

# IRON ABSORPTION



## WHY DO WE NEED IRON?

Iron is a mineral found in every cell in the body. It is vital for both physical health and mental well-being. Iron has three main functions:

- carrying oxygen from the lungs to the rest of the body;
- maintaining a healthy immune system;
- aiding energy production.

Insufficient dietary iron can result in iron deficiency. Effects of this include (1):

- fatigue;
- lethargy;
- more frequent infections;
- reduced resistance to cold;
- impaired learning.

Iron deficiency and brain function are closely related. Long-term iron deficiency in infants and young children can lead to developmental delay and learning difficulties which may be irreversible (2).

Lack of iron is one of the most common nutritional disorders in the world, particularly in developing countries. Infants, children, teenagers and pre-menopausal women are most likely to be iron deficient. In New Zealand it is estimated about 42% of women aged 15-44 are eating less iron than the recommended dietary intake (RDI) (3).

## RECOMMENDED DIETARY IRON INTAKE

The amount of iron needed to meet the recommended dietary intake (RDI) is dependent not only on total iron intake but also the bioavailability of that iron. Bioavailability refers to the body's ability to absorb and use the iron in a food. It is based on the assumption that 18% of total iron will be absorbed (4). For example, the iron RDI for women under 50 years is 18 mg per day, with about 3 mg absorbed.

### RECOMMENDED DIETARY INTAKES FOR IRON

	mg iron per day
Infants (7-12 months)	11
Children (1-13 years)	8 – 10
Boys (14-18 years)	11
Girls (14-18 years)	15
Women (19-50 years)	18
Pregnant women	27
Breastfeeding women	9 – 10
Women over 50 years	8
Men over 19 years	8

## TYPES OF IRON

### THERE ARE TWO TYPES OF IRON IN FOOD:

- haem iron, derived from the haemoglobin and myoglobin found in meat tissue;
- non-haem iron, derived mainly from cereals, legumes, fruit and vegetables.

Absorption and excretion of iron are tightly controlled by the body. Absorption appears to be the prime factor controlling the amount of iron in the body (5). The absorption of haem and non-haem iron is quite different.

### HAEM IRON

- Haem iron is found only in animal foods. The iron in meat is approximately 40% haem iron and 60% non-haem iron. Plant foods do not contain any haem iron (6).
- Haem iron is well absorbed and relatively unaffected by other factors (7,8).
- It is influenced to some extent by the body's iron stores. This can vary from 15% absorption in an individual with replete iron stores, to 35% absorption in an individual with depleted iron stores (9). The average absorption of haem iron in meat is about 25%.

### NON-HAEM IRON

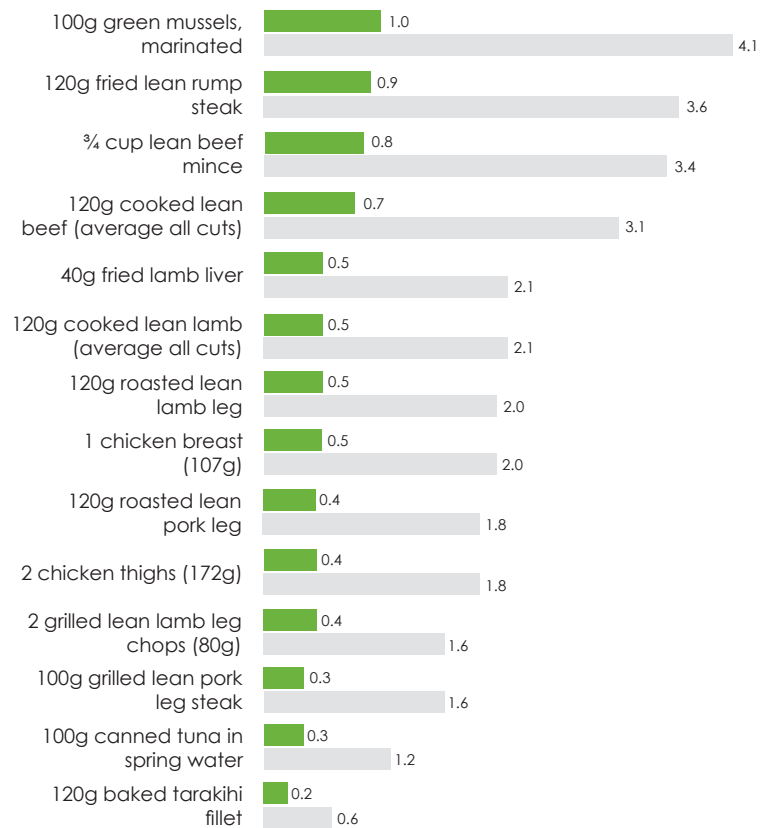
- Non-haem iron is found in both plant and animal foods.
- It is not as well absorbed as haem iron and is affected by both the iron status of an individual, and components in foods eaten at the same time (10).
- Absorption of non-haem iron can vary from under 1% in an individual with replete stores to 20% in an individual with depleted iron stores (5).
- Generally non-haem iron absorption is less than 5% (11).

