International Journal of Pharmacy and Industrial Research (IJPIR)

IJPIR |Vol.15 | Issue 4 | Oct - Dec -2025

www.ijpir.com

DOI : https://doi.org/10.61096/ijpir.v15.iss4.2025.632 -638

ISSN: 2231-3656
Print: 2231-3648

Review

Fighting Anaemia: Unpacking the Iron Power of Meat vs Greens

Katteti Pujitha[1], Chevuru Baby Shalini[*2], Dr. Afroz Patan[3], Yadala Prapurna Chandra[4]

[1]Ratnam institute of pharmacy, Pidhapulour(V), Muthukur(M), SPSR Nellore Dt.524346 A.P., India.
[2]Assistant Professor, Department of Pharmacy Practice, Ratnam Institute of Pharmacy, Pidathapolur (V), Muthukur(M), SPSR Nellore Dt.524346 A.P., India.
[3]HOD & Associate Professor, Department of Pharmacy Practice, Ratnam Institute of Pharmacy, Pidathapolur (V), Muthukur(M), SPSR Nellore Dt.524346 A.P., India.
[4]Principal & Professor, Department of Pharmacology, Ratnam Institute of Pharmacy, Pidathapolur (V), Muthukur (M), SPSR Nellore Dt.524346 A.P., India.

*Author for Correspondence: Chevuru Baby Shalini
Email: shalinichevuru99@gmail.com

Published on: 24 Oct 2025

Published by:
Futuristic Publications

Abstract

Iron is an essential micronutrient required for oxygen transport, energy production, and immune function. Despite its importance, iron deficiency remains one of the most common nutritional disorders worldwide, particularly among women and children. Adequate dietary intake alone does not always guarantee sufficient iron levels, as the body's ability to absorb and utilize iron plays a crucial role. Learning how to boost iron absorption is therefore vital in preventing anaemia and maintaining overall health. Several dietary and lifestyle factors influence iron bioavailability. Consuming home iron sources such as meat, poultry, and fish significantly improve absorption compared to plant – based non-heme iron. However, pairing non-heme iron foods like legumes, spinach, and fortified cereals with vitamin C – rich foods __ such as citrus fruits, tomatoes, and peppers _ can enhance absorption by converting iron into a more soluble form. Conversely, certain compounds like phytates in grains, tannins in tea and coffee, and calcium in dairy products can inhibit absorption when consumed in excess. Cooking techniques, including soaking, fermenting, or sprouting legumes and grains, also reduce inhibitors and improve iron uptake. Additionally, maintaining gut health through probiotics may further support nutrient absorption. Education on meal planning and food combinations can empower individuals to optimize iron intake without necessarily increasing consumption. Understanding these strategies provides a practical, cost – effective, and sustainable way to combat iron deficiency and improve overall well-being.

Keywords: Iron absorption, heme iron, non-heme iron, vitamin C, phytates, tannins, calcium, anaemia, neutrino, dietary strategies

INTRODUCTION

Iron is an essential trace mineral required for numerous physiological processes. Red blood cells and myoglobin in muscle both oxygen and transport it throughout the body [(1)]. Beyond oxygen delivery, iron is crucial for cellular energy production, as it is part of cytochromes in the electron transport chain, enabling ATP synthesis [(2)]. It also contributes to immune system function, DNA synthesis, and proper neurological development, particularly in infants and children [(3)].

IRON DEFICIENCY

- Iron deficiency is a condition in which the body does not have enough iron to meet its physiological needs. Since iron is essential for the production of haemoglobin, its deficiency reduces the blood's capacity to transport oxygen, often leading to iron-deficiency anaemia (IDA) [(2)].
- The symptoms of iron deficiency can range from mild to severe and include fatigue, weakness, pale skin, dizziness, brittle mails, and impaired cognitive or physical performance[(3)]. If untreated, iron deficiency can result in reduced work capacity, impaired learning and memory in children, and complications during pregnancy such as premature birth or low birth weight [(4)].

