern and Southern Africa. Nutrition reviews. 2021. 79(1): 35-51.doi.org/10.1093/nutrit/nuaa137
[48] Landahl G et al. Iron deficiency and anemia: a common problem in female elite soccer players. International Journal of Sports Nutrition and Exercise Metabolism.2005.15(6): 689-694.doi.org/10.1123/ijsnem.15.6.689

DOI:https://doi.org/10.54393/pbmj.v5i3.336

[49] Sim M et al. Iron considerations for the athlete: a narrative review. European Journal of Applied Physiology. 2019. 119(7): 1463-1478.doi.org/10.1007/s00421-019-04157-y

[50] McCormick R et al. Refining Treatment Strategies for Iron Deficient Athletes. Sports Medicine.2020. 1-13.doi.org/10.1007/s40279-020-01360-2

[51] Sheridan HC, Parker LJ and Hammond KM. Dietary supplements for consideration in elite female footballers. European Journal of Sport Science.2021:1-17. doi.org/10.1080/17461391.2021.1988149

[52] Badenhorst CE et al. Iron status in athletic females, a shift in perspective on an old paradigm. Journal of sports sciences.2021: 1-11. doi.org/10.1080/02640414.2021.1885782

[53] Akalu Y et al. Iron-rich food consumption and associated factors among children aged 6–23 months in sub-Saharan Africa: A multilevel analysis of Demographic and Health Surveys. Plos one. 2021, 16(6): e0253221. doi.org/10.1371/journal.pone.0253221

[54] Baker RD, Greer FR and Committee on Nutrition American Academy of P. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0-3 years of age). Pediatrics. 2010.126:1040-50.doi.org/10.1542/peds.2010-2576

[55] Davis KE et al. Infant feeding practices and dietary consumption of US infants and toddlers: National Health and Nutrition Examination Survey (NHANES) 2003-2012. Public Health Nutr. 2018.21:711-720. doi.org/10.1017/S1368980017003184

[56] Eldridge AL et al. Trends in mean nutrient intakes of US infants, toddlers, and young children from 3 Feeding Infants and Toddlers Studies (FITS). J Nutr 2019.149:1230-1237.doi.org/10.1093/jn/nxz054

[57] Centers for Disease Control and Prevention. Breastfeeding among U.S. children born 2010–2017, CDC National Immunization Survey. 2017. Available from https://www.cdc.gov/breastfeeding/data/nis_data/results.html.

[58] Van Elswyk ME, Murray RD and McNeill SH. Iron-rich Complementary Foods: Imperative for All Infants. Current Developments in Nutrition. 2021.doi.org/10.1093/cdn/nzab117

[59] Estecha QS et al. Adolescent undernutrition in South Asia: A scoping review. Nutrition Research Reviews.2021: 1-11. doi:10.1017/S0954422421000068

[60] Habib MA et al. Prevalence and determinants of iron deficiency anemia among nonpregnant women of reproductive age in Pakistan. Asia Pacific J. Clin. Nutrit.2018.27(1): 195–203. doi.org/10.6133/apjcn.042017.14. 29222899.

[61] Usman M et al. Malabsorption; acase of Microcytic Anemia in Pakistan. Baqai J. Health Sci. 2019. 2(2).https://baqai.edu.pk/baqaiassets/bjhs/admin/articlefiles/2021/1623906814upl0.pdf

[62] Lone NM et al. Role of TMPRSS6 rs855791 (T> C) polymorphism in reproductive age women with iron deficiency anemia from Lahore, Pakistan. Saudi journal of biological sciences.2021. 28(1): 748-753.doi.org/10.1016/j.sjbs.2020.11.004

[63] Imran IK et al. Incidence of Anemia in the Population of Dir (Lower) Khyber Pakhtunkhwa. RADS Journal of Pharmacy and Pharmaceutical Sciences.2021. 9(1): 1-6. doi.org/10.37962/jpps.v9i1.419

[64] 64. Ali H et al. Assessment of nutritional status of lactating mothers in Multan, Pakistan: A case study. The Professional Medical Journal.2021. 28(06): 813-818.doi.org/10.29309/TPMJ/2021.28.06.6119

[65] Abdelhaleim AF, Amer AY and Abdo Soliman JS. Association of zinc deficiency with iron deficiency anemia and its symptoms: results from a case-control study, Cureus. 2019.doi: 10.7759/cureus.3811.

