

Comparison of Nutritional Microencapsulated Iron Particles

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ABSTRACT SUMMARY

Five samples of available microencapsulated iron particles were characterized by several properties. Coating composition, coating percentage, color, and particle size distribution were compared as well as the rate of core release in a heated acidic environment.

Keywords: iron, microencapsulation, fortification, release profile, particle size.

INTRODUCTION

Iron is an important mineral for numerous metabolic functions in the body including oxygen transport, DNA synthesis, and electron transport¹. Iron deficiency, which can result in fatigue, irritability, headaches, lack of energy, and anemia, is the most common nutrient deficiency in the world². The use of iron particles to fortify food has been investigated in numerous vehicles. There are multiple motivations for encapsulating iron particles for fortification including prevention of ingredient interaction, color and taste masking, and site-targeted release in the GI tract. There is great variability in the properties of available microencapsulated iron particles. Coated iron products for fortification must be chosen for the characteristics imparted by the coated particle.

EXPERIMENTAL METHODS

Five samples of coated iron particle products were obtained for analysis. The samples and their corresponding known physical properties prior to analysis are listed in Table 1. The iron contained in the particles was ferrous sulfate, ferrous fumarate, or reduced iron. The samples also differed in the coating composition, coating percentage, and color of particles. The particle size analysis was done using an ATM Model L3-P Sonic Sifter at pulse setting seven and amplitude setting seven for three minutes. U.S. mesh screens 20, 30, 40, and 60 were used for

Samples A-D, and U.S. mesh screens 100, 120, 140, 200, and 325 were used for Sample E. The release profile was determined using an iron release assay in 30 g concentrated HCl. The acid was heated to approximately 45°C and 175 - 250 mg of coated product was added. The encapsulated iron was stirred in the HCl for time increments of 30, 45, 60, and 120 minutes. After stirring for the appropriate amount of time the sample was filtered and rinsed with distilled water. The filtrate was brought to 100 g with distilled water. 5.0 mls of the filtrate was transferred to a 100 ml volumetric flask and 1 ml of hydroxylamine HCl 10% solution, 10 mls o-phenanthroline 0.1% solution, and 10 mls 10% sodium acetate solution was added. The flask was then brought to volume with distilled water. A blank was made with the same materials except for the filtrate from the coated iron. The absorbance of the sample at 509 nm in a 1 cm cell was then read on a Cary-50 UV/Visible spectrophotometer. This test was not intended to measure bioavailability, but rather was used to make comparisons between the release rates of the samples in a warm acidic environment.

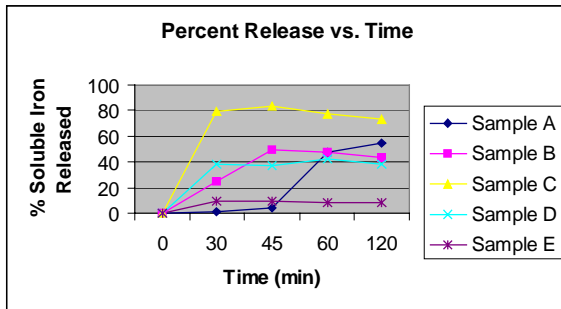
RESULTS AND DISCUSSION

The differences in the release profiles of each sample in a warm acidic environment are seen in Figure 1. In the acidic environment the tested products displayed release profiles ranging from immediate release to a delayed release of up to 45 minutes. To illustrate the fact that there are large differences in the characteristics of available products let us consider the two ferrous sulfate products with the fastest and slowest release: sample A and sample C. Sample A showed a release of 3.8% in the initial 45 minutes, which corresponds to a release rate of 0.084%/min. After the 45 minute mark the release rate increased to ~2.9%/min from time increments 45 to 60 minutes. Following the 60 minute mark, the rate of release slowed to 0.13%/min up to the 120 minute mark. Overall sample A displayed a delayed release until the 45 minute mark, then released the soluble iron core for a period of time and slowed as it approached two hours in the acidic environment.

Table 1. Physical Properties

	A _{1,3}	B _{2,3}	C _{1,3}	D _{1,3}	E ₃
Core	Ferrous Sulfate	Ferrous Fumarate	Ferrous Sulfate	Ferrous Sulfate	Reduced Iron
% Core	50%	60%	60%	60%	87%
Iron Content ₄	32.2%	32.9%	32.2%	32.2%	100%
Coating	Hydrogenated Palm Oil	Hydrogenated Soy Oil	Mono/Di-glycerides	Mono/Di-glycerides	Zein/HPMC
% Coating	50%	40%	40%	40%	13%
Color	Off-white greenish	Red-brown	Light Grey	Tan/Cream	Dark Grey

1. The core of samples A, C, and D consisted of Dried Ferrous Sulfate USP. The USP monograph for dried ferrous sulfate states that it contains 86.0-89.0% anhydrous ferrous sulfate (FeSO₄). Assuming 87.5% anhydrous ferrous sulfate content for each sample, the calculated Fe²⁺ content of the salt in each sample was calculated to be 32.2%.
2. The core of sample B consisted of Ferrous Fumarate USP. The USP monograph for ferrous fumarate states that it consist of 97.0-101.0% C₄H₂FeO₄. Assuming 100% C₄H₂FeO₄ content for the sample, the Fe²⁺ content was calculated to be 32.9%.
3. Sources of the iron samples are available upon request.
4. Number represents percent elemental iron in core.

Figure 1. Percent Release vs. Time

Sample C displayed quite a different release profile as that of sample A. The thirty-minute release of sample C was 79.6%. The measured iron released in the 45, 60, and 120 minute assays did not significantly increase so the assumption can be made that all of the soluble iron that can be released in the acidic environment of the assay was released within the first 30 minutes.

The differences shown in the release profiles of these two products may indicate a difference in the performance of the products in terms of bioavailability, interaction with other ingredients, or taste when used in supplements or fortified food products. A separate study has shown evidence that the absorption of unencapsulated ferrous sulfate is significantly lower than the absorption of encapsulated ferrous sulfate in milk. That study suggested the iron absorption was inhibited by

Table 2. Particle Size Data

	*+20	*+30	*+40	*+60	*+100	Pan
Sample A	0.2%	0.3%	3.6%	50.8%	39.0%	6.2%
Sample B	0.0%	0.1%	2.7%	78.2%	19.0%	0.0%
Sample C	6.1%	18.0%	19.1%	19.1%	8.9%	28.7%
Sample D	0.0%	0.7%	0.8%	4.8%	46.1%	47.6%

	*+100	*+120	*+140	*+200	*+325	Pan
Sample E	8.3%	10.4%	26.6%	44.8%	8.2%	1.7%

interactions between the iron and constituents of the milk that produced insoluble compounds³.

CONCLUSIONS

As the data shows, there is quite a wide range in the release profiles and particle sizes of the samples studied. Clearly these differences must be considered when choosing among the available iron particles for applications in fortification. There have been studies done suggesting bioavailability is improved when iron is encapsulated^{3,4}. A possible area for future investigation may be to determine how the differences between coated iron particles affects bioavailability and other properties of the final supplement or fortified product. Considering the known inhibition of absorption of iron by compounds present in the stomach, another topic to investigate may be the bioavailability of enteric-coated iron versus iron coated with non-enteric formulations.

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