Effects of iron deficiency (lack of iron)

- When iron is insufficient, the body cannot make enough haemoglobin, leading to iron-deficiency anaemia (IDA). This reduces oxygen transport and causes fatigue, weakness, pale skin, dizziness, poor concentration, and reduced exercise capacity [(2)].
- Long-term deficiency impairs cognitive development in children, reduce immune function, and in pregnant women increases risks of premature birth and low birth weight [(4, 5)].

Effects of iron overload (excess iron)

Excessive iron, known as iron overload, is equally harmful. It can result from genetic conditions like hereditary hemochromatosis, repeated blood transfusions, or over-supplementation [(8)].

When iron accumulates beyond storage capacity, it generates free radicals that damage tissues oxidative stress. This may cause:

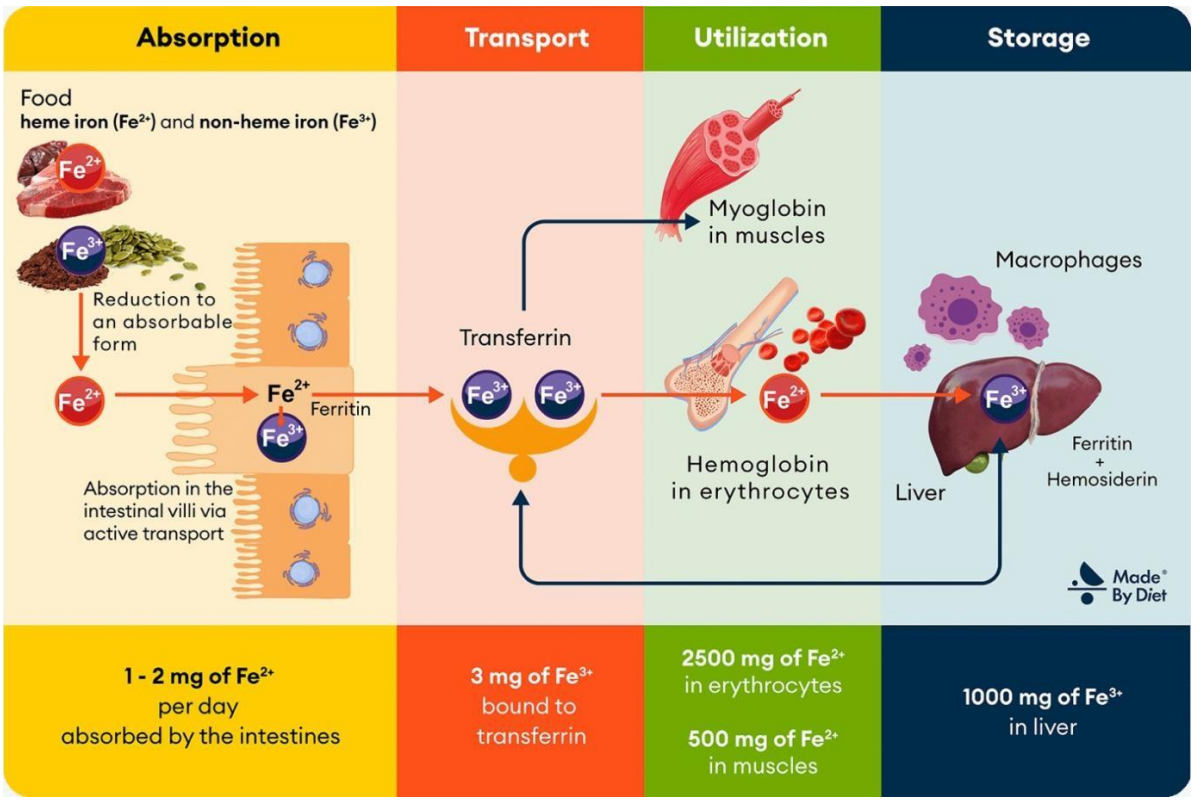
- liver damage (cirrhosis, liver cancer)
- Heart disease (arrhythmias, heart failure)
- Diabetes mellitus (from pancreatic injury)
- Skin hyperpigmentation (bronze discoloration) [(2, 8)].

