Iron Fortificants in Food Industry

Christina Omelchenko

National University of Food Technologies

Introduction. Fortification of foods is a common method used to deliver nutritionally important minerals in required quantities to the consumer. Many technological problems can occur in fortified foods due to the chemical reactivity of minerals. These problems are reflected as changes in color, flavor, and functional properties of the product. The solubility and chemical reactivity of the added mineral salt as a fortifier determines the kind and extent of reactions that may occur within the food system.

Materials and methods. The following factors are considered to be important when choosing a mineral for the fortification of foods: relative bioavailability of the mineral, reactivity of the mineral, stability of the mineral under processing and storage conditions, and compatibility with other food components. In the past, one of the main conflicts which has arisen surrounding iron fortification is delivering bioavailability while maintaining the product characteristics that the consumer is used to. The general consensus is that a greater bioavailability is found in iron ingredients which have increased solubility at the duodenal pH of 6-6.5, with ferrous sulfate seen as having the ideal properties. Probably the most commonly used iron fortificants within the food industry are ferrous sulfate, ferrous fumarate, NaFeETDA, and elemental iron. Ferrous sulfate is freely water soluble, highly bioavailable (100%), and cheap to buy, therefore making it a popular choice with many food manufacturers. However, its solubility means that it is likely to interact with other ingredients in the food matrix and cause oxidation of fats and discoloration, and deteriorate in terms of organoleptic properties over long-term storage. Less soluble iron fortificants can be incorporated into food products relatively easily, with their reduced solubility meaning that there are fewer side effects experienced with the product. Ferrous fumarate has a similar bioavailability to ferrous sulfate and works well in most food products; however, issues have arisen when acid conditions in food products caused complete dissolution of the fumarate affecting both product color and taste. Chelated forms of iron are also a convenient choice with solubility occurring at high pHs which render it available for absorption within the body. As the iron is bound to a ligand, it is prevented from interacting with various inhibitors present in the food matrix. The inclusion of these fortificants is dependent on product characteristics such as pH like most other fortificants. NaFeEDTA is an example of one such chelated iron product which is widely used in both the food and animal feed industries, at a higher cost to the producer and therefore consumer. Another example of an iron fortificant which is used frequently in the food industry is ferrous glycinate which while stable in most conditions is not stable at low pH.

Results. The liposome particles previously discussed are on the nano scale and this seems to be the way forward in some respects. Other particle size-associated technologies include micronization of compounds such as ferric chloride and sodium pyrophosphate to form ferric pyrophosphate. The studies have shown that decreasing the particle size of iron powders toward the nano size improves absorption of iron in rats. The bioavailability of ferric phosphate ($FeP0_4$) nanoparticles has been investigated. $FeP0_4$ is a poorly water-soluble compound; however, after micronisation to nanoparticles, the Fe was more soluble *in vivo,* leading to an increase in bioavailability. The increase in surface area means that the Fe can be more readily absorbed. Micronisation also renders ferric pyrophosphate soluble in aqueous solutions and in the same bioavailability range as ferrous sulphate.

In 2009 an iron-containing nano ingredient was described. The patent describes a method for producing nanoparticles in the range of 5-1000 nm which contain an iron salt stabilized by biopolymers (in particular dairy-based proteins and amino acids). Due to the size of the particles, the iron is said to be very stable in terms of reactivity within a food product and does not sediment in liquid preparations. Nestle has examined the effect of iron addition to casein, and claims to have an iron casein complex which is stable in a food system while the iron remaining bioavailable to the body. This complex is formed by the addition of iron to a casein solution and adjustment of the pH to between 5.8 and 6.2 before addition of the ferric iron solution. The complexes formed which are insoluble but dispersible in water can be either used in a liquid form or can be spray dried to form an iron-fortified ingredient.

Conclusions. Milk is a poor source of iron and contributes only 0.2-0.5 mg/L to the daily nutritional requirements of the human body. Of this minor quantity of iron in cow's milk, 14% is associated with the fat globule membrane, 24% is bound to casein, 29% to whey proteins, and the rest (32%) is associated with the low-molecular-weight fraction. However, when externally added to milk, iron binds strongly to proteins, especially caseins. In order to achieve a greater understanding of how milk proteins are involved in iron binding, the physico-chemical aspects of the proteins involved should be investigated.

References

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Scientific supervisor: Iryna Dovgun