Although most of the iron we eat is from non-haem sources, we actually obtain up to 80% of our iron from haem iron because it is more bioavailable (11,12).

## IRON FOODS

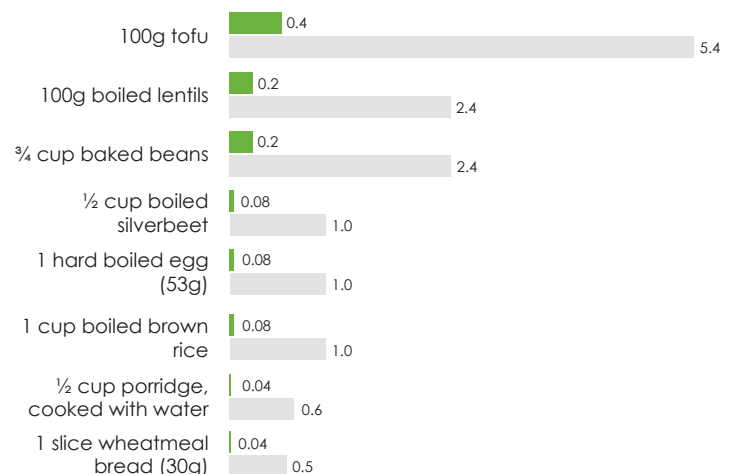
### HAEM IRON FOODS

- Best absorbed (typically 10 to 25%)



### NON-HAEM IRON FOODS

- Less absorbed (typically under 1 to 8%)



### KEY

- Absorbed Iron (mg)
- Total Iron (mg)

Source: The Concise New Zealand Food Composition Tables, 10th ed. (13).

# MEAT AND VITAMIN C IMPROVE NON-HAEM IRON ABSORPTION

## MEAT

Red meat enhances iron status in two ways:

- by providing easily absorbable haem iron;
- by increasing the availability of non-haem iron from cereals, legumes, fruit and vegetables.

Animal protein from beef, lamb, other meats, fish and poultry increases non-haem iron absorption by up to four times. The mechanism for this effect has not been established (11,14).

Not all foods of animal origin have the same effect as meat protein. Animal proteins in milk, cheese and eggs do not show the same enhancing effect.

## VITAMIN C (ASCORBIC ACID)

- Vitamin C can increase the absorption of non-haem iron by two to three times. There is a dose-related effect; the more vitamin C in a meal, the greater the iron absorption - up to a limit of around 100mg vitamin C (11,14). Vitamin C is found in fruit and vegetables. Both heat and air reduce vitamin C content, so care should be taken when cooking and storing fruit and vegetables.

## FOODS HIGH IN VITAMIN C

- Kiwifruit
- Capsicum
- Citrus fruit - oranges, grapefruit, lemons and limes
- Fruit juice
- Tomatoes
- Broccoli
- Cauliflower
- Feijoa
- Tamarillos

# FACTORS THAT INHIBIT NON-HAEM IRON ABSORPTION

The factors that inhibit non-haem iron absorption are mainly present in plant foods. These include polyphenols, oxalate, phytates, soy protein and dietary fibre.

## POLYPHENOLS

Almost all plants contain phenol compounds but only a few inhibit iron absorption, in particular the tannins in tea, coffee and cocoa. Tea can reduce iron absorption by as much as 60- 75% (16), so should be drunk between meals to optimise iron absorption (15,16). Infants and young children should not be given tea (17).