INTRODUCTION TO DIETARY IRON ABSORPTION

Dietary iron exists in two main forms: heme iron, derived from animal sources such as meat and fish, and non – heme iron, which is present in plant – based foods, fortified cereals, and dairy products. Heme iron is generally absorbed more efficiently (15 -35 %) compared to non- heme iron (2-20%), largely because its absorption is less affected by dietary inhibitors [(9)]. Non- heme iron absorption, in contrast, is highly influenced by enhancers such as vitamin c and organic acids, as well as inhibitors like phytates, polyphenols, and calcium [(10)].

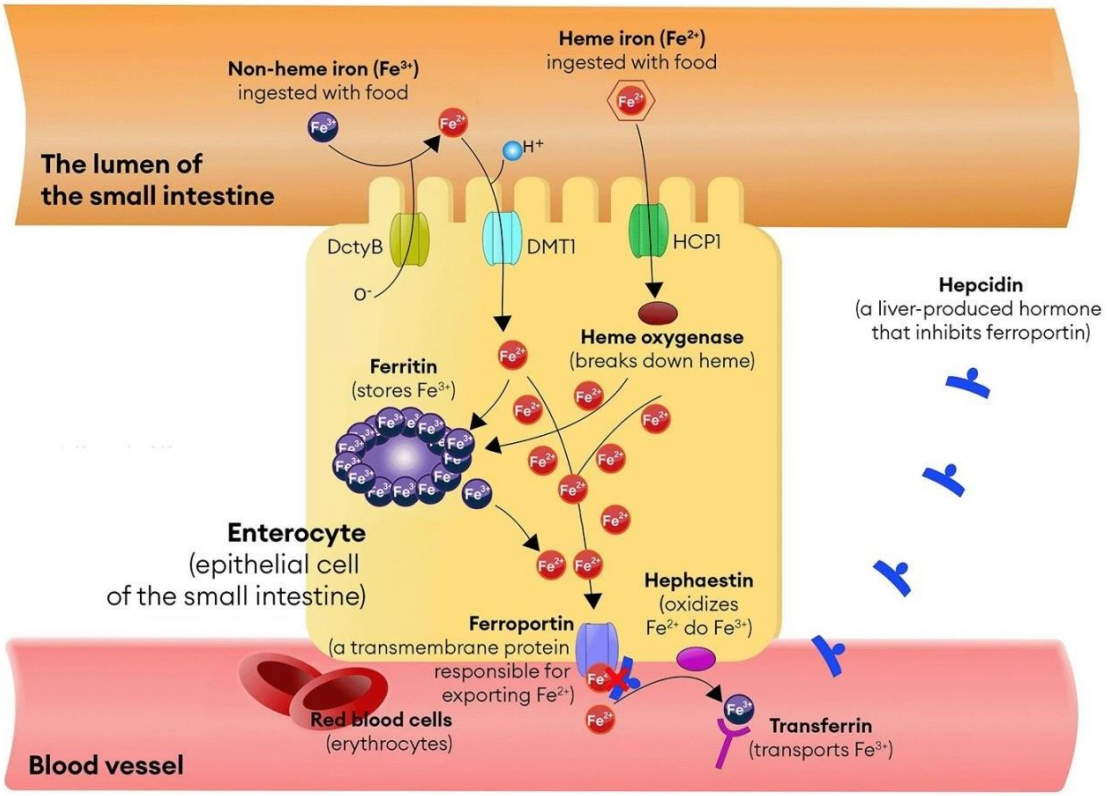
HEME IRON
Source: Found only in animal – based foods such as red meat, poultry, liver, and fish.
Structure: present as part of haemoglobin (in blood) and myoglobin (in muscles)
Absorption: Readily absorbed by the intestine (15-35%), and its absorption is largely unaffected by other dietary factors.
Significance: Although it makes up a smaller portion of dietary intake compared to non- heme iron; it contributes significantly to total iron adsorbed due to its high bioavailability [(9)].