[66] Migone De Amicis M et al., Acquired Refractory Iron Deficiency Anemia. Mediterranean journal of hematology and infectious diseases. 2021. 13(1): e2021028. doi.org/10.4084/MJHID.2021.028

[67] Harrabi MA et al. Iron deficiency anemia induces postural control disorders in young women. Journal of Trace Elements in Medicine and Biology.2021. 68: 126868.doi.org/10.1016/j.jtemb.2021.126868

[68] Mantadakis E, Chatzimichael E and Zikidou P. Iron deficiency anemia in children residing in high and low-income countries: risk factors, prevention, diagnosis and therapy. Mediterr. J Hematol Infect Dis. 2020.12(1): e2020041,doi.org/10.4048/MJHID.2020.041

[69] Griffin IJ and Rogido M. Temporal Trends in Iron Intake, Iron Fortification, and Iron Deficiency. The Journal of Nutrition. The Journal of Nutrition Commentary. 2021. doi.org/10.1093/jn/nxab141.

[70] Paul P, Maiti D and Adhikary T. Iron deficiency anemia-An updated overview. International Journal of Research in Pharmacy and Pharmaceutical Sciences. 2021. 6(4): 28-33. https://www.researchgate.net/publication/354447233

[71] Murray-Kolb LE and Beard JL. Iron treatment normalizes cognitive functioning in young women. The American journal of clinical nutrition. 2007. 85(3): 778-787.doi: 10.1093/ajcn/85.3.778.

DOI:https://doi.org/10.54393/pbmj.v5i3.336

[72] Zulfiqar H et al. Dietary association of iron deficiency anemia and related pregnancy outcomes. Food Sci Nutr. 2021. 9:4127–4133. doi: 10.1002/fsn3.2373
[73] Sungkar A. The Role of Iron Adequacy for Maternal and Fetal Health. World Nutrition Journal.2021. 5(1-1): 10-15. doi.org/10.25220/WNJ.V05.S1.0002
[74] Slywitch E et al. Iron Deficiency in Vegetarian and Omnivorous Individuals: Analysis of 1340 Individuals. Nutrients. 2021. 13(9). 2964. https://www.mdpi.com/2072-6643/13/9/2964#
[75] Hou Y et al. Estrogen regulates iron homeostasis through governing hepatic hepcidin expression via an estrogen response element. Gene.2012.511(2): 398-403.doi.org/10.1016/j.gene.2012.09.060
[76] Pasricha SR et al. Control of iron deficiency anemia in low-and middle-income countries. Blood, The Journal of the American Society of Hematology.2013. 121(14): 2607-2617.doi.org/10.1182/blood-2012-09-453522
[77] Samuelson Bannow B, McLintock C and James P. Menstruation, anticoagulation, and contraception: VTE and uterine bleeding. Research and Practice in Thrombosis and Haemostasis.2021. 5(5): e12570.doi.org/10.1002/rth2.12570
[78] Kayande S, Patil S and Ansari IT. Herbal remedies and dietary supplement during menstrual cycle. 2021. 1(2): 38-44. https://dimpsij.in/wp-content/uploads/2021/09/DIMPSIJ_01_02_04-Shivhari-Shruti.pdf
[79] Zhang YY et al. Opportunities for plant-derived enhancers for iron, zinc, and calcium bioavailability: A review. Comprehensive Reviews in Food Science and Food Safety. 2021. 20(1): 652-685. doi.org/10.1111/1541-4337.12669
[80] Regula J, Krejpcio Z and Staniek H. Bioavailability of iron from cereal products enriched with dried shittake mushrooms (Lentinula edodes) as determined by iron regeneration efficacy method in female rats. Journal of medicinal food.2010. 13(5): 1189-1194.doi.org/10.1089/jmf.2009.0200
[81] Khoja KK et al. In vitro bioaccessibility and bioavailability of iron from fenugreek, baobab and moringa. Food Chemistry. 2021.335: 127671. doi.org/10.1016/j.foodchem.2020.127671
[82] Kepp KP. Heme: From quantum spin crossover to oxygen manager of life. Coordination Chemistry Reviews.2017. 344:363–374. doi.org/10.1016/j.ccr.2016.08.008
[83] Schönfeldt HC and Hall NG. Determining iron bio-availability with a constant heme iron value, Journal of Food Composition and Analysis. 2011. 24(4–5): 738-740. doi.org/10.1016/j.jfca.2011.01.002.
[84] Saunders AV et al. Iron and vegetarian diets. The Medical Journal of Australia.2013. 199(4): S11-S16. doi: 10.5694/mja11.11494