## OXALATE

Oxalic acid forms complexes with iron, making it unavailable for absorption. Oxalic acid is present in plants, especially spinach, beetroot and rhubarb. These foods are generally not eaten in large amounts and their effect on iron absorption overall is insignificant for most individuals.

## PHYTATES

Phytates are compounds that bind minerals such as iron, zinc and calcium, making them unavailable for absorption in the body. They are present in wholegrain breads, cereals, grains, seeds, nuts, vegetables and fruit. As phytate levels increase in a food, iron absorption is reduced.

## SOY PROTEIN

Soy protein inhibits non-haem iron absorption independent of its phytate content (18). However, bioavailability is improved in fermented soy foods such as tempeh fermentation and miso because fermentation helps to degrade the protein (19).

## DIETARY FIBRE

An increased intake of dietary fibre from wheat bran, extraction flour and oats leads to a reduction of total iron absorption. The nutritional benefits of dietary fibre such as increasing faecal bulk and preventing constipation must be balanced against the disadvantage of reduced iron absorption (20).

## CALCIUM

It was previously believed calcium inhibited the absorption of non-haem iron, but recent research has shown this to be incorrect (21,22). Both calcium and iron from breast milk are well-absorbed.

## FACTORS AFFECTING NON-HAEM IRON ABSORPTION

Improve absorption	Inhibit absorption
Meat, fish and poultry	Tannins in tea, coffee and cocoa
Citrus fruit	Phytates in wholegrains
Kiwifruit	Soy protein
Tomatoes	Dietary fibre
Capsicum	
Broccoli, cauliflower	

## NON-DIETARY FACTORS

There are also non-dietary factors which can affect iron absorption. These include certain medications, e.g. omeprazole and conditions such as infection.

## GROUPS WITH SPECIAL NEEDS

Some groups in the population are at greater risk of developing iron deficiency. This may be due to increased iron requirements through menstrual losses or pregnancy, high requirements of infants and young children for physical and mental growth and development, high iron requirements for athletes, or reduced energy intake of some frail, older adults.

### INFANTS AND YOUNG CHILDREN

Full-term infants are born with sufficient iron to meet their needs for the first four to six months of life. Iron transfer to the foetus seems to occur mainly in late gestation therefore pre-term babies (those born before 35-36 weeks gestation) may be at particular risk of iron deficiency.

Breast milk is not particularly high in iron, but its iron is very well absorbed (50%) (23). Only about 10% of the iron in infant formula is absorbed, therefore proportionally more iron and vitamin C is added to formula to ensure an adequate supply. All of the commercially available infant formulas in New Zealand are fortified with iron. The introduction of plain cows' milk as a substitute for breast milk is not recommended for infants under the age of one. It does not contain sufficient iron to meet the needs of infants at this age and the iron in cows' milk is poorly absorbed. Iron absorption from complementary foods, such as infant cereals, can almost double when foods containing vitamin C are consumed at the same meal (24). Increased meat intake during weaning has also been shown to prevent a decrease in haemoglobin in late infancy, probably by enhancing iron absorption (25).

#### Nutrition advice for infants and young children

(26)

- Include lean red meat - for iron intake as well as improving non-haem iron absorption.
- Eat a variety of fruit and vegetables, especially those high in vitamin C.
- Choose iron-fortified breakfast cereals.
- Do not give tea to infants and young children.

### PREGNANT WOMEN

During pregnancy iron needs can increase by as much as 80%. Additional iron supply is required for the growing foetus and placenta and to increase the maternal total red cell mass. Iron requirements during the first 20 weeks of pregnancy are about the same as those of a non-pregnant woman. They may be even less due to cessation of menstruation (27). At about 20 weeks iron requirements increase markedly. To partially compensate for this, the body increases iron absorption threefold.

Iron deficiency anaemia has been linked to an increased risk of pre-term delivery and low birth weight. Iron deficiency may increase the risk of complications during pregnancy (28).

### BREASTFEEDING WOMEN

Assuming menstruation doesn't resume until after six months of exclusive breastfeeding, iron requirements during lactation are less than in pregnancy. The iron content of breast milk (0.35ml/L) is generally unaffected by maternal intake (29).