Foods rich in heme iron (per 100 g, approximate iron content)
- Chicken liver – 9 mg
- Beef liver – 6.5 mg
- Oysters – 6 mg
- Beef (lean red meat) – 2.5–3 mg
- Sardines (canned) – 2.9 mg
- Tuna – 1.3 mg
- Chicken – 1.3 mg
- Turkey (dark meat) – 1.4 mg



NON-HEME IRON:
Source: Found in plant based foods such as legumes, cereals, vegetables, nuts, and fortified products.
Structure: Exists as inorganic iron salts or bound to plant compounds (e.g., phytates, polyphenols).
Absorption: less efficiently absorbed (2-20%) and strongly influenced by enhancers (e.g., vitamin c, meat, and fish) and inhibitors (e.g., phytates, tannins, calcium) [(10)].
Significance: Represent the majority dietary iron intake worldwide, particular in populations with plant-based diets, but requires careful dietary planning to improve absorption [(11)].

Foods rich in non-heme iron (per 100 g, approximate iron content)
- Pumpkin seeds – 8.8 mg
- White beans – 8 mg
- Lentils (cooked) – 3.3 mg
- Spinach (cooked) – 3.6 mg
- Quinoa (cooked) – 2.8 mg
- Tofu – 5.4 mg
- Fortified breakfast cereals – up to 12–18 mg (varies by brand)
- Chickpeas – 2.9 mg



EPIDEMIOLOGY
- Iron deficiency is the most common nutritional disorder worldwide, affecting an estimated **1.**2 billion people, with the highest prevalence among women of reproductive age, pregnant women, and young children [(12)]. Despite adequate dietary iron intake in many populations, poor absorption is a major contributing factor to deficiency. This makes strategies to enhance iron absorption a critical public health concern.
- Globally, the prevalence of iron deficiency anemia (IDA) ranges from 20–50% in developing countries and around 10–15% in industrialized nations [(14)]. Regional dietary habits play a significant role populations consuming plant-based diets rich in phytates, tannins, and polyphenols often experience reduced bioavailability of non-heme iron. Conversely, populations with higher consumption of meat, fish, and vitamin C–rich foods show better iron status due to improved absorption.
- Epidemiological evidence indicates that interventions aimed at enhancing absorption such as fortification, supplementation, and dietary modifications are effective in reducing iron deficiency. For example, fortification of staple foods with iron and vitamin C in several countries has significantly lowered IDA

prevalence in children and women. Additionally, educational programs promoting dietary enhancers like ascorbic acid, heme iron sources, and fermented foods while reducing inhibitors like tea, coffee, and phytates have shown positive outcome[12].

ETIOLOGY

Iron absorption mainly occurs in the duodenum and upper jejunum, and its efficiency is influenced by several physiological, dietary, and pathological factors. Impaired iron absorption can lead to iron deficiency and subsequently iron- deficiency anemia.

1. Dietary factors:

- **Low intake of bioavailability iron:** diets lacking heme iron sources (meat, poultry, and fish) reduce overall absorption efficiency [10].
- **Presence of inhibitors:** substances such as phytates (in cereals, legumes), polyphenols (in tea, coffee), and excessive calcium interfere with non-heme iron absorption [15].
- **Enhancers absent:** lack of vitamin c and animal proteins reduces solubility and uptake of non-heme iron [10].

2. Physiological factors:

- **Gastric acid deficiency:** reduced stomach acid (from aging or proton pump inhibitors) impairs iron solubilization and absorption [16].
- **Increased demand:** pregnancy, growth, or chronic blood loss increases iron needs, making absorption insufficient even if intake is normal [17].

