Dietary Iron and Iron Storage Disease

Debra McDonald

Physiological Requirement for Iron

Most body iron is organic
a) haemal
b) nonhaemal

Haemal iron, part of porphyrin group, 70-75% total iron:
- Haemoglobin
- Myoglobin
- Cytochromes
- Cytochrome oxidase
- Catalase
- Peroxidase

Nonhaemal iron, iron transport and storage forms
- Transferrin
- Ferritin
- Haemosiderin
- Iron proteinates

Iron Absorption

Absorbed in duodenum after ferric iron reduced to ferrous form

Reduction of iron enhanced by ascorbic acid

Iron of plant origin more readily absorbed than animal origin

Factors Influencing Bioavailability

Species
- Greater utilisation in cat (carnivore) than chick from beef source
- Greater utilisation in chicks than cats from corn gluten

Ascorbic Acid
- Reduces and chelates nonhaeme iron, increasing absorption
- Maintains soluble complex when intestinal pH increases to enhance solubility of ferric iron (needs to be < pH 4.0)

Protein
- Iron from animal sources is more available because of the higher content of haemal iron
- Cysteine, histidine and lysine form tridentate chelates and improve iron absorption
- Low protein diets increases or interferes with iron uptake
- Iron in soy isolate may be unavailable and increase iron requirement

Pectin
- Pectin in water-soluble fibre can decrease Fe availability
- Can also enhance iron absorption

Minerals
- Increasing dietary Ca +/or P decreases Fe absorption in chicks
- XS Zn can antagonise Fe if also high phytate and soluble fibre

Food Processing
- Heat and pressure increase bioavailability
- Reduction of bioavailability of nonhaeme iron with prolonged heating due to loss of ascorbic acid

Other Factors
- Cellulose and oxalate increase bioavailability
- Fibre from corn or wheat decreases iron retention
    - Inclusion of citrate or ascorbic acid alleviates negative influences

Iron Storage Disease

Common in insectivores and frugivores
Results from an accumulation of iron in various tissues, with liver most frequently involved

Hemosiderosis
- XS accumulation of iron in hepatocytes or free circulation in blood
- Can be a precursor to hemochromatosis

Species Susceptibility

Rhamphastids, Mynahs, Birds of Paradise, Starlings, Flamingo, Lories, Psittacines

Genetic Predisposition

Species that are highly frugivorous or insectivorous are more susceptible

Hemochromatosis in humans:
- correlated with two genes that result in poor regulation of iron uptake across the intestine
- digestive system takes up more iron than normal through the mucosal cells, depositing it in liver and other organs
- diet high in iron has no effect on the progress of the disease

Genetic predisposition not implicated in all species

- Diet has only minor influence on iron distribution in Rothschild mynah
- Other mynah species not able to regulate iron absorption sufficiently

ISD and Immune System

Immunological stress and crowded conditions
High in psittacines with infectious diseases, Polyomavirus
Bacterial infections: sequester free iron temporarily in liver

- Available to bacteria

Diminished production of erythrocytes in final stages of disease

- XS storage in liver

Reduced peristalsis or neuropathic gastric dilatation

- (observed in macaws)
- increases iron absorption.

Dietary Recommendations

Recommended that commercial diets contain less than 100 mg/kg

Preferably below 25 mg/kg

Birds maintained on organic diets of 150 mg/kg

ISD and Diet

Adaptation to low iron diet (insects and fruits)
Fruits high in vitamin C:

- increases transformation of ferric to ferrous
- Studies in humans indicate that high levels of dietary vitamin C doesn't influence iron uptake

Saturated fats increase iron uptake
Stress reduces vitamin E and antioxidant activity
XS vitamin A can diminish vitamin E uptake
Tannins may reduce absorption of bioavailable iron

ISD and Vitamin A

Vitamin A in invertebrates low or negligible
Vitamin A from produce arises from carotenoids (regulated)
Low serum retinol associated with anaemia

- vitamin A and iron supplement increases haemoglobin concentrations
- iron deficiency inhibits mobilisation of vitamin A stores
- inhibits affect of phytate on iron absorption

Vitamin A competes with vitamin E uptake

- carotenoids partially inhibit loss of α-tocopherol

Iron/Vitamin A Content of Invertebrates

Iron content of commercially raised insects varies considerably with highest levels in wildcaught earthworms.
Vitamin A content low in all commercially raised insects but reasonably high in wildcaught earthworms
Possible that diets provided to insects influences vitamin A content

- Maybe birds in the wild are obtaining more vitamin A than captive counterparts

Vitamin A Content of Commercial Foods

Generally high in commercial foods
High productivity on low vitamin A

Carotenoids and Vitamin A

Varying vitamin A activity from different carotenoids
Lycopene has no vitamin A activity
β-carotene can enhance iron uptake

Carotenoids and Lipid Peroxidation

Astaxanthin has greater protective affect than β-carotene or α-tocopherol
protects against lipid peroxidation

Canthaxanthin

- supplemented to promote feather pigmentation
- alters tocopherol status
- decreases glutathione peroxidase
  - protects against hydrogen peroxide
  - haemoglobin in ferrous form is oxidised to ferric form by hydrogen peroxide to yield methaemaglobin
  - glutathione peroxidase protects against formation of methaemaglobin by consuming hydrogen peroxide
- ISD diagnosed in flamingos

Iron/Vitamin C Content of Domestic Fruits

Often fruits that are low in iron have high levels of vitamin C
Enhances uptake
Some of the common fruits fed to birds such as strawberries, cantaloupe, orange and papaya are all high in vitamin C and should be restricted in the diets of birds susceptible to ISD.

Iron/Vitamin C Content of Australian Fruits

Both iron and vitamin C content of some Australian fruits is low

Iron/Vitamin C Content of Australian Insects

Variation in iron content of insects but generally low.
Haeme iron is more available than nonheme iron of plants
Vitamin C content is extremely low but may have lower requirement as not required to enhance iron uptake

Possible that Australian birds have evolved mechanism to convert precursors to vitamin C or have a low dietary requirement for vitamin C