Enhancers

This is my research notes for this section which I’ve left in incase they’re useful. References are at the end.

1. Ascorbic

1.1. How it works
1. by forming a soluble compound with iron (chelating)
2. by reducing ferric to ferrous iron so it can be absorbed (Conrad & Schade, 1968)
3. reducing the effects of all the inhibitors (Fidler 2003)

1.2. General info/studies

(Lynch 1997)
“Ascorbic acid acts by maintaining iron in a soluble bioavailable form as the luminal pH rises once the gastric contents enter the duodenum. Iron, particularly when it is in the ferric form, is soluble only at acid pH. [...] Above a pH of 4 almost all the iron is precipitated from a solution of ferric chloride. However, if ascorbic acid is added to soluble ferric chloride in an acid solution, a complex of iron and ascorbic acid is formed that remains soluble over a wide pH range.”

![Figure 1](image)

Figure 1. Relationship between mean nonheme iron absorption corrected for reference absorption and molar ratio of ascorbic acid to iron in vegetable meals (redrawn from Lynch and Cook\textsuperscript{13} with permission).

My summary
There is a roughly linear relationship between ascorbic dose and absorption (up to a point). How much effect the ascorbic has on absorption also depends on the inhibitors present and on the iron type. It has a smaller effect when added to meat containing meals. Ascorbic acid has increased absorption from vegetable meals by as much as sixfold (Lynch and Cook 1980).

(Fidler 2003)
“Since ascorbic acid has repeatedly been shown to enhance native food iron absorption and fortification iron absorption from single meals, it has been assumed that ascorbic acid would
also have long-term effects on iron absorption and thus iron status. However, intakes of high amounts of ascorbic acid over a long period of time (up to 2 years) failed to show positive effects on iron status in iron replete as well as iron deplete subjects (Cook et al. 1984; Hunt et al. 1994). Further, when iron absorption was measured from the complete diet over a period of 5 days, the intake of high amounts in comparison to low amounts of ascorbic acid did not influence iron absorption (Cook & Reddy, 2001). However, mean ascorbic acid intake when consuming the diet low in ascorbic acid was 51 mg/d, which may be a sufficient amount to enhance iron absorption from a Western diet."

Ascorbic has no effect on heme iron (Lynch et al. 1985)

(Hallberg, Brune, and Rossander 1989) - interesting compares the affect of ascorbic and meat on phytic acid. Shows that ascorbic is more effective than meat in lower doses of phytic

(Fisher and Naughton 2004)
This article talks pretty negatively about the effects of excess ascorbic and iron

The amount of ascorbic to add has been suggested at a molar ratio of 2:1 to iron (Derman et al. 1980a; Stekel et al. 1986; Davidsson et al. 1998b). However higher may be needed when iron taken with inhibitors.


It needs to be eaten with iron. (Cook and Monsen 1977) showed that it had little effect taken 4 or 8 hours before the meal.

(Teucher, Olivares, and Cori 2004)
“The promotion of iron absorption in the presence of AA is more pronounced in meals containing inhibitors of iron absorption. Meals containing low to medium levels of inhibitors require the addition of AA at a molar ratio of 2:1 (e.g., 20 mg AA: 3 mg iron).”

2. Other organic acids

(Lynch 1997)
Natural acids like citric, malic, tartaric, ascorbic, lactic all seem to have comparable enhancing effects as synthetic ascorbic. Vegetables that are considered to have high bioavailability tend to contain more organic acid

(Garcia et al. 1998) study showing lime juice with meal increasing iron absorption
(Gillooly et al. 1983; Derman et al. 1987) showed it increased iron absorption in rice and soybean meals by 2 to 3 times.

(Hallberg & Rossander, 1984) citric acid decreased iron absorption by 50% when added to a simple Latin American meal

(Derman et al. 1980b) showed that lactic acid which is formed during fermentation processes can triple iron absorption from gruels.

(Baynes et al. 1990) showed that lactic acid has no effect on iron absorption

(Gillooly et al. 1983) showed that other fruit and vegetable acids (malic and tartaric) double iron absorption when added to a rice meal.