3. Disease – related factors:

- **Gastrointestinal disorders:** conditions such as celiac disease, inflammatory bowel disease, and gastric bypass surgery impair absorption due to mucosal damage or reduced absorptive surface area [18].
- **Parasitic infections:** hookworm and schistosomiasis contribute to both iron loss and impaired absorption [20].

CLINICAL MANIFESTATIONS

Iron absorption itself does not directly produce symptoms because it is a physiological process that occurs mainly in the duodenum and upper jejunum. However, when iron absorption is impaired or insufficient, it can lead to iron deficiency and eventually iron deficiency anemia (IDA), which present with recognizable clinical symptoms. Fatigue and weakness – The most common symptom due to reduced hemoglobin synthesis and decreased oxygen transport in tissues [14].

- Pallor (pale skin and mucous membranes) – Caused by reduced hemoglobin concentration [21].
- Shortness of breath and dizziness – Occur as compensatory responses to inadequate oxygen supply [22].
- Headache and difficulty concentrating – Result from cerebral hypoxia associated with anemia [12].
- Cold hands and feet – Due to poor oxygen delivery to peripheral tissues [23].
- Glossitis and angular cheilitis – Inflammation of the tongue and cracks at the corners of the mouth are common mucosal change [14].
- Brittle nails and koilonychia (spoon-shaped nails) – Classic signs of chronic iron deficiency [22].
- Restless legs syndrome – Frequently reported in individuals with low iron levels [7].

TREATMENT

NON-PHARMACOLOGICAL TREATMENT

Non-pharmacological strategies play a vital role in improving iron absorption, particularly in populations where iron deficiency is widespread. These methods focus on dietary modifications, meal planning, and lifestyle interventions that enhance bioavailability of dietary iron without the use of drugs or supplements.

- **Enhancing Intake of Heme Iron Foods**
  Heme iron, present in animal products such as red meat, poultry, and fish, is more efficiently absorbed compared to non-heme iron from plant sources. Including moderate amounts of heme iron in meals can improve overall iron status and also facilitate the absorption of non-heme iron when consumed together [10].
- **Vitamin C–Rich Foods**
  Ascorbic acid is a strong enhancer of non-heme iron absorption. Consuming vitamin C-rich foods like citrus fruits, tomatoes, bell peppers, or guava with iron-rich meals can convert ferric iron into its more absorbable ferrous form, thereby improving uptake [15].
- **Food Preparation Techniques**
  Traditional methods such as soaking, germination, and fermentation of legumes and cereals can reduce phytate content, thus improving iron bioavailability. For instance, fermentation of cereals into sourdough bread has been shown to lower phytate levels and increase iron absorption [25].
- **Dietary Diversification**
  A balanced diet combining both plant and animal sources of iron with enhancers such as fruits and

vegetables helps improve iron status naturally. Promoting locally available iron-rich foods, especially in resource-limited settings, is considered a sustainable approach [26,27].

CONCLUSION

Enhancing iron absorption is a key strategy in preventing and managing iron deficiency and iron deficiency anemia, which remain significant global health problems. Since dietary iron exists in two forms heme and non-heme understanding the factors that influence their absorption is crucial. Heme iron from animal sources is more efficiently absorbed, while non-heme iron from plant-based foods requires supportive dietary practices to improve its bioavailability. Non-pharmacological measures, such as increasing vitamin C intake, consuming meat alongside plant foods, and reducing inhibitors like phytates, tannins, and calcium during iron-rich meals, have been shown to markedly improve absorption efficiency. Public health approaches, including dietary diversification, food fortification, and education on meal composition, further strengthen individual and community outcomes. Ultimately, adopting these strategies can significantly reduce the burden of iron deficiency, especially in vulnerable groups such as women of reproductive age, children, and pregnant women. Therefore, boosting iron absorption through and accessible dietary practices is an effective pathway to improving overall health and preventing anemia worldwide.