#### Nutrition advice for pregnant and breastfeeding women

(29)

- Choose a wide variety of foods.
- Eat at least two servings of lean meat, poultry, seafood, eggs, nuts and seeds or legumes per day.
- Eat plenty of fruit and vegetables containing vitamin C to help iron absorption from non-haem sources.
- Avoid drinking tea with meals.

### VEGETARIANS

Although vegetarian diets are often higher in total iron content, body iron stores may be lower because the non-haem iron in plant foods is poorly absorbed (30). A diet based on cereals, legumes, fruit and vegetables contains a reasonably high proportion of phytates, polyphenols and fibre which all inhibit iron absorption.

The nutrient reference values for Australia and New Zealand state, "iron absorption is about 18% from a mixed Western diet including animal foods and about 10% from a vegetarian diet, so vegetarians will need intakes about 80% higher" (4).

Pre-menopausal vegetarian women, in particular, need to be aware of iron-rich foods and the dietary factors that improve or inhibit the absorption of non-haem iron (31).

#### Nutrition advice for vegetarians

- Plan meals carefully.
- Include plenty of vitamin C-rich foods to enhance iron absorption from legumes, nuts, grains and cereals.
- Choose iron-fortified breakfast cereals.
- Avoid tea and coffee with meals.
- Include some fermented soy foods, such as tempeh and miso.

## ATHLETES

Heavy exercise increases iron requirements by increasing iron loss from the body through sweat and gastro-intestinal blood loss. In endurance runners, red blood cells can be destroyed by excessive impact and jarring. Athletes most at risk are endurance runners, those on restricted diets and females with heavy periods.

A condition known as 'Sports or Pseudo anaemia' can occur in some athletes and is a normal adaptation to hard training. It is unrelated to dietary iron intake and therefore does not respond to supplementation. It is referred to as 'pseudo' because iron stores and haemoglobin appear to be low. This is not the case as it is simply due to heavy training increasing plasma volume and diluting haemoglobin levels. An adequate dietary iron intake should be maintained, but additional iron is not required (32).

### Nutrition advice for athletes

- Choose a variety of foods with carbohydrate-containing foods such as breads, cereals, fruits, vegetables and pulses making up around half the intake of energy.
- Ensure protein and iron needs are met by including at least two servings of lean meat, poultry, seafood, eggs, nuts and seeds or legumes per day.

## OLDER ADULTS

The iron needs of post-menopausal women actually reduce once menstruation has stopped. Other factors such as chronic blood loss, drug therapy, disease and cancers are the principal causes of iron deficiency in this age group (33).

Those whose appetite is small and eat very little, have a limited selection of foods, particularly meat, fish and poultry and consume tea or coffee with meals, may be at greater risk of iron deficiency.

## IRON SUPPLEMENTS

The first step when an individual appears to be low in iron is to ensure an adequate intake of lean red meat, as well as fruit and vegetables rich in vitamin C.

Iron supplements should only be used when advised by a dietitian or prescribed by a medical practitioner for diagnosed iron deficiency. Iron supplements should be used cautiously as they may interfere with the absorption of other nutrients such as zinc and calcium.

## CONCLUSION

- Haem and non-haem iron are absorbed differently.
- Meat, fish, poultry and vitamin C improve the absorption of non-haem iron.
- Tannin, oxalate, phytates and dietary fibre all reduce the absorption of non-haem iron.
- Haem iron absorption is not affected by any of these factors.
- For infants, iron and calcium in breast milk are both well absorbed.
- Iron from food is always the first choice before iron tablets, unless recommended by a dietitian or medical practitioner.
- With careful food choices, groups at risk of iron deficiency (infants, pregnant women, vegetarians, athletes and some older adults) can improve the availability of iron in their diets.

## WHAT DOES THIS MEAN FOR HEALTH PROFESSIONALS?

- Encourage people to follow national nutrition guidelines, including at least two servings of lean meat, fish, poultry or legumes and at least five servings of fruit and vegetables each day.
- Give special consideration to infants and young children, teenage girls, pregnant women, female athletes, vegetarians and frail, older adults with limited food intake.
- Encourage people to eat lean red meat as an effective way to improve iron status.
- In low meat and vegetarian diets, focus on iron enhancers. Eat plenty of vitamin C-rich fruit and vegetables.
- Recommend drinking tea only between meals.
- Discourage tea as a beverage for young children.

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