3. Other acids

3.1. Erythorbic acid
Erythorbic acid is an ascorbic acid derivative, and appears to have an enhancing effect on iron almost double that of ascorbic. It’s used widely in processed foods and interestingly may be a reason why the effect of vitamin C on iron absorption in meals hasn’t been clearly shown. Erythorbic doesn’t have much vitamin C activity. (Fidler MC, Davidsson L, Zeder C, Hurrell RF. Erythorbic acid is a potent enhancer of nonheme-iron absorption. Am J Clin Nutr 2004; 79:99–102. 41. Cook JD, Reddy MB. Effect of ascorbic acid intake on nonheme-iron absorption from a complete diet. Am J Clin Nutr 2001;73:93–8.)

3.2. Disodium Ethylenediaminetetraacetic Acid (Na2EDTA)
An alternative enhancer to ascorbic acid. It can bind with nearly every other metal which may be why it doesn’t enhance the iron’s with low solubility. By the time these substances have had their iron released and become soluble with the help of the stomach gastric acids, the Na2EDTA has hooked up with something else.

(Fidler 2003)
"stable during storage and food preparation. However, it has the disadvantage of not being an essential nutrient and concerns exist regarding its potential toxicity,"

“an effective enhancer of iron absorption from ferrous sulfate fortified foods containing phytic acid, when added at a molar ratio of Na2EDTA to iron of 1:1 (el Guindi et al. 1988; MacPhail et al. 1994; Hurrell et al. 2000; Davidsson et al. 2001c). However, when added at
Na2EDTA to iron molar ratio greater that 1:1, Na2EDTA has been shown to act as an inhibitor of iron absorption (Cook & Monsen, 1976b; MacPhail et al. 1994); thus the effect of Na2EDTA on iron absorption is dose-dependent."

“For some foods it has been to be more effective at smaller ratios than 1:1. Like ascorbic it is likely dependent on the amount of inhibitors “

4. Meat tissue
(Monsen et al. 1978)
30 g muscle tissue is considered equivalent to 25 mg ascorbic acid

(Björn-Rasmussen & Hallberg, 1979; Layriss et al. 1984) show that animal tissue is an effective enhancer of non-heme iron absorption.

(Hurrell 1997) Absorption is increased in the presence of muscle tissue, perhaps because the protein digestion products prevent the polymerization of haem (McPhail et al, 1985)

(Reddy MB, Hurrell RF, Cook JD. Meat consumption in a varied diet marginally influences nonheme iron absorption in normal individuals. J Nutr 2006;136:576–81.) reported only a marginal improvement in iron absorption (35%) in self-selected diets over 5 d when daily muscle tissue intake was increased to ’300 g/d

(Bach Kristensen M, Hels O, Morberg C, Marving J, Bugel S, Tetens I. Pork meat increases iron absorption from a 5-day fully controlled diet when compared to a vegetarian diet with similar vitamin C and phytic acid content. Br J Nutr 2005;94:78–83.) in a 5-d study, 60g pork meat added to a vegetarian diet increased iron absorption by 50%.

5. Vitamin A
It’s needed to make red blood cells, so like iron, a lack of it can cause anemia. Unsure whether vitamin A affects iron absorption directly or not. more studies are needed.

(Garcia-Casal et al. 1998) says vitamin A enhances iron absorption. Bit of controversy around it that it may not have to do with iron absorption but vitamin A status.

(Walczyk et al. 2003) showed vitamin A to have no effect from ferrous sulfate fortified meals

(No enhancing effect of vitamin A on iron absorption in humans. Am J Clin Nutr 2003;77:144–9. 88. Davidsson L, Adou P, Zeder C, Walczyk T, Hurrell R.) study indicates that a relationship between vitamin A status and iron absorption exists, but vitamin A doesn’t directly influence iron. Need to read study to understand, only read abstract.

(Hurrell and Egli 2010) "The interaction of iron and vitamin A metabolism is clearly complex and subject factors or methodologic issues could explain the contradictory findings. The possible influence of carotenoids on iron absorption is important because carotenoids are widely present in fruit and vegetables."
6. Riboflavin

(Powers HJ. Riboflavin (vitamin B-2) and health. Am J Clin Nutr 2003; 77:1352–60.) Human studies showed that the correction of riboflavin deficiency improved the response to iron supplements

(Fairweather Tait SJ, Powers HJ, Minski MJ, Whitehead J, Downes R. Riboflavin deficiency and iron-absorption in adult Gambian men. Ann Nutr Metab 1992;36:34–40.) An absorption study in Gambian men indicated that the efficiency of iron use is impaired in riboflavin deficiency but that iron absorption is unaffected

7. References