REFERENCES

1. Harvard T.H. Chan School of Public Health. Iron. The Nutrition Source. 2024 [cited 2025 oct 6].
2. National Institutes of Health, Office of Dietary Supplements. Iron: Fact Sheet for Health Professionals. 2022 [cited 2025 Oct 6].
3. MedlinePlus. Iron. U.S. National Library of Medicine. 2023 [cited 2025 Oct 6].
4. World Health Organization. Micronutrient deficiencies: Iron deficiency anaemia. 2020 [cited 2025 Oct 6].
5. Lozoff B. Early iron deficiency has brain and behavior effects consistent with dopaminergic dysfunction. J Nutr. 2011;141(4):740S–746S.
6. Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning. J Nutr. 2001;131(2):568S–580S.
7. Allen RP, Picchietti DL, Garcia-Borreguero D. Restless legs syndrome/Willis-Ekbom disease diagnostic criteria. Sleep Med. 2013;14(4):275–280.
8. Pietrangelo A. Hereditary hemochromatosis: Pathogenesis, diagnosis, and treatment. Gastroenterology. 2015;149(5):1240–1251.
9. Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. J Res Med Sci. 2014;19(2):164–174.
10. Hurrell R, Egli I. Iron bioavailability and dietary reference values. Am J Clin Nutr. 2010;91(5):1461S–1467S. doi:10.3945/ajcn.2010.28674F
11. Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet. 2007;370(9586):511–520.
12. World Health Organization (WHO). Guideline on Use of Ferritin Concentrations to Assess Iron Status in Individuals and Populations. Geneva: WHO; 2021.
13. World Health Organization (WHO). Anaemia. 2021 [cited 2025 Oct 6].
14. Camaschella C. Iron-deficiency anemia. N Engl J Med. 2015;372(19):1832–1843.
15. Hallberg L, Brune M, Rossander L. Iron absorption in man: ascorbic acid and dose-dependent inhibition by phytate. Am J Clin Nutr. 1989;49(1):140–144. doi:10.1093/ajcn/49.1.140
16. Hutchinson C. A review of iron studies in overweight and obese children and adolescents: a double burden in the young? Eur J Nutr. 2018;57(3):873–884. doi:10.1007/s00394-017-1491-1
17. Milman N. Iron in pregnancy: how do we secure an appropriate iron status in the mother and child? Ann Nutr Metab. 2011;59(1):50–54. doi:10.1159/000332129
18. Short MW, Domagalski JE. Iron deficiency anemia: evaluation and management. Am Fam Physician. 2013;87(2):98–104.
19. Weiss G, Goodnough LT. Anemia of chronic disease. N Engl J Med. 2005;352(10):1011–1023. doi:10.1056/NEJMra041809
20. McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Health Nutr. 2009;12(4):444–454. doi:10.1017/S1368980008002401
21. Cappellini MD, Musallam KM, Taher AT. Iron deficiency anaemia revisited. J Intern Med. 2020;287(2):153–170.
22. Lopez A, Cacoub P, Macdougall IC, Peyrin-Biroulet L. Iron deficiency anaemia. Lancet. 2016;387(10021):907–916.
23. Killip S, Bennett JM, Chambers MD. Iron deficiency anemia. Am Fam Physician. 2007;75(5):671–678.

24. Allen RP, et al. Restless legs syndrome: Diagnostic criteria, special considerations, and epidemiology. Sleep Med. 2013;14(7):825–834.
25. Gibson RS, Perlas L, Hotz C. Improving the bioavailability of nutrients in plant foods at the household level. Proc Nutr Soc. 2010;65(2):160–168. doi:10.1079/PNS2006499
26. FAO/WHO. Vitamin and mineral requirements in human nutrition. 2nd ed. Geneva: World Health Organization; 2004.
27. Made by Diet. Iron in the diet: Iron-rich foods, excess and deficiency symptoms. [cited 2025 Oct 6].