

The effect of change in pH on the solubility of iron bis-glycinate chelate and other iron compounds

María Nieves García-Casal and Miguel Layrisse

Instituto Venezolano de Investigaciones Científicas (IVIC). Centro de Medicina Experimental.
Laboratorio de Fisiopatología- Caracas, Venezuela

SUMMARY. The effect of a pH change from 2 to 6 was tested on the solubility of ferrous sulfate, ferrous fumarate, iron bis-glycine chelate (Ferrochel) and sodium-iron ethylenediaminetetraacetic acid (NaFeEDTA). It was found that at pH 2 ferrous sulfate, Ferrochel and NaFeEDTA were completely soluble and only 75% of iron from ferrous fumarate was soluble. When pH was raised to 6, iron from amino acid chelate and NaFeEDTA remained completely soluble while solubility from ferrous sulfate and ferrous fumarate decreased 64 and 74%, respectively compared to the amount of iron initially soluble at pH 2. These results suggest that iron solubility from iron bis-glycine chelate and NaFeEDTA is not affected by pH changes within the ranges tested, probably because iron remained associated to the respective compounds.

Key words: Iron solubility, pH changes, iron bis-glycine chelate, NaFeEDTA, ferrous fumarate, ferrous sulfate.

RESUMEN. Efecto de cambios de pH sobre la solubilidad del hierro bis-glicinato quelado y de otros compuestos de hierro. Se estudió el efecto del cambio de pH de 2 a 6 sobre la solubilidad del hierro de sulfato ferroso, fumarato ferroso, hierro bis-glicinato quelado (Ferrochel) y ácido etilendiaminetetraacético sódico-férrico (NaFeEDTA). Se encontró que a pH 2 el hierro proveniente de sulfato, Ferrochel y NaFeEDTA estaba completamente soluble, mientras que para el fumarato ferroso solo el 75% del hierro se hallaba en solución. Cuando se incrementó el pH a 6, el hierro del glicinato quelado y del NaFeEDTA permaneció completamente soluble mientras que la solubilidad a partir de sulfato y de fumarato disminuyó 64 y 74%, respectivamente comparado con la cantidad de hierro soluble a pH 2. Estos resultados sugieren que la solubilidad del hierro proveniente del glicinato quelado y del NaFeEDTA no fue afectada por los cambios de pH estudiados, probablemente debido a que el hierro permanece asociado a los respectivos compuestos.

Palabras clave: Solubilidad de hierro, cambios de pH, hierro bisglicinato quelado, NaFeEDTA, fumarato ferroso, sulfato ferroso.

INTRODUCTION

According to their solubility iron compounds have been classified as water soluble (ferrous sulfate, ferrous gluconate, ferrous lactate, ferric ammonium citrate), poorly water soluble but soluble in diluted acids (ferrous fumarate, ferrous succinate, ferric saccharate), poorly soluble in water acid solutions (ferric pyrophosphate, ferric orthophosphate, elemental iron) and protected compounds (hemoglobin, ethylenediaminetetraacetic acid (NaFeEDTA), iron bis-glycinate chelate). To establish relative iron bioavailability of these compounds, absorption values are compared to a standard compound which is ferrous sulfate, with a relative bioavailability of 100 (1).

During the last two years the Nutritional Anemia Laboratory of the Instituto Venezolano de Investigaciones Científicas (IVIC), has been studying the properties of various iron compounds, including iron bis-glycine chelate (Ferrochel), for food fortification under various conditions. This iron compound has the advantage of being soluble in

water and does not change the organoleptic properties of the food vehicle(2). The purpose of the present study was to evaluate the solubility of iron compounds (ferrous sulfate, ferrous fumarate, Ferrochel and NaFeEDTA) currently used in food fortification programs, when the pH is changed from 2 to 6.

MATERIAL AND METHODS

Iron solubility when the pH is changed from 2 to 6 was evaluated under equal conditions for ferrous sulfate, ferrous fumarate, iron bis-glycine chelate (Ferrochel) and ethylenediaminetetraacetic acid (NaFeEDTA). Iron solutions of each of the compounds mentioned containing 5 mg iron, were prepared in 0.1 mol/L HCl. Duplicate 1-mL aliquots were taken after 30 min at room temperature to measure soluble iron at pH2, and to the remaining solution, the pH was adjusted to 6 with careful addition of NaOH (3). After standing 10 min at room temperature, duplicate 1-mL aliquots from the top of the solution were taken to measure iron concentration by a published digestion method (4).

RESULTS AND DISCUSSION

The selection of the iron compound for fortification is important in order to avoid interactions with the food vehicle or the total meal, because a minor change in organoleptic characteristics of the food, will result in consumers rejection. When the iron compound is added, it is necessary to evaluate possible changes in food color, taste or appearance with time and storage on adverse temperature and humidity conditions. Solubility, chemical reactivity, bioavailability and cost are other important issues when selecting an iron compound. For instance, ferrous sulfate is a highly bioavailable and relatively inexpensive compound, but because of its reactivity produces undesirable changes in some

fortified foods. On the other hand, elemental iron (reduced, electrolytic or carbonyl) is also inexpensive but it has been reported to have a low bioavailability depending on particle size and the food vehicle to be fortified. Protected iron compounds have been reported to have a high bioavailability, but they are usually expensive (5-7).

Variations in iron solubility when pH was changed from 2 to 6 are presented in Table 1. At pH 2 iron from ferrous sulfate, Ferrochel and NaFeEDTA was completely soluble while the amount of soluble iron from ferrous fumarate was 76.6% of the expected amount of 5 mg, after 30 min incubation. Solubility of this compound in acidic solutions increases with longer incubation time.

TABLE 1
Iron solubility from ferrous sulfate, ferrous fumarate, NaFeEDTA and Ferrochel at pH 2 and 6

pH	Ferrous sulfate		Ferrous fumarate		Ferrochel		NaFeEDTA	
	mg	%	mg	%	mg	%	mg	%
2	6.22±0.2 ^a	100.0	3.83±0.1 ^a	100.0	5.71±0.3 ^a	100.0	5.40±0.1 ^a	100.0
6	2.24±0.2 ^b	36.0	0.99±0.2 ^b	25.8	5.33±0.2 ^a	93.3	5.12±0.1 ^a	94.8

¹ Values are means ± SEM. n = 10. Values in any given column with different letters are significantly different. p<0.05. Initial iron content: 5 mg.

Increasing pH to 6 produced a decrease in solubility for ferrous sulfate and ferrous fumarate. After 10 min incubation at pH 6, 64% of the iron from ferrous sulfate became insoluble while 74% of the iron from ferrous fumarate, was precipitated. This percentage for ferrous fumarate is based on the amount soluble at pH 2, that was already reduced in approximately 23%. For Ferrochel and NaFeEDTA solutions, the change in pH from 2 to 6 did not modify the amount of soluble iron, showing in both cases that more than 90% remained in solution.

These results indicate that iron from Ferrochel and NaFeEDTA remains soluble even when the pH is changed over a wide range as happens when food moves from the stomach to the small intestine. This finding may indicate that the observed high iron absorption from these two compounds is related to their resistance to pH changes and that within the studied range, the molecules are not altered, maintaining their capability to keep iron in a protected, soluble